SYARAHAN PERDANA 2011

WIRELESS TECHNOLOGY: CAN WE LIVE WITHOUT IT?

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AYOB JOHARI

Penerbit UTHM
2011

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PREFACE

This book provides useful information and knowledge of wireless technology starting from the fundamental of communication, application, and satellite communication, evolution of wireless and impact of wireless technology on social.

Wireless technology is very synonym to all of us in modern living. This book is written in a simple manner for readers from all walks of life to understand. It is written in such a manner especially for readers of non-engineering education background. Wireless technology is indeed very broad and wide; covers almost every spectrum in electronic communication. It is with intention that the wireless technology should be transcended and grasped by all so that it is fully understood and appreciated.

This book consists of eight chapters. Chapter One is on Introduction of Communication System in which it describes the basic of communication, terminology in communication, noise and attenuation, types of communication, signal, frequency, frequency spectrum, band allocation, frequency assignment and wavelength.

Chapter Two is on Basic of Wireless Communication. It describes about wireless technology, definition of wireless communication, modulation, the importance of modulation, bandwidth, amplitude modulation, frequency modulation, phase modulation, and types of digital modulation. The differences between analog and digital signals AM and FM are clearly explained.

Chapter Three touches on wireless system in which it describes radio communication as the most basic of wireless system. It also describes transmitter, AM and FM transmitters, AM and FM receivers, frequency band and FM channels in Malaysia. This chapter gives insight knowledge on the fundamental of wireless system.

Readers will be given basic knowledge and understanding on wireless application in Chapter Four. This chapter describes on types of wireless device, RF and infrared devices, basic on cellular phone, RF and infrared remote control devices, ham radio, wireless using microwave, radar system, RFID, barcode, Bluetooth, wi-fi, broadband network and Wi-MAX.

Introduction to satellite communication is available in Chapter 5. This chapter describes on the types of satellite, ionosphere, satellite system, GPS and types of application using satellite system.

The rest of the chapters 6, 7 and 8 describe on the development of wireless in Malaysia, the evolution of wireless communication, prediction of electronic gadget for 2011, related research work titles carried out in the faculty, and impact of wireless technology on social in general.

CHAPTER 1

INTRODUCTION

1.1 Communication System

One of the most pervasive human activities during the late twentieth and early twenty-first centuries is communication. Although most of the time human beings have always communicated face-to-face, long distance communication have become even more widespread and inevitable. These phenomena have indeed in line with the development of new technologies in communication system. A communication system is a technology system used for communication since forms a medium to link a sender and receiver such that information may be passed to each other. Human communication took a great leap forward in the nineteenth century with the development of the telephone and the telegraph.

The wireless break through technology was achieved in the twentieth century with the development of radio, TV, radar, cell phone, fax machine and other dozens of devices that contributed to further increased our ability to communicate. In order to receive radio signals, for instance from AM/FM radio stations, a radio antenna must be used. However, since the antenna will pick up thousands of radio signals at a time, a radio tuner is necessary to tune in to a particular frequency (or frequency range). This is typically done via a resonator (in its simplest form, a circuit with a capacitor and an inductor). The resonator is configured to resonate at a particular frequency (or frequency band), thus amplifying sine waves at that radio frequency, while ignoring other sine waves. Usually, either the inductor or the capacitor of the resonator is adjustable, allowing the user to change the frequency at which it resonates.

1.2 Terminology

1.2.1 Electronic communication

Communication is the basic process of exchanging information. It is human beings do to convey their thoughts, ideas, and feelings to one another. Human beings have been communicating with one another from the beginning of humankind. Most humans communicated through the spoken words, as they do today.

Most human communication in the beginning was limited to face-to-face conversation. Long distance communication was first initiated by blowing a horn, lighting a signal fire, or waving a flag (semaphore). But despite these attempts, transmission distances were still limited. Long distance communication not only limited to voice, but was extended to written message (words), images and video. The transmission of this information over long distance can only be carried out by means of electronic circuit. Electronic communication involves transmission, reception and processing of information between two or more locations using electronic circuits.

1.2.2 Information

The message or data is the source of information for electronic communication. The information can be in the form of analog or digital signal with its own original frequency. For voice information signal, its frequency is in the range of audible frequency to human. The original signal frequency by itself cannot be transmitted via wireless system. It had to be converted to electromagnetic energy before transmission.

1.2.3 Transmitter

A transmitter is an electronic device or collection of one or more electronic devices or circuits which, usually with the aid of an antenna, propagates an electromagnetic signal such as radio, television, or other telecommunications. It converts the original source into a signal that is more suitable for transmission over a given transmission medium.

In radio electronics and broadcasting, a transmitter usually has a power supply, an oscillator, a modulator, and amplifiers for audio frequency (AF) and radio frequency (RF).

1.2.4 Receiver

A communications receiver is a type of radio receiver used as a component of a radio communication link. It is also collection of electronic devices and circuits that receives the transmitted signal from the transmission medium and converts them back to their original form.

Commercial communications receivers are characterised by high stability and reliability of performance, and are generally adapted for remote control and monitoring. For marketing purposes, almost any hobby-type receiver is advertised as a "communications receiver" although none are suited for heavy-duty, reliable 24-hour use as the primary form of communication for an isolated station.

1.2.5 Transmission impairments

Transmission impairment is defined as any undesired effect on the signals while traveling from the transmitter to the receiver, such as noise, attenuation, interference and other losses caused by the atmosphere or the medium itself. When signals in the context of analog or digital communication systems are sent over the different physical media (wire or wire less communication) they suffer from various types of degradation or impairment during transmission and processing.

1.2.5.1 Noise

Noise is anything that interferes with, slows down, or reduces the clarity or accuracy of a communication. Random disturbance introduced into a communication signal, caused by circuit components, electromagnetic interference, or weather conditions. Noise that is commonly occurred along the transmission medium is called line noise. Noise is a random, undesired electrical energy that enters the communication system via the communication media (i.e. inserted between TX and RX) and interferes with the transmitted message. Figure 1.1 shows example of common noise and signal waveforms in communication system.

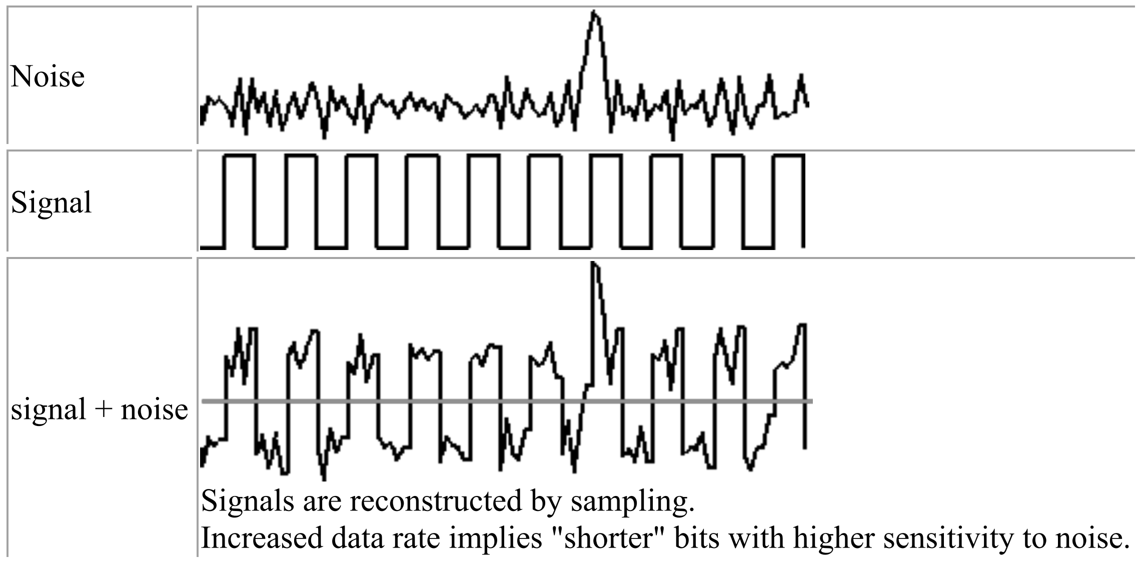


Figure 1.1 Signal and noise

1.2.5.2 Attenuation

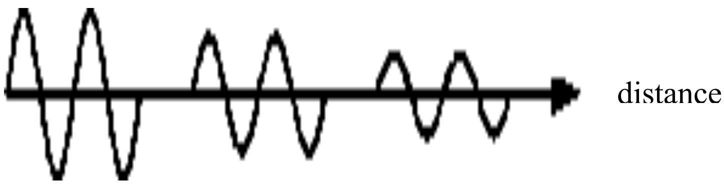


Figure 1.2 Signal

Attenuation is a general term that refers to any reduction in the strength of a signal. Attenuation occurs with any type of signal, whether digital or analog. Sometimes called *loss*, attenuation is a natural consequence of signal transmission over long distances as shown in Figure 1.2. The extent of attenuation is usually expressed in units called decibels (dBs).

If P_s is the signal power at the transmitting end (source) of a communications circuit and P_d is the signal power at the receiving end (destination), then $P_s > P_d$. The power attenuation A_p in decibels is given by the formula:

$$A_p = 10 \log_{10}(P_s/P_d)$$

Attenuation can also be expressed in terms of voltage. If A_v is the voltage attenuation in decibels, V_s is the source signal voltage, and V_d is the destination signal voltage, then:

$$A_v = 20 \log_{10}(V_s/V_d)$$

In conventional and fiber optic cables, attenuation is specified in terms of the number of decibels per meter, 1,000 feet, kilometer, or mile. The lesser the attenuation per unit distance, the more efficient the cable. When it is necessary to transmit signals over long distances via cable, one or more repeaters can be inserted along the length of the cable.

The repeaters boost the signal strength to overcome attenuation. This greatly increases the maximum attainable range of communication.

1.2.5.3 Interference

Interference is anything which alters, modifies, or disrupts a message; as it travels along a channel, between a source and a receiver. Noise signal has the same frequency as the information signal. It is the superposition (overlapping) of two or more waves resulting in a new wave pattern. As most commonly used, the term usually refers to the interference of waves of the same or nearly the same frequency.

The principle of superposition of waves states that the resultant displacement at a point is equal to the sum of the displacements of different waves at that point. If a crest of a wave meets a crest of another wave at the same point then the crests interfere *constructively* and the resultant wave amplitude is greater. If a crest of a wave meets a trough then they interfere *destructively*, and the overall amplitude is decreased.

1.3 Type of Electronic Communication

There are three type of electronic communication system namely simplex, half duplex and full duplex. All can be in a form of analog or digital. The simplest method of electronic communication is referred to as simplex. This type of communication is one-way. Examples are:

- Radio
- TV broadcasting
- Beeper (personal receiver) or pager.

Half duplex forms two-way communication in which only one party transmits at a time. The two parties in the half duplex communication system have to assign an understandable signal or word that a person has done the talking before the second person starts. Examples are:

- Police, military, etc. radio transmissions
- Citizen band (walkie- talkie)
- Family radio
- Amateur radio

Full duplex is the most widely used electronic communication system over the globe. It is a system that allows people to talk and listen simultaneously. The fix line or mobile telephones are typical examples of this of communication. Despite the tradition of fix wired system, most full duplex system are now being wireless.

1.4 Types of Signal

1.4.1 Analog

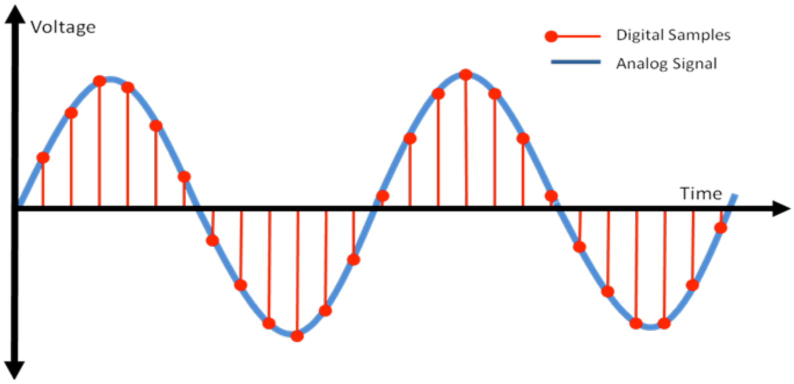


Figure 1.3 Analog signal

Communications signals can be either by analog signals or digital signals. There are analog communication systems and digital communication systems. For an analog signal, the signal is varied continuously with respect to the information.

An analog or analogue signal is any continuous signal for which the time varying feature (variable) of the signal is a representation of some other time varying quantity, i.e., analogous to another time varying signal (Figure 1.3). Analog is usually thought of in an electrical context; however, mechanical, pneumatic, hydraulic, and other systems may also convey analog signals. An analog signal uses some property of the medium to convey the signal's information. Electrically, the property most commonly used is voltage followed closely by frequency, current, and charge.

The main advantage is the fine definition of the analog signal which has the potential for an infinite amount of signal resolution. Compared to digital signals, analog signals are of higher density. Another advantage with analog signals is that their processing may be achieved more simply than with the digital equivalent. An analog signal may be processed directly by analog components, though some processes aren't available except in digital form.

The primary disadvantage of analog signaling is that any system has noise – i.e., random unwanted variation. As the signal is copied and re-copied, or transmitted over long distances, these apparently random variations become dominant. Electrically, these losses can be diminished by shielding, good connections, and several cable types such as coaxial or twisted pair. The effects of noise create signal loss and distortion. This is impossible to recover, since amplifying the signal to recover attenuated parts of the signal amplifies the noise (distortion/interference) as well. Even if the resolution of an analog signal is higher than a comparable digital signal, the difference can be overshadowed by the noise in the signal. Most of the analog systems also suffer from generation loss.

1.4.2 Digital

A signal in which the original information is converted into a string of bits before being transmitted is called digital system. It is transmitted as binary code that can be either the presence or absence of current, high and low voltages or short pulses at a particular frequency.

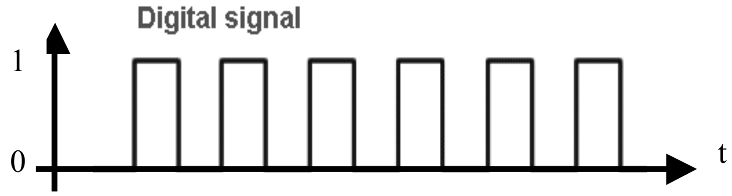


Figure 1.4 Digital signal

A digital signal is composed only of electrical pulses representing either zero or one. Because digital signals are made up only of binary streams, less information is needed to transmit a message. Digital encoding therefore increases the capacity of a given radio frequency.

The advantages of digital signals:

- Optical fibres can transmit digital signals (and optical fibres are cheap).
- Digital signals can be compressed so more channels can be transmitted along the same fibre.
- It's easy to combine several types of information on one channel (e.g. video and audio) by multiplexing. Video phones would be impossible with analogue systems as there wouldn't be enough channels available to send all the information for everyone's phone calls.
- Digital signals are more secure – it is easier to encrypt digital signals making internet shopping less risky for example.
  - Can connect several different users to the same link – such as video conferencing.
  - Digital signals suffer less from noise because any errors can be detected and corrected using regenerators. Therefore any received signal is more easily decoded and, on television, picture or sound is found to be much clearer.
  - The electronics can make corrections to the signal if it has been corrupted during transmission which means that the image or sound is complete.

The disadvantages of digital signals:

- Digital communications require greater bandwidth than analogue to transmit the same information.
- The detection of digital signals requires the communications system to be synchronised, whereas generally speaking this is not the case with analogue systems.

1.5 Frequency

Frequency is defined as the rate of occurrence of anything; the relationship between incidence and time period. For an oscillating or varying current, frequency is the number of complete cycles per second in alternating current direction. Frequency *f* is the reciprocal of the time *T* taken to complete one cycle (the period), or 1/*T*. Frequency is usually expressed in units called hertz (Hz). One hertz is equal to one cycle per second; one kilohertz (kHz) is 1,000 Hz, and one megahertz (MHz) is 1,000,000 Hz. The electrical energy supplied by Tenaga Nasional (TEN) to our house is alternating in nature with its frequency of 50 Hz. Figure 1.5 shows an alternating signal with its frequency.

1.5.1 Frequency Spectrum

The frequency spectrum is very significant in wireless communication. It is a time-domain representation of that signal in the frequency domain. The frequency spectrum can be generated via a Fourier transform of the signal, and the resulting values are usually presented as amplitude and phase, both plotted versus frequency.

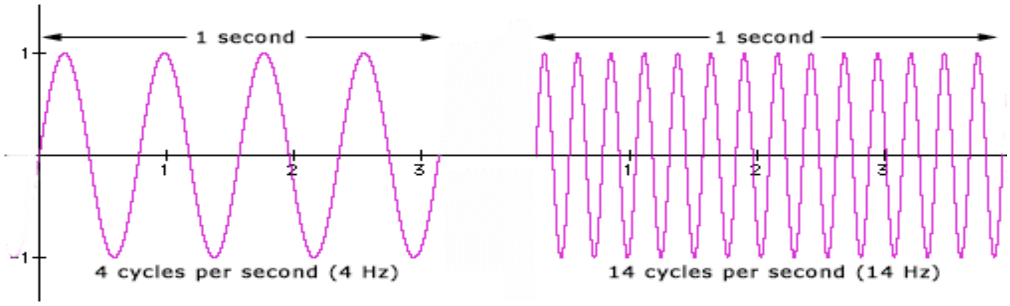


Figure 1.5 Alternating signal

Any signal that can be represented as an amplitude that varies with time has a corresponding frequency spectrum. This includes familiar concepts such as visible light (color), musical notes, radio/TV channels, and even the regular rotation of the earth. When these physical phenomena are represented in the form of a frequency spectrum, certain physical descriptions of their internal processes become much simpler. Often, the frequency spectrum clearly shows harmonics, visible as distinct spikes or lines that provide insight into the mechanisms that generate the entire signal. Figure 1.6 and Table 1.1, 1.2 and 1.3 show the Frequency Spectrum and Bandwidth Allocation respectively.

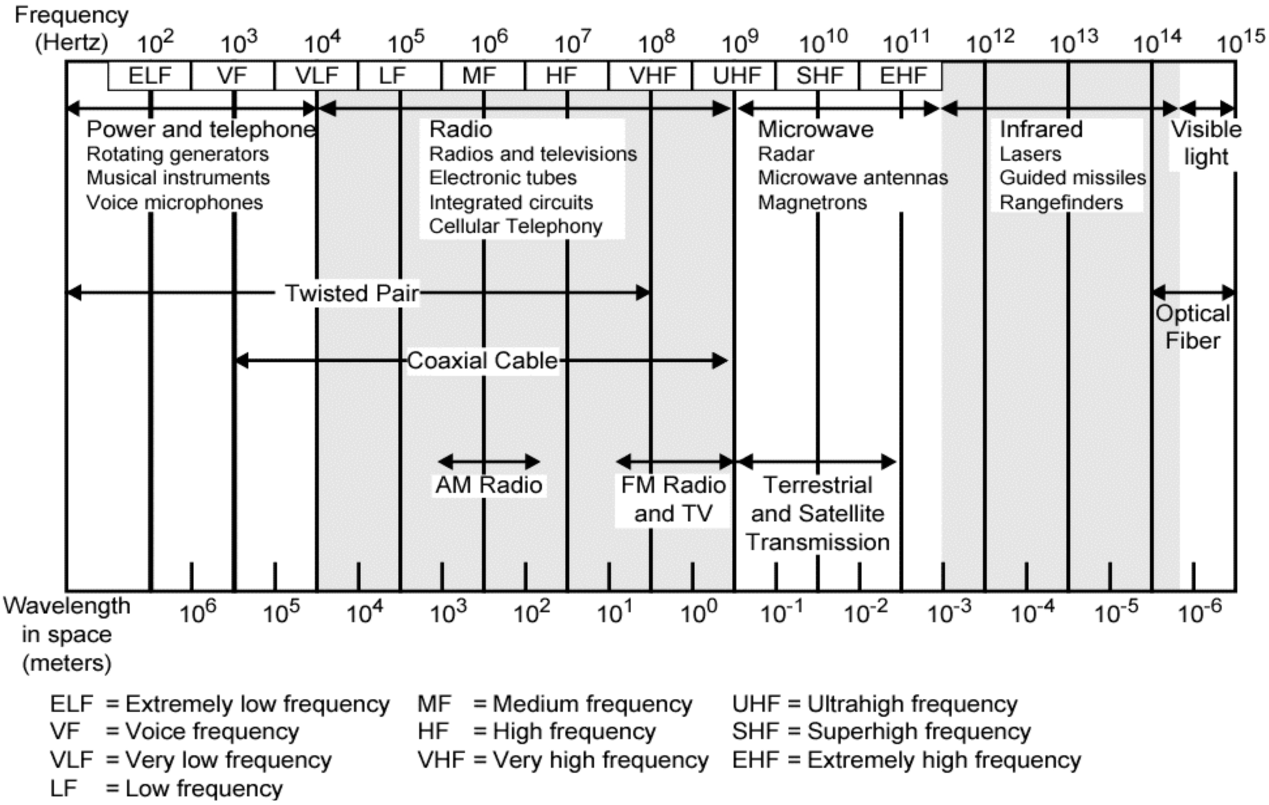


Figure 1.6 Frequency Spectrum

Table 1.1 Frequency band and its use

Band name	Abbr	ITU band	Frequency and wavelength in air	Example uses
sub-hertz	subHz	0	< 3 Hz > 100,000 km	Natural and man-made electromagnetic waves (millihertz, microhertz, nanohertz) from earth, ionosphere, sun, planets, etc.
Extremely low frequency	ELF	1	3–30 Hz 100,000 km – 10,000 km	Communication with submarines
Super low frequency	SLF	2	30–300 Hz 10,000 km – 1000 km	Communication with submarines, Main power (50/60Hz)
Ultra low frequency	ULF	3	300–3000 Hz 1000 km – 100 km	Communication within mines
Very low frequency	VLF	4	3–30 kHz 100 km – 10 km	Submarine communication, avalanche beacons, wireless heart rate monitors, geophysics
Low	LF	5	30–300 kHz	Navigation, time signals, AM longwave

frequency			10 km – 1 km	broadcasting, RFID, amateur radio
Medium frequency	MF	6	300–3000 kHz 1 km – 100 m	AM (medium-wave) broadcasts, amateur radio
High frequency	HF	7	3–30 MHz 100 m – 10 m	Shortwave broadcasts, citizens' band radio, amateur radio and over-the-horizon aviation communications, RFID, Over-the-horizon radar, Automatic link establishment (ALE) / Near Vertical Incidence Skywave (NVIS) radio communications, Marine and mobile radio telephony
Very high frequency	VHF	8	30–300 MHz 10 m – 1 m	FM, television broadcasts and line-of-sight ground-to-aircraft and aircraft-to-aircraft communications. Land Mobile and Maritime Mobile communications, amateur radio
Ultra high frequency	UHF	9	300–3000 MHz 1 m – 100 mm	Television broadcasts, microwave ovens, mobile phones, wireless LAN, Bluetooth, ZigBee, GPS and two-way radios such as Land Mobile, FRS and GMRS radios, amateur radio
Super high frequency	SHF	10	3–30 GHz 100 mm – 10 mm	Microwave devices, wireless LAN, most modern radars, communications satellites, amateur radio
Extremely high frequency	EHF	11	30–300 GHz 10 mm – 1 mm	Radio astronomy, high-frequency microwave radio relay, microwave remote sensing, amateur radio
Terahertz	THz	12	300–3,000 GHz 1 mm – 100 μm	Terahertz imaging – a potential replacement for X-rays in some medical applications, ultrafast molecular dynamics, condensed-matter physics, terahertz time-domain spectroscopy, terahertz computing/communications, sub-mm remote sensing, amateur radio

Table 1.2 Bandwidth Allocation

Band	**Frequency range**	**Origin of name**
HF band	3 to 30 MHz	**H**igh **F**requency
VHF band	30 to 300 MHz	**V**ery **H**igh **F**requency
UHF band	300 to 1000 MHz	**U**ltra **H**igh **F**requency
L band	1 to 2 GHz	**L**ong wave
S band	2 to 4 GHz	**S**hort wave
C band	4 to 8 GHz	**C**ompromise between S and X
X band	8 to 12 GHz	Used in WW II for fire control, X for cross (as in crosshair)
K_u band	12 to 18 GHz	**K**urz-**u**nder
K band	18 to 27 GHz	German **K**urz (short)
K_a band	27 to 40 GHz	**K**urz-**a**bove
V band	40 to 75 GHz	
W band	75 to 110 GHz	**W** follows V in the alphabet
mm band	110 to 300 GHz	

Table 1.3 Bandwidth Allocation

BANDWIDTH DESCRIPTION	**FREQUENCY RANGE**				
Extremely Low Frequency (ELF)	0		to	3	kHz
Very Low Frequency (VLF)	3	kHz	to	30	kHz
Radio Navigation & maritime/aeronautical mobile	9	kHz	to	540	kHz
Low Frequency (LF)	30	kHz	to	300	kHz
Medium Frequency (MF)	300	kHz	to	3000	kHz
AM Radio Broadcast	540	kHz	to	1630	kHz
Travelers Information Service	1610	kHz			
High Frequency (HF)	3	MHz	to	30	MHz
Shortwave Broadcast Radio	5.95	MHz	to	26.1	MHz
Very High Frequency (VHF)	30	MHz	to	300	MHz
Low Band: TV Band 1 - Channels 2-6	54	MHz	to	88	MHz
Mid Band: FM Radio Broadcast	88	MHz	to	174	MHz

High Band: TV Band 2 - Channels 7-13	174	MHz	to	216	MHz
Super Band (mobile/fixed radio & TV)	216	MHz	to	600	MHz
Ultra-High Frequency (UHF)	300	MHz	to	3000	MHz
Channels 14-70	470	MHz	to	806	MHz
L-band:	500	MHz	to	1500	MHz
Personal Communications Services (PCS)	1850	MHz	to	1990	MHz
Unlicensed PCS Devices	1910	MHz	to	1930	MHz
Superhigh Frequencies (SHF) (Microwave)	3	GHz	to	30.0	GHz
C-band	3600	MHz	to	7025	MHz
X-band:	7.25	GHz	to	8.4	GHz
Ku-band	10.7	GHz	to	14.5	GHz
Ka-band	17.3	GHz	to	31.0	GHz
Extremely High Frequencies (EHF) (Millimeter Wave Signals)	30.0	GHz	to	300	GHz
Additional Fixed Satellite	38.6	GHz	to	275	GHz
Infrared Radiation	300	GHz	to	430	THz
Visible Light	430	THz	to	750	THz
Ultraviolet Radiation	1.62	PHz	to	30	PHz
X-Rays	30	PHz	to	30	EHz
Gamma Rays	30	EHz	to	3000	EHz

1.5.2 Frequency Assignment

Extremely Low Frequencies (ELFs) are those in the 30 to 300 Hz range. These include ac power line frequencies (50 and 60 Hz) as well as those frequencies in the low end of human hearing range.

Voice Frequencies (VFs); are those in the range of 300 to 3000 Hz or 3 kHz. This is the normal range of human speech. Although human hearing extends from approximately 20 to 20 kHz, most intelligent sound occurs in the voice frequency range.

Very Low Frequencies (VLFs); include the higher end of the human hearing range up to 15 to 20 kHz. Many musical instrument also make sounds in this range as well as in the ELF and VF ranges. VLF radio transmission is used by the navy to communicate with submarines.

Low Frequencies (LFs); are those on the 30 to 300 kHz range. These frequencies are used in aeronautical and marine navigation. Frequencies in this range are also used as subcarriers. Subcarriers are signals that carry baseband modulating information but which, in turn, modulate another higher-frequency carrier.

Medium Frequencies (MFs); are in the range 300 – 3000 kHz or 3 MHz range. The major application of frequencies in this range is Amplitude Modulation (AM) radio broadcasting (535 to 1605 kHz). Other services in this range include aeronautical communication applications.

High Frequencies (HFs); are those in the 3 to 30 MHz range. These frequencies are known as short waves (SWs). All kind of radio communications take place in this range as well as some shortwave radio broadcasting. Government and military services use these frequencies for two-way communications. Amateur radio and Citizen Band (CB) communications also occur in this part of the spectrum.

Very High Frequencies (VHFs) cover the 30 to 300 MHz range. This is an extremely popular frequency range and is used by many services including mobile radio, marine and aeronautical communication. Frequency Modulation (FM) radio broadcasting (88 to 108 MHz), and TV channels 2 through 13. Radio amateurs also have numerous bands in this frequency range.

Ultrahigh Frequencies (UHs) cover the 300 to 3000 MHz or 3 Gigahertz (GHz). It is used fo UHF TV channels 14 through 67. It is also widely used for land mobile communication and services such as cellular telephones. The military, some radar and navigation widely use these frequencies for communications. Frequencies above 1000 MHz (1 gigahertz GHz) are called microwaves.

Superhigh Frequencies (SHFs); are those in the 3 to 30 GHz range. These are microwave frequencies that are widely used for satellite communication and radar.

Extremely High Frequencies (EHFs) extends from 30 to 300 GHz. Equipment use to generate and receive signals in this range is extremely complex and expensive. The activities in this frequency range include satellite communications and some specialized radar. Signals directly above this range are generally referred to as millimeter waves.

Electromagnetic signals whose frequencies are higher than 300 GHz are referred as Infrared. It is not referred to as radio waves anymore. The infrared region is sandwiched between the highest radio frequencies and the visible portion of the electromagnetic spectrum. It occupies the range approximately 0.01 millimeter and 700 nanometers (nm) or 0.7 to 10 microns (µm). Infrared refers to radiation generally associated with heat. Anything that produces heat generates infrared signals. Infrared is produced by light bulbs, our bodies, and any physical equipment that genet-rates heat. Infrared signals can also be generated by special types of light-emitting diodes.

Infrared signals are used for various special kind of communications such as in astronomy to detect stars, heat detector and in military to guide missile towards the target. It is also used in many remote control devices such as TV, hi-fi system and others house hold equipments.

1.6 Wavelength

Wave length is defined as the distance between corresponding points of two consecutive waves. "Corresponding points" refers to two points or particles that have completed identical fractions of their periodic motion as shown in Figure 1.7. In transverse waves, wavelength is measured from crest to crest or from trough to trough. In longitudinal waves, it is measured from compression to compression or from rarefaction to rarefaction. It is the distance traveled by an electromagnetic wave during one period. The time taken to complete one cycle is period T. If there is one complete cycle within a period T of one second, so its frequency is one cycle per second or Hertz (Hz). Wavelength, λ, is equal to the speed *v* of a wave in a medium divided by its frequency *f*, or $\lambda = v/f$.

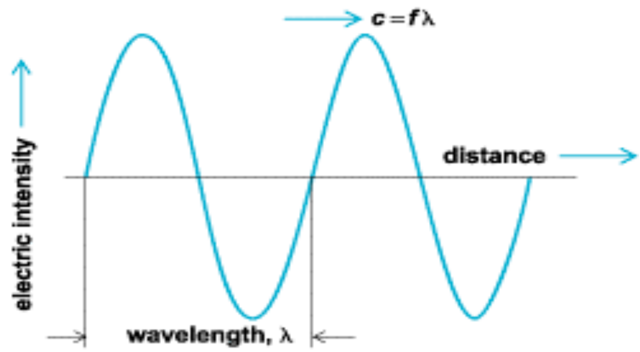


Figure 1.7 Signal Wavelength

1.7 The relation between frequency and distance of communication.

The relation between frequency and distance of communication in this case is referred to terrestrial or Earthbound radio communications, not communications in outer-space. For point to point communications on the earth, high frequencies in the 100 kHz to 30MHz ranges can be used for the longest range communications. Much higher frequencies, like VHF and UHF, in the 100's of MHz or GHz ranges are for the most part, limited to line of sight. What that means is that for all practical purposes, the much higher frequencies are limited by the Earth's Horizon. The lower frequencies are not. The reason the lower frequencies tend to travel farther around the earth's horizon is due to a phenomenon called skip. The lower frequency waves are reflected back by the ionosphere surrounding the earth, and literally can skip distances of 100's or thousands of miles, and be heard strongly at a specific range, while not heard at all at closer range. For the case of VHF, UHF and higher frequencies, those waves are absorbed, rather than reflected back by the ionosphere.

Amateur Radio operators are very familiar with skip, and some actually keep track of solar activity, which affects the ionosphere. The altitude and reflectivity of the ionosphere can vary due to solar flares and sunspot activities and even by the differing effects each day as the earth rotates and the path of sunlight changes across the planet. That is why the radio operators can communicate with parts of the world very easily at certain times of the day with very little power, while at other times, can not communicate at all.

CHAPTER 2

BASIC OF WIRELESS COMMUNICATION

2.1 Wireless Technology

Wireless technology has actually been around for a very long time. The first radios were the early days of wireless. Wireless technology used to be very expensive, slow, and proprietary. However, the latest wireless technology delivers fast, and more standardized in service.

The demand for wireless technology has been pushed by the increasing importance of portable computing applications, electronic devices and gadgets, mobile devices, entertainment devices and many others. In more specific application, almost every new notebook computer now comes with wireless ready.

2.2 Early wireless work

In the history of wireless technology, the demonstration of the theory of electromagnetic waves by Heinrich Hertz in 1888 was important. The theory of electromagnetic waves was predicted from the research of James Clerk Maxwell and Michael Faraday. Hertz demonstrated that electromagnetic waves could be transmitted and caused to travel through space at straight lines and that they were able to be received by an experimental apparatus. Jagadish Chandra Bose around this time developed an early wireless detection device and help increase the knowledge of millimeter length electromagnetic waves. Practical applications of wireless radio communication and radio remote control technology were implemented by later inventors, such as Nikola Tesla.

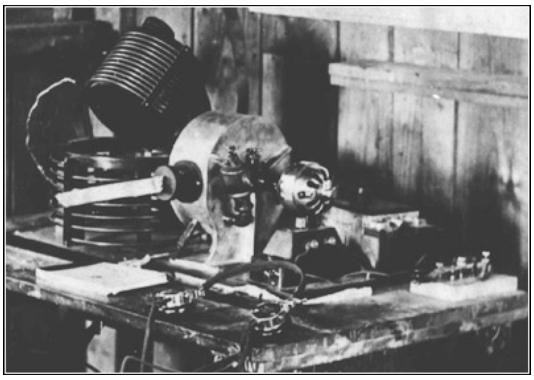


Figure 2.1 The World War I era wireless transmitter

The early wireless radio transmitter is shown in Figure 2.1. A Bell rotary spark gap with a general purpose electric motor is in the center of the operating table. The rotary spark gap has been modified with the addition of an oil cap an experimental method to improve the tone of the signal by adding a small amount of hydrocarbon vapor (kerosene, etc.) to the spark chamber. An adjustable oscillation transformer behind the gap looks as if it had been made by the William B. Duck Company. The rotary gap and oscillation transformer are connected by a metal strap.

A nice transmitting condenser is to the right of the gap, as is the sending key, which appears to be a Clapp-Eastham spark key on a marble base. This key had to be very heavily made, as it directly keyed the spark transformer primary from 110 VAC.

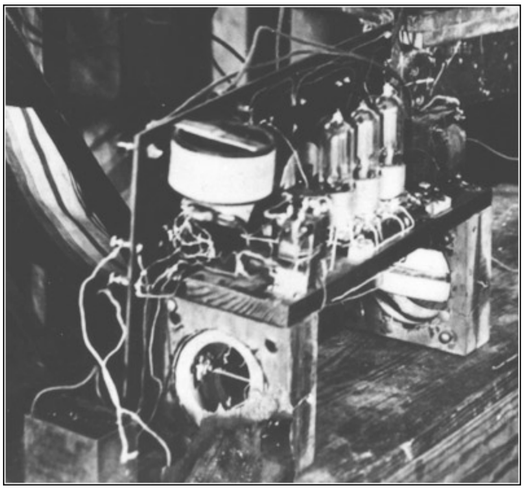


Figure 2.2 The World War I era wireless receiver

The section of the cover photo in Figure 2.2 shows the receiver in the foreground on the bench. It uses three VT-1 tubes, which were sold as Army surplus. It also uses wooden variometers, probably in a tuned plate/tuned grid circuit - a sign of early construction. Two stages of audio amplification are also included.

In the lower right corner, two alligator clips are visible. They appear to connect to a lead-acid battery to power the tube filaments. In front of the receiver, a B battery can be seen. The headset is in front of the transmitter.

2.3 Definition of Wireless Communication

Wireless communication can be defined as the transfer of information over a distance without the use of enhanced electrical conductors or "wires". The distances involved may be short (a few meters as in television remote control) or long (thousands of kilometers for radio communications). When the context is clear, the term is often shortened to "wireless". Wireless communication is generally considered to be a branch of telecommunications.

Wireless encompasses various types of fixed, mobile, and portable two-way radios, cellular telephones, personal digital assistants (PDAs), and wireless networking. Other examples of wireless technology include GPS units, garage door openers, wireless computer mice, keyboards and headsets, satellite television and cordless telephones.

2.4 Modulation

Modulation is the process of modifying the characteristic of one signal in accordance with some characteristic of another signal. In most cases the, the information signal, be it voice, video, binary data, or some other information is normally used to modify a higher frequency signal known as the carrier. The information signal is normally called the *modulating signal* and the higher frequency signal which is being modulated is called the *carrier* or *modulated wave*. Modulation is performed by mixing two signals (carrier and information) together using modulator. The carrier is usually a sine wave, while the information signal can be of any shape, permitting both analog and digital signals to be transmitted. In most cases, the carrier frequency is considerably higher than the highest information frequency to be transmitted.

The modulated signal preserves the original modulating signal in that it can be recovered from the modulated signal at the receiver by the process of demodulation.

2.5 Why modulation? Can we just transmit the information signal right away?

In theory, audio or information signal of between 20 Hz to 20 kHz can be transmitted to the air (wireless) right away but it is generally impractical. Let us take voice signals as an example. First, these occur in the frequency range of 300 to 3 kHz. After being amplified prior to transmission, they could be sent to the air using a long wire antenna at the transmitter end. The resulting electromagnetic waves would be propagated through space to a receiver. In order this to be done effectively, the antenna would have to be enormous. Antenna length is usually one-quarter or one-half the length of the waves it set up to transmit. For audio signals, the antenna would be in between of 3750 m to 7500 km long. That, of course would be impractical because of the size and cost.

Secondly, simultaneous audio signal transmission would interfere with one another since they occupy the same frequency range. The audio spectrum would be nothing but a jumble of hundreds or thousands of simultaneous communications.

For these reasons, the information signal, be it audio, video, or data, need a specified higher frequency for transmission. The signals will modulate the high-frequency carrier amplitude or frequency to form an Amplitude Modulation (AM) or Frequency Modulation (FM) respectively. At higher frequencies antenna sizes are much smaller and signals propagate farther. There is also more room at higher frequencies; so many channels can be formed to carry thousands of simultaneous communication without interference.

2.6 Bandwidth

Bandwidth is the portion of electromagnetic spectrum occupied by a transmitted signal. It is also the frequency range over which an information signal is transmitted or over which a receiver or other electronic circuit operates. More specifically, bandwidth (BW) is the difference between the upper and lower frequency limits of the signal or the equipment operation range. Let's take an example the bandwidth of the voice frequency range from 300 to 3000 Hz. The upper frequency if f_H and the lower frequency is f_L.

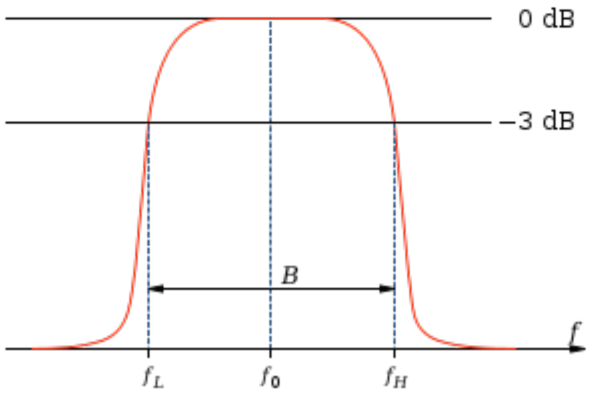


Figure 2.3 Bandwidth

The bandwidth then is

$$\begin{aligned} BW &= f_H - f_L \\ &= 3000 - 300 \\ &= 2700 \ Hz \end{aligned}$$

The bandwidth is typically measured in hertz, and may sometimes refer to *passband bandwidth*, or *baseband bandwidth*, depending on context (see Figure 2.3). Passband bandwidth is the difference between the upper and lower cutoff frequencies of, for example, an electronic filter, a communication channel, or a signal spectrum. In case of a low-pass filter or baseband signal, the bandwidth is equal to its upper cutoff frequency. The term baseband bandwidth always refers to the upper cutoff frequency, regardless of whether the filter is bandpass or low-pass.

2.7 Analog Modulation

There are three types of modulation for analogue signal namely Amplitude Modulation (AM), Frequency Modulation (FM) and Phase Modulation (PM). The oldest and simplest form of modulation is AM.

2.7.1 Amplitude Modulation

Consider a carrier wave represented by $e_C = E_C \cos(\omega_C t + \theta)$

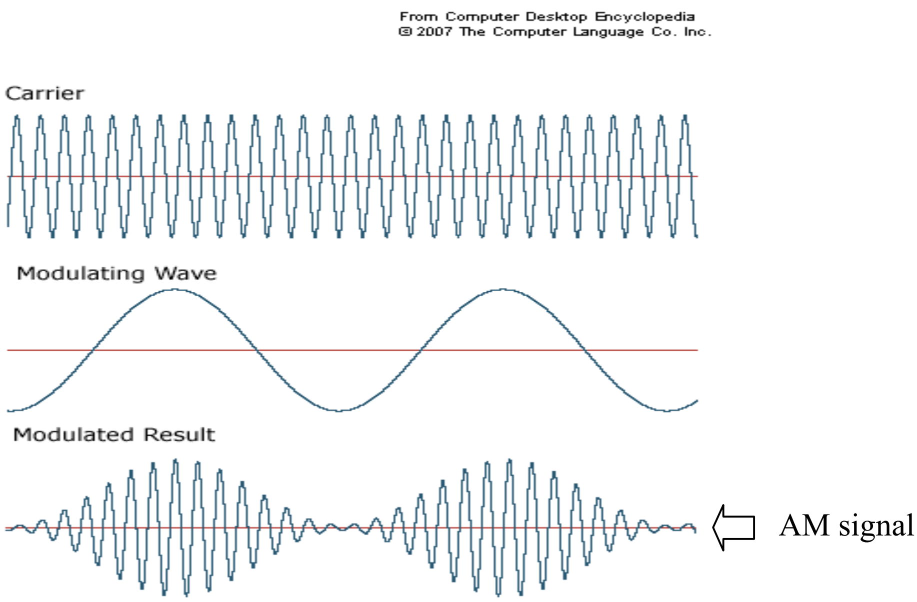
Here e_c is instantaneous value, E_c is amplitude (maximum value), ω_c is angular frequency and θ is the phase angle of carrier voltage. Corresponding to the three variables E_c, ω_c and θ, we can have three different types of modulation. Amplitude Modulation occurs when a voice signal's varying voltage is applied to a carrier frequency. The carrier frequency's amplitude changes in accordance with the modulated voice signal, while the carrier's frequency does not change. When combined the resultant AM signal consists of the carrier frequency, plus UPPER and LOWER sidebands. This is known as Double Sideband - Amplitude Modulation (DSB-AM), or more commonly referred to as plain AM. Figure 2.4 shows the carrier, modulating and modulated signals in AM system.

The carrier frequency may be suppressed or transmitted at a relatively low level. This requires that the carrier frequency be generated, or otherwise derived, at the receiving site for demultiplexing. This type of transmission is known as Double Sideband - Suppressed Carrier (DSB-SC).

It is also possible to transmit a single sideband for a slight sacrifice in low frequency response (it is difficult to suppress the carrier and the unwanted sideband, without some low frequency filtering as well). The advantage is a reduction in analog bandwidth needed to transmit the signal. This type of modulation, known as Single Sideband - Suppressed Carrier (SSB-SC), is ideal for Frequency Division Multiplexing (FDM).

Another type of analog modulation is known as Vestigial Sideband. Vestigial Sideband modulation is a lot like Single Sideband, except that the carrier frequency is preserved and one of the sidebands is eliminated through filtering. Analog bandwidth requirements are a little more than Single Sideband however.

Vestigial Sideband transmission is usually found in television broadcasting. Such broadcast channels require 6 MHz of analog bandwidth, in which an Amplitude Modulated Picture carrier is transmitted along with a Frequency Modulated Sound carrier.



Note that the AM signal i **Figure 2.4** Carrier, modulating and AM signals

$$A(1+\beta \sin\omega_m t)\cos(\omega_c t)$$

$$= A\cos\omega_c t + \frac{A\beta}{2}\left[\cos((\omega_c+\omega_m)t)+\cos((\omega_c-\omega_m)t))\right]$$

Note that $A\cos\omega_c t$ = carrier signal

$\frac{A\beta}{2}\left[cos(\omega_c + \omega_m)t\right]$ = upper side band

$\frac{A\beta}{2}\left[cos(\omega_c - \omega_m)t\right]$ = lower side band

This has frequency components at frequencies

$$\begin{aligned}&\omega_c,\ \textit{the carrier frequency}\\&\omega_c + \omega_m,\ \textit{upper sideband frequency}\\&\omega_c - \omega_m,\ \textit{lower sideband frequency}\end{aligned}$$

2.7.2 Frequency modulation

In telecommunications, frequency modulation (FM) conveys information over a carrier wave by varying its instantaneous frequency (contrast this with amplitude modulation, in which the amplitude of the carrier is varied while its frequency remains constant). Figure 2.5 shows the FM signal generated by the carrier modulated signal. It's frequency is swung above and below where it sits (center frequency) at a rate proportional to the frequency of the modulating signal, and at an amount proportional to the amplitude of the modulating signal. In analog applications, the difference between the instantaneous and the base frequency of the carrier is directly proportional to the instantaneous value of the input signal. In FM single sideband, the carrier frequency and the frequencies above the carrier are transmitted and the frequencies below the carrier are suppressed (upper sideband transmission). Or the frequencies below the carrier are transmitted with the carrier and the upper frequencies are suppressed (lower sideband transmission). In conventional television, the video signal is single sideband, suppressed carrier.

Digital data can be sent by shifting the carrier's frequency among a set of discrete values, a technique known as frequency-shift keying.

Frequency modulation can be regarded as phase modulation where the carrier phase modulation is the time integral of the FM modulating signal.

The frequency deviation of a radio is of particular importance in relation to bandwidth, because less deviation means that more channels can fit into the same amount of frequency spectrum. The FM broadcasting range (88-108 MHz) uses a channel spacing of 200 kHz, with a maximum frequency deviation of 75 kHz, leaving a 25 kHz buffer above the highest and below the lowest frequency to reduce interaction with other channels. AM broadcasting uses a channel spacing of 10 kHz, but with amplitude modulation frequency deviation is irrelevant.

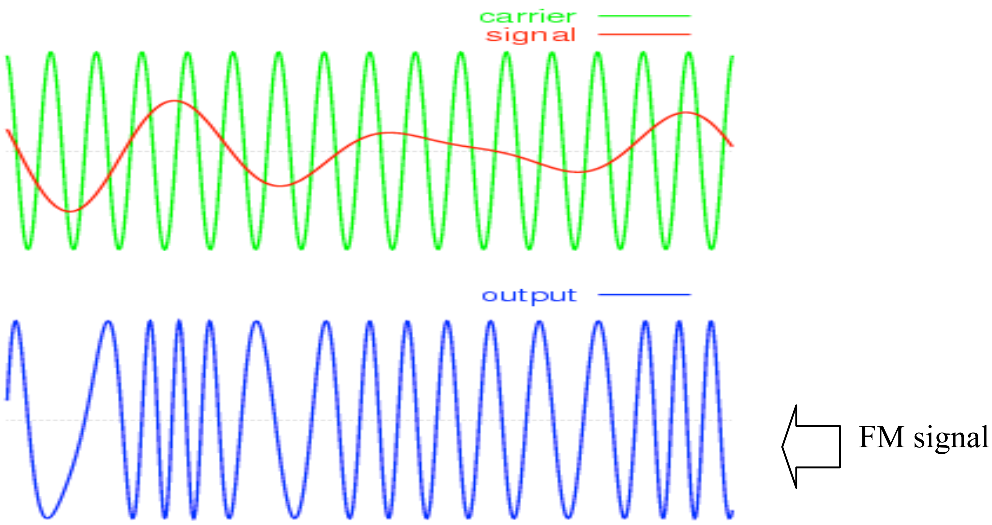


Figure 2.5 Carrier, modulating FM signal

From the definition of frequency deviation, an equation can be written for the signal frequency of an FM wave as a function of time:

$$f_{\text{signal}} = f_C + k_f\, e_M(t) = f_C + k_f\, E_M \sin\omega_M t \text{ and substitution of } \delta = k_f \times E_M \text{ yields:}$$

$$f_{\text{signal}} = f_C + \delta \sin\omega_M t$$

An FM wave will consist of three or more frequency components vectorially added together to give the appearance of a sine wave that's frequency is varying with time when displayed in the time domain. A somewhat complex mathematical analysis will yield an equation for the instantaneous voltage of an FM wave of the form shown here: $e_{\text{FM}}(t) = E_C \sin(\omega_C t + m_f \sin\omega_M t)$ where E_C is the rest-frequency peak amplitude, ω_C and ω_M represent the rest and modulating frequencies, and m_f is the index of modulation. This equation represents a single low-frequency sine wave, f_M, frequency modulating another high-frequency sine wave, f_C. Note that this equation indicates that the argument of the sine wave is itself a sine wave.

2.7.3 Phase Modulation

Phase modulation is a technique used in telecommunications transmission systems whereby the phase of a periodic carrier signal is changed in accordance with the characteristics of an information signal. Phase modulation (PM) is a form of angle modulation (Figure 2.6). For systems in which the modulating signal is digital, the term "phase-shift keying" (PSK) is usually employed. Phase shift refers to time separation between two sine waves of the same frequency. The amount of the shift depends on the amplitude of the input modulating signal. The greater the amplitude of the modulating signals, the greater the phase shifts.

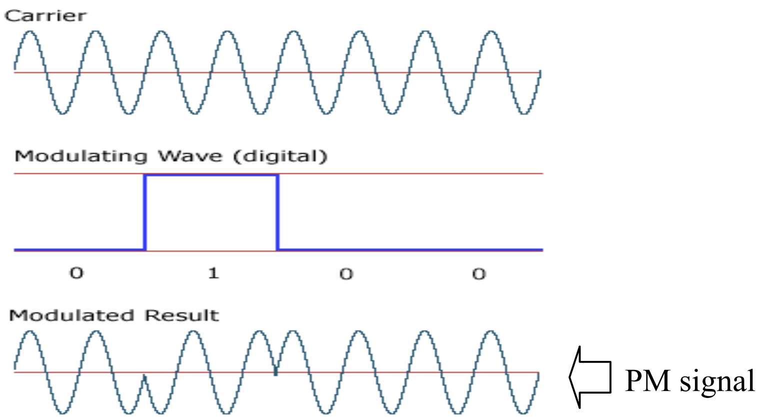


Figure 2.6 Phase modulation

In typical applications of phase modulation or phase-shift keying, the carrier signal is a pure sine wave of constant amplitude, represented mathematically as Eq. (1),

$$c(t) = A \sin \theta(t) \text{---------}(1)$$

where the constant A is its amplitude, $\theta(t) = \omega t$ is its phase, which increases linearly with time, and $\omega = 2\pi f$ and f are constants that represent the carrier signal's radian and linear frequency, respectively.

Phase modulation varies the phase of the carrier signal in direct relation to the modulating signal $m(t)$, resulting in Eq. (2), where k is a constant of proportionality.

$$\theta(t) = \omega t + km(t) \text{----------}(2).$$

The resulting transmitted signal $s(t)$ is therefore given by Eq. (3).

$$s(t) = A \sin [\omega t + km(t)] \text{-------------} (3).$$

At the receiver, $m(t)$ is reconstructed by measuring the variations in the phase of the received modulated carrier.

Phase modulation is intimately related to frequency modulation (FM) in that changing the phase of $c(t)$ in accordance with $m(t)$ is equivalent to changing the instantaneous frequency of $c(t)$ in accordance with the time derivative of $m(t)$.

Among the advantages of phase modulation are superior noise and interference rejection, enhanced immunity to signal fading, and reduced susceptibility to nonlinearities in the transmission and receiving systems.

2.8 Digital Modulation

The objective of a digital communication system is to transport digital data between two or more nodes. In radio communications this is usually achieved by adjusting a physical characteristic of a sinusoidal carrier, either the frequency, phase, amplitude or a combination thereof. This is performed in real systems with a modulator at the transmitting end to impose the physical change to the carrier and a demodulator at the receiving end to detect the resultant modulation on reception.

The move to digital modulation provides more information capacity, compatibility with digital data services, higher data security, better quality communications, and quicker system availability. Developers of communications systems face these constraints:

• available bandwidth
• permissible power
• inherent noise level of the system

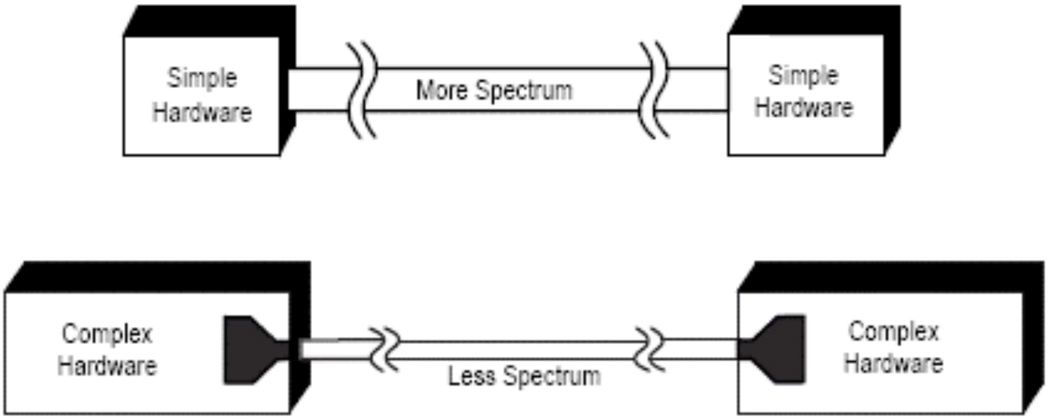


Figure 2.7 The fundamental trade-off

The RF spectrum must be shared, yet every day there are more users for that spectrum as demand for communications services increases. Digital modulation schemes have greater capacity to convey large amounts of information than analogue modulation schemes. Figure 2.7 illustrates a general idea the need of digital modulation.

In digital modulation, an analog carrier signal is modulated by a digital bit stream. It is similar to analog modulation, but rather than being able to continuously change the amplitude, frequency, or phase of the carrier, there are only discrete values of these attributes that correspond to digital codes. Digital modulation methods can be considered as analog-to-digital conversion, and the corresponding demodulation or detection as digital-to-analog conversion. The changes in the carrier signal are chosen from a finite number of M alternative symbols (the *modulation alphabet*). There are three basic types of digital modulation techniques. These are; Amplitude-Shift Keying (ASK), Frequency-Shift Keying (FSK) and Phase-Shift Keying (PSK).

Over the past few years a major transition has occurred from simple analogue Amplitude Modulation (AM) and Frequency/Phase Modulation (FM/PM) to new digital modulation techniques. Examples of new digital modulation include:

FSK (Frequency Shift Keying)
QPSK (Quadrature Phase Shift Keying)
QAM (Quadrature Amplitude Modulation)
MSK (Minimum Shift Keying)

2.8.1 Frequency Shift Keying - FSK

FSK is a frequency modulation scheme in which digital information is transmitted through discrete frequency changes of a carrier wave. The simplest FSK is *binary FSK* (BFSK). BFSK literally implies using a pair of discrete frequencies to transmit binary (0s and 1s) information. With this scheme, the "1" is called the mark frequency and the "0" is called the space frequency. The time domain of an FSK modulated carrier is illustrated in the Figure 2.8 to the right.

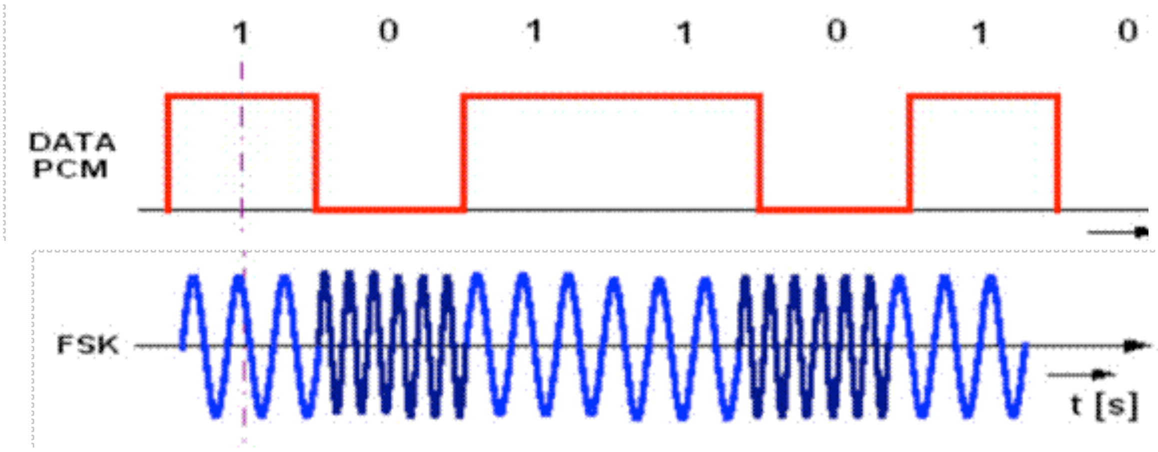


Figure 2.8 Frequency Shift Keying (FSK)

The two binary states, logic 0 (low) and 1 (high), are each represented by an analogue waveform. Logic 0 is represented by a wave at a specific frequency, and logic 1 is represented by a wave at a different frequency. With binary FSK, the centre or carrier frequency is shifted by the binary input data. Thus the input and output rates of change are equal and therefore the bit rate and baud rate are also equal.

The frequency of the carrier is changed as a function of the modulating signal (data), which is being transmitted. Amplitude remains unchanged. Two fixed-amplitude carriers are used, one for a binary zero, the other for a binary one.

Today FSK Modems are used for short haul data communication over private lines or any dedicated wire pair. These are many used for communication between industrial applications like railroad signaling controls and mobile robotic equipment. The short haul modem offers the following specs;

- Speeds of up to 9600 bps
- Full-duplex or half duplex operation.
- Distance up to 9.5 miles

In the past FSK was used in the Bell 103 and Bell 202. These were the first data modem but due to there low bit rate there not being used any more. The Bell 103 had a data rate of only 300 bauds. This modem was predominant until the early 1980s

Audio frequency-shift keying (AFSK) is a modulation technique by which digital data is represented by changes in the frequency (pitch) of an audio tone, yielding an encoded signal suitable for transmission via radio or telephone. Normally, the transmitted audio alternates between two tones: one, the "mark", represents a binary one; the other, the "space", represents a binary zero.

AFSK differs from regular frequency-shift keying in performing the modulation at baseband frequencies. In radio applications, the AFSK-modulated signal normally is being used to modulate an RF carrier (using a conventional technique, such as AM or FM) for transmission. AFSK is still widely used in amateur radio, as it allows data transmission through unmodified voiceband equipment. Radio control gear uses FSK, but calls it FM and PPM instead.

AFSK is not always used for high-speed data communications, since it is far less efficient in both power and bandwidth than most other modulation modes. In addition to its simplicity, however, AFSK has the advantage that encoded signals will pass through AC-coupled links, including most equipment originally designed to carry music or speech.

Most early telephone-line modems used audio frequency-shift keying to send and receive data, up to rates of about 300 bits per second.

2.8.2 Amplitude-shift keying (ASK)

ASK is a form of modulation that represents digital data as variations in the amplitude of a carrier wave.

The amplitude of an analog carrier signal varies in accordance with the bit stream (modulating signal), keeping frequency and phase constant. The level of amplitude can be used to represent binary logic 0s and 1s as illustrated in Figure 2.10. We can think of a carrier signal as an ON or OFF switch. In the modulated signal, logic 0 is represented by the absence of a carrier, thus giving OFF/ON keying operation and hence the name given.

Like AM, ASK is also linear and sensitive to atmospheric noise, distortions, propagation conditions on different routes in PSTN, etc. Both ASK modulation and demodulation processes are relatively inexpensive. The ASK technique is also commonly used to transmit digital data over optical fiber. For LED transmitters, binary 1 is represented by a short pulse of light and binary 0 by the absence of light. Laser transmitters normally have a fixed “bias” current that causes the device to emit a low light level. This low level represents binary 0, while a higher-amplitude lightwave represents binary 1.

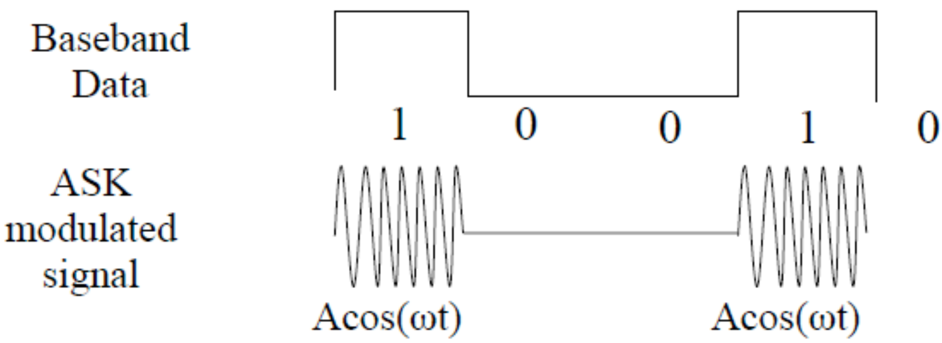


Figure 2.10 Amplitude Shift Keying (ASK)

2.8.3 Phase-shift keying

Phase-shift keying (PSK) is a digital modulation scheme that conveys data by changing, or modulating, the phase of a reference signal (the carrier wave).

Any digital modulation scheme uses a finite number of distinct signals to represent digital data. PSK uses a finite number of phases, each assigned a unique pattern of binary digits. Usually, each phase encodes an equal number of bits. Each pattern of bits forms the symbol that is represented by the particular phase. The demodulator, which is designed specifically for the symbol-set used by the modulator, determines the phase of the received signal and maps it back to the symbol it represents, thus recovering the original data. This requires the receiver to be able to compare the phase of the received signal to a reference signal such a system is termed coherent (and referred to as CPSK).

Alternatively, instead of using the bit patterns to *set* the phase of the wave, it can instead be used to *change* it by a specified amount. The demodulator then determines the *changes* in the phase of the received signal rather than the phase itself. Since this scheme depends on the difference between successive phases, it is termed differential phase-shift keying (DPSK). DPSK can be significantly simpler to implement than ordinary PSK since there is no need for the demodulator to have a copy of the reference signal to determine the exact phase of the received signal (it is a non-coherent scheme). In exchange, it produces more erroneous demodulations. The exact requirements of the particular scenario under consideration determine which scheme is used.

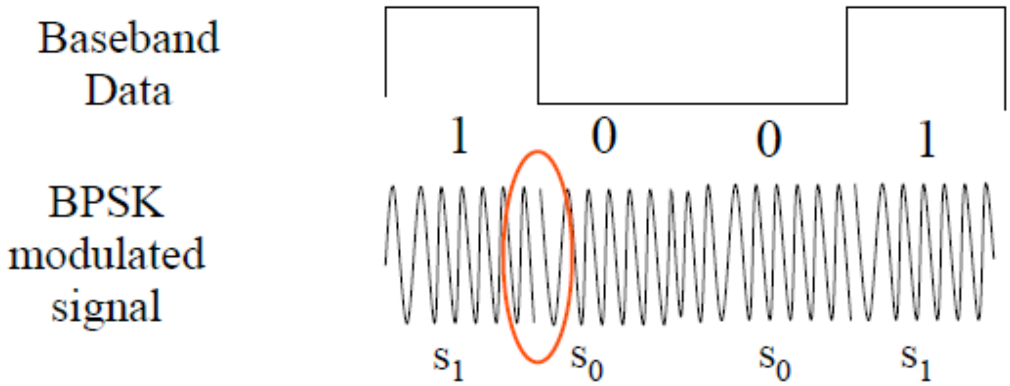


Figure 2.11 Phase-shift keying

Phase-shift keying is used in the following;

- Binary Phase Shift Keying (BPSK) is mainly used in deep space telemetry and also cable modems.
- The Quadrature Phase Shift Keying (QPSK) and it Variants are used in Satellites,
- CDMA, (Code-Division Multiple Access) refers to any of several protocols used in so-called second-generation (2G) and third-generation (3G) wireless communications.
- TETRA, Terrestrial Trunked Radio) is a set of standards developed by the European Telecommunications Standardisation Institute (ETSI) that describes a common mobile radio communications infrastructure throughout Europe This infrastructure is targeted primarily at the mobile radio needs of public safety groups (such as police and fire departments), utility companies, and other enterprises that provide voice and data communications services.
- PHS, (Personal Handy-phone System) Developed by the Nippon Telegraph and Telephone Corporation, the Personal Handy-phone is a lightweight portable wireless telephone that functions as a cordless phone in the home and as a mobile phone elsewhere. The Personal Handy-phone also handles voice, fax, and video signals. The phone is now being marketed in other Asian countries.
- LMDS, (Local Multipoint Distribution System) is a system for broadband microwave wireless transmission direct from a local antenna to homes and businesses within a line-of-sight radius, a solution to the so-called last-mile technology problem of economically bringing high-bandwidth services to users. LMDS is an alternative to installing optic-fibre all the way to the user or to adapting cable-TV for broadband Internet service.

CHAPTER 3

WIRELESS SYSTEM

3.1 Radio Communication

The most basic wireless system is radio communication as shown in Figure 3.1. It consists of transmitter, transmitting medium and receiver. Radio communication systems send signals by radio in the Radio Frequency (RF) range of (30 Hz – 3000 MHz or 3 GHz). A transmitter consists of input signal, modulator, amplifier, and transmitting antenna. Types of radio communication systems deployed depend on technology, standards, regulations, radio spectrum allocation, user requirements, service positioning, and investment. The radio equipment involved in communication systems includes a transmitter and a receiver, each having an antenna and appropriate terminal equipment such as a microphone at the transmitter and a loudspeaker at the receiver in the case of a voice-communication system

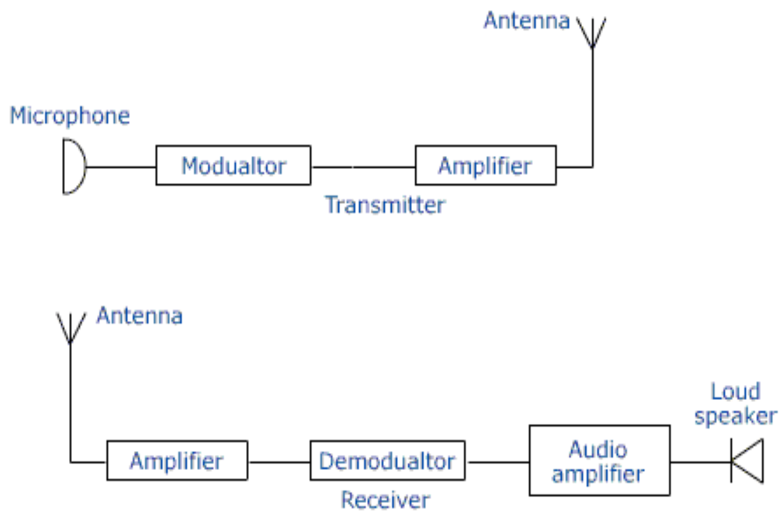


Figure 3.1 Radio system

Carrier signal either in Amplitude Modulation (AM) or Frequency Modulation (FM) frequency band is modulated by modulating signal (audio signal) using a modulator. The modulated signal is amplified before transmitting it through antenna.

3.2 Transmitter

A *transmitter* is an electronic device which, usually with the aid of an antenna, propagates an electromagnetic signal such as radio, television, or other telecommunications. It accepts the information signal to be transmitted and converts it into an RF (radio frequency) signal capable of being transmitted over long distances. The propagated signal through the antenna is in a form of modulated signal. Every transmitter has three basic functions. First, the transmitter has to generate a signal of the correct frequency at a desired point in the spectrum. Second, it must provide some form of modulation that causes the information signal to modify the carrier signal.

Third, it must provide sufficient power amplification to ensure that the signal level is high enough so that it will carry over the desired distance.

3.2.1 AM Transmitter

Modulator is an important section of any transmitter circuit. It is a place where two signals; input and carrier being mixed together prior to transmission. Figure 3.2 shows an example of common three-transistor modulator circuit for an AM transmitter.

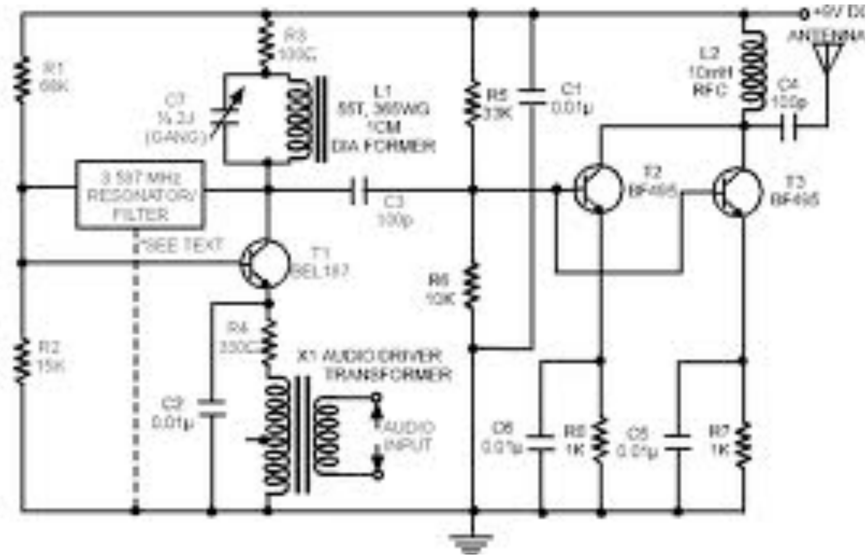


Figure 3.2 AM modulator

AM transmitter also can be divided into two major sections according to the frequencies at which they operate radio-frequency (RF) and audio-frequency (AF) units. The AF section which is the input contains information signal or audio that need to be transmitted. The second section of the transmitter contains the audio circuitry. This section of the transmitter takes the small signal from the microphone and increases its amplitude to the amount necessary to fully modulate the carrier.

The RF unit is the section of the transmitter used to generate the RF carrier wave. As illustrated in Figure 3.3, the carrier originates in the master oscillator stage where it is generated as a constant-amplitude, constant-frequency sine wave. The carrier is not of sufficient amplitude and must be amplified in one or more stages before it attains the high power required by the antenna. With the exception of the last stage, the amplifiers between the oscillator and the antenna are called buffer amplifier (intermediate power amplifier - IPA). The final stage, which connects to the antenna, is called the final power amplifier (FPA). It amplifies the modulated RF wave to the required level before transmission.

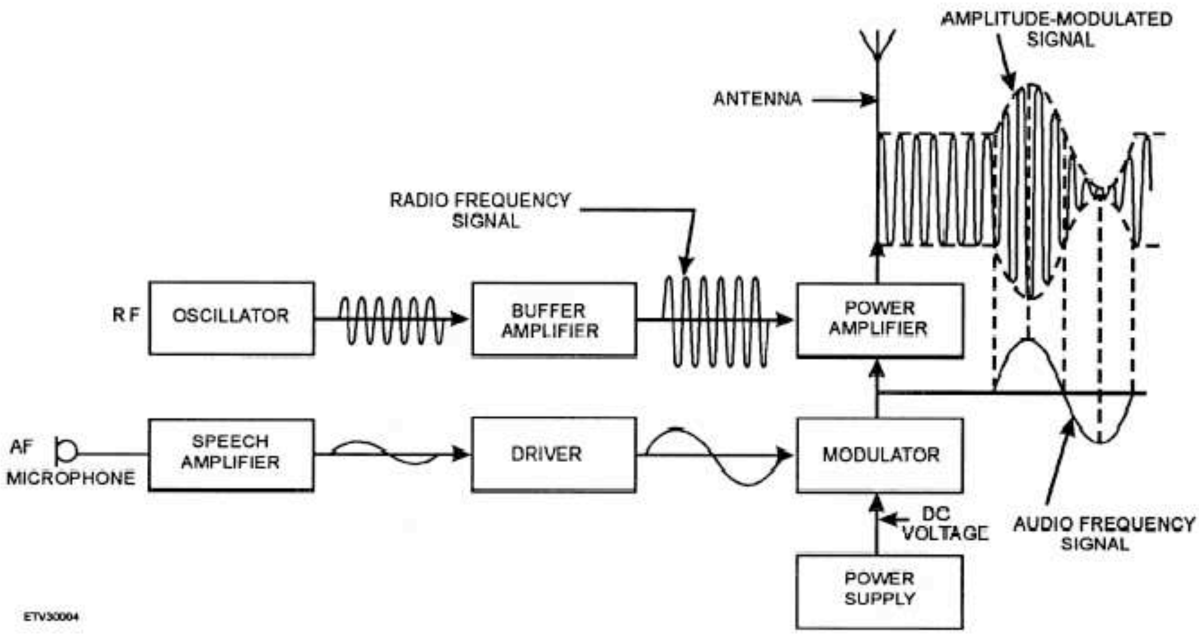


Figure 3.3 AM Transmitter

Modulation enables low frequency audio signals to be radiated long distances. This is done by superimposing the low frequency audio signal on the high frequency carrier wave by the process of modulation. The microphone converts sound waves into electrical signals (a range of 20 Hz to 20 kHz). These signals are amplified by the audio frequency amplifier. The carrier frequency is generated by the radio frequency oscillator. The audio is superimposed onto the carrier by the modulator. The low power modulated carrier is boosted in amplitude by the radio frequency power amplifier. The antenna produces an electromagnetic wave which is radiated into space.

3.2.2 FM Transmitter

In frequency modulation (FM) the modulating signal (input signal that need to be transmitted) combines with the carrier to cause the frequency of the resultant wave to vary with the instantaneous amplitude of the modulating signal. The instantaneous frequency of a carrier wave is varied from the center frequency by an amount proportional to the instantaneous amplitude of the modulating signal. Main advantages of FM are improved signal to noise ratio and less radiated power.

The carrier signal is represented by

$$c(t) = A\cos(w_c t).$$

The modulating signal is represented by

$$m(t) = B\sin(w_m t).$$

Then the final modulated signal is

$$A\cos(w_c t + m(t)) = A\cos(w_c t + B\sin(w_m t)).$$

Modulation is carried out by modulator circuit as shown in Figure 3.4. Figure 3.5 shows the block diagram of a frequency-modulated transmitter signal. The modulating signal applied to the first and second Audio Frequency (AF) amplifiers for audio signal amplification. The FM carrier frequency is generated by crystal controlled oscillator. It is then amplified by Radio Frequency (RF) sub-carrier amplifier. With no modulating signal, the oscillator generates a steady center frequency. With the modulating signal applied, phase shifter network causes the frequency of the oscillator to vary around the center frequency in accordance with the modulating signal. This results a frequency modulated carrier. The modulated carrier is fed to a frequency multiplier or doubler to increase the frequency and then to a power amplifier to increase the amplitude to the desired level for transmission.

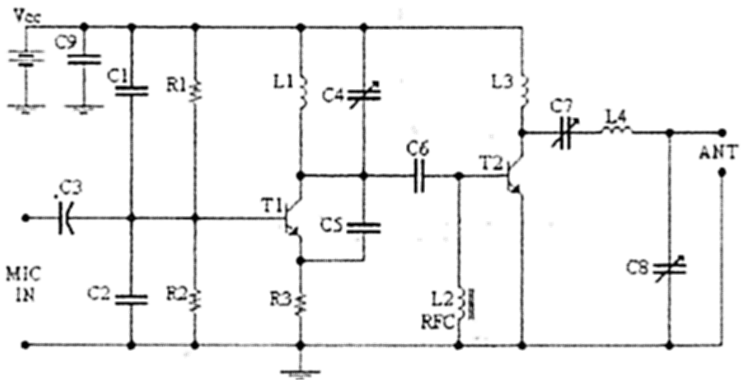


Figure 3.4 FM modulator

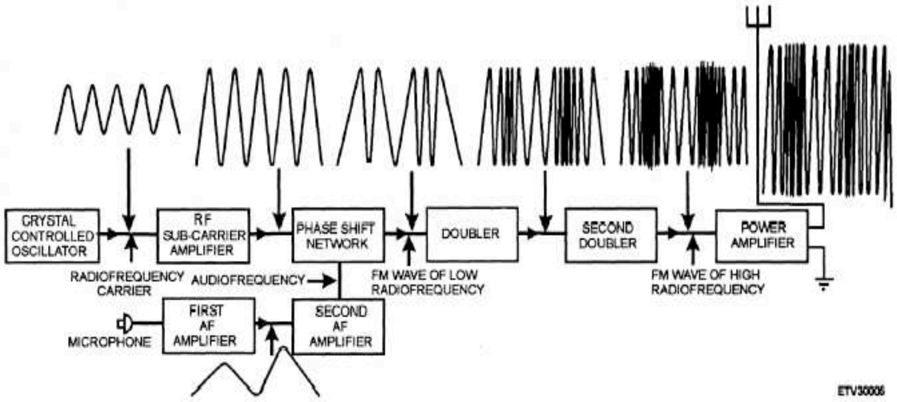


Figure 3.5 FM Ttransmitter

3.3 AM Receiver

Typical AM receiver system is shown in Figure 3.6. The RF amplifier selects one of the many signals on the antenna, amplifies it, and sends the amplified signal to the mixer. Here, a second
signal is applied from the local oscillator. The two signals are mixed in this stage, producing four predominant frequencies: the two inputs, the sum of the two, and the difference between the two. For example, if the frequency at the antenna is 1,500

kHz and the local oscillator frequency is 1,045 kHz, the frequencies at the output of the mixer are:
Antenna = 1,500 kHz, Local oscillator = 1,045 kHz, Sum = 2,545 kHz, Difference =455 kHz.

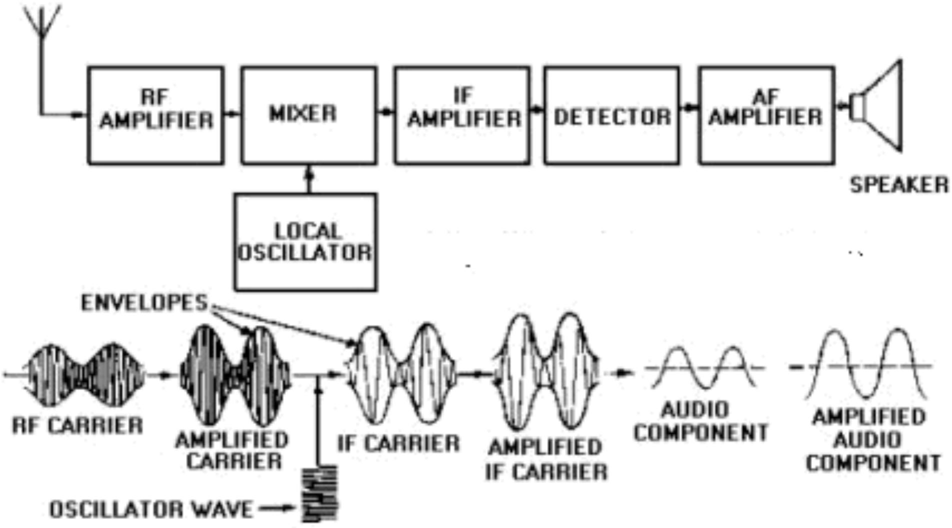


Figure 3.6 AM receiver

The difference frequency is usually selected as the output and is known as the IF signal. It carries the information of the received RF signal. This frequency is amplified by the Intermediate Frequency (IF) amplifier stage and finally sends it to the detector. Here, the information (AF voltage) and the carrier are separated. The carrier is filtered out, leaving only the audio. The audio is amplified by the audio amplifier stages and reproduced by the speaker.

3.4 FM Receiver

Figure 3,7 shows the block diagram of an FM receiver. The FM band covers 88-108 MHz. There are signals from many radio transmitters in this band inducing signal voltages in the aerial. The RF amplifier selects and amplifies the desired station from the many. It is adjustable so that the selection frequency can be altered. This is called tuning. In cheaper receivers the tuning is fixed and the tuning filter is wide enough to pass all signals in the FM band.

The selected frequency is applied to the mixer. The output of an oscillator is also applied to the mixer. The mixer and oscillator form a frequency changer circuit. The output from the mixer is the intermediate frequency (IF) . The IF is a fixed frequency of 10.7 MHz. No matter what the frequency of the selected radio station is, the IF is always 10.7 MHz. The IF signal is fed into the IF amplifier. The advantage of the IF amplifier is that its frequency and bandwidth are fixed, no matter what the frequency of the incoming signal is. This makes the design and operation of the amplifier much simpler.

The amplified IF signal is fed to the demodulator. This circuit recovers the audio signal and discards the RF carrier. Some of the audio is fed back to the oscillator as an Automatic Frequency Control voltage. This ensures that the oscillator frequency is stable in spite of temperature changes. The audio signal voltage is increased in amplitude by a voltage amplifier. The power level is increased sufficiently to drive the loudspeaker by the power amplifier.

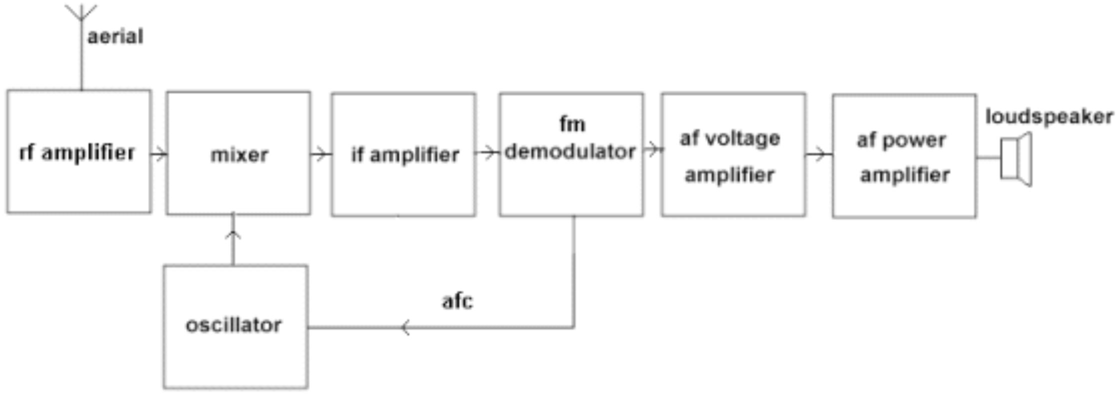


Figure 3.7 FM receiver

3.5 Frequency Bands

AM radio is broadcast on several frequency bands. The allocation of these bands is governed by the International Telecommunication Union (ITU's) Radio Regulations and, on the national level, by each country's telecommunications administration (the FCC in the U.S., for example) subject to international agreements.

- *Long wave* is 148.5 kHz–283.5 kHz, with 9 kHz channel spacing generally used. Long wave is used for radio broadcasting in Europe, Africa and parts of Asia (ITU region 1), and is not allocated in the Western Hemisphere. In the United States and Canada, Bermuda and U.S. territories this band is mainly reserved for aeronautics navigational aids, though a small section of the band could theoretically be used for micro-broadcasting under the United States Part 15 rules. Due to the propagation characteristics of long wave signals, the frequencies are used most effectively in latitudes north of 50°.
- *Medium wave* is 520 kHz –1,610 kHz. In the Americas (ITU region 2) 10 kHz spacing is used; elsewhere it is 9 kHz. ITU region 2 also authorizes the Extended AM broadcast band between 1610 kHz and 1710 kHz. Medium wave is by far the most heavily used band for commercial broadcasting. This is the "AM radio" that most people are familiar with.
- *Short wave* is 1.711 MHz–30.0 MHz, divided into 15 broadcast bands. Shortwave broadcasts generally use a narrow 5 kHz channel spacing. Short wave is used by audio services intended to be heard at great distances from the transmitting station. The long range of short wave broadcasts comes at the expense of lower audio fidelity. The mode of propagation for short wave is different (see high frequency). AM is used mostly by broadcast services – other shortwave users may use a modified version of AM such as SSB or an AM-compatible version of SSB such as SSB with carrier reinserted.

3.6 FM Channels in Malaysia

There are a total of 19 private and 34 government-owned radio stations in Malaysia. Stations owned by the government operate under the **Radio Televisyen Malaysia** (**RTM**) group. Other stations such as BBC World Service, China Radio International, Suara Malaysia and Voice of Vietnam are available in Malaysia via AM. Almost all commercial radio channels broadcasting in Malaysia use FM. The followings are the major FM commercial radio channels broadcasting all over states in Malaysia (see Table 3.1). Table 3.2 shows the FM station transmitted over Kuala Lumpur.

Table 3.1 FM channels of all states in Malaysia

RADIO	KL	PNANG	IPOH	T'PING	M'KA	JB	S'BAN	K'TAN	KB	KT	KCH	KK
Hitz FM	94.50	91.00	94.30	91.30	91.10	99.10	94.20	94.10	94.60	NA	97.70	101.60
Mix FM	92.90	92.80	92.70	93.60	93.00	97.60	95.00	93.20	92.80	98.30	95.30	100.80
Lite FM	105.70	104.40	101.50	89.30	92.20	104.30	104.60	104.70	104.30	105.90	100.10	103.20
My FM	101.80	99.70	100.60	100.20	106.40	95.40	100.60	101.10	102.30	101.20	96.90	104.00
988	---	94.50	98.80	101.00	98.20	99.90	93.30	90.40	---	---	---	---
Red 104.9	104.90	107.60	106.40	98.20	98.90	92.80	106.00	91.60	---	---	---	NA
Suria FM	105.30	---	96.00	91.70	88.50	101.40	107.00	96.10	106.10	102.40	---	105.90
Era	103.30	103.60	---	95.20	90.30	104.50	103.60	98.00	103.30	102.80	96.10	102.40
Muzik FM	88.50	100.50	89.7	---	96.60	101.70	91.70	95.30	101.90	91.70	---	---
Traxx FM	90.30	98.70	---	105.30	97.40	102.90	88.70	105.30	104.70	89.70	---	105.30
Ai FM	89.30	101.30	92.10	---	100.40	104.90	89.70	106.10	105.70	90.50	---	---
THR	99.30	102.40	---	97.90	---	---	101.50	---	---	---	---	---
Best 104	104.1 Riau	---	---	---	94,8	104.10	94.80	102.50	---	---	---	---
IKIM FM	91.50	89.00	102.70	---	89.50	106.20	102.70	89.60	89.80	100.20	93.60	93.90
FLY FM	95.80	89.90	87.90	---	94.00	94.00	---	98.60	---	---	---	---
XFRESH FM	103.00	106.50	98.50	104.90	107.30	103.30	97.90	100.00	99.80	104.00	103.70	98.60
SINAR FM	96.70	97.10	96.90	96.40	96.00	87.80	96.90	97.20	93.80	97.50	102.10	104.90
MUTIARA FM	---	95.7 N.PNG 93.9 BALIK PULAU 90.9	---	---	---	---	---	---	---	---	---	---

Table 3.2 FM Station – Kuala Lumpur

Frequency	Station	Operator	Language	Format	Area served
87.7 MHz	Klasik Nasional FM	RTM	Malay	News Talk Music	Nationwide
88.1 MHz	One FM	Media Prima	Chinese and Cantonese	Talk, Music	Nationwide
88.5 MHz	Muzik FM	RTM	Malay	Music	Nationwide
88.9 MHz	Capital FM	Capital FM	English	Talk, music	Kuala Lumpur and Selangor
89.3 MHz	Ai FM	RTM	Chinese	Talk, music	Nationwide
89.9 MHz	BFM 89.9	BFM Media]	English	News, music	Selangor, Kuala Lumpur, Putrajaya, Negri Sembilan & Malacca
90.3 MHz	TraXX FM	RTM	English	Talk, music	Nationwide
90.7 MHz	Putra FM	Universiti Putra Malaysia	Malay, English	Talk, music	Serdang, Kajang, Sri Kembangan and Putrajaya only
91.1 MHz	Asyik FM and Salam FM	RTM	Orang Asli	Talk, music	Selangor, Kuala Lumpur, Southern Perak, Western Pahang and part of Negeri Sembilan
91.5 MHz	IKIM.fm	IKIM	Malay, English, Arabic	Talk, music	Nationwide
92.3 MHz	Minnal FM	RTM	Tamil	Talk, music	Nationwide
92.9 MHz	Hitz.fm	AMP Radio Networks	English	Talk, music	Nationwide
93.6 MHz	UFM	Universiti Teknologi MARA	Malay, English	Talk, music	Shah Alam, Klang and Petaling Jaya only
93.9 MHz	Radio24	Bernama	Malay, English	News, music	Kuala Lumpur and Selangor
94.5 MHz	Mix FM	AMP Radio Networks	English	Talk, Music	Nationwide
95.3 MHz	Muzik FM	RTM	Malay	Music	Nationwide
95.8 MHz	Fly FM	Media Prima	English,	Talk,	Nationwide

			Malay	music	
96.3 MHz	Minnal FM	RTM	Tamil	Talk, music	Nationwide
96.7 MHz	Sinar FM	AMP Radio Networks	Malay	Talk, music	Nationwide
97.2 MHz	KLFM	RTM	Malay	Talk, music	Selangor & Kuala Lumpur
97.6 MHz	Hot FM	Media Prima	Malay	Talk, music	Nationwide
98.3 MHz	Klasik Nasional FM	RTM	Malay	Music	Nationwide
98.8 MHz	988	STAR Rfm Sdn.Bhd (The Star)	Chinese (Cantonese)	Talk, music	Peninsular Malaysia
99.3 MHz	THR.fm	AMP Radio Networks	Tamil, Malay	Talk, music	Peninsular Malaysia
100.1 MHz	TraXX FM	RTM	English	Talk, music	Nationwide
100.9 MHz	Selangor FM	RTM	Malay	Talk, music	Selangor & Kuala Lumpur
101.8 MHz	MY FM	AMP Radio Networks	Chinese (Cantonese)	Talk, music	Nationwide
102.5 MHz	Asyik FM and Salam FM	RTM	Orang Asli	Talk, music	Selangor, Kuala Lumpur, Southern Perak, Western Pahang and part of Negeri Sembilan
103.0 MHz	XFM	AMP Radio Networks	Malay	Talk, music	Nationwide
103.3 MHz	Era FM	AMP Radio Networks	Malay	Talk, music	Nationwide
104.1 MHz	Best 104	Suara Johor Sdn.Bhd	Malay	Music	Selangor, Negeri Sembilan, Melaka, Johor, Singapore and parts of Riau, Indonesia
104.9 MHz	Red FM (Malaysia)	STAR Rfm Sdn.Bhd (The Star)	English, Malay	Talk, music	Peninsular Malaysia
105.3 MHz	Suria FM	STAR Rfm Sdn.Bhd (The Star)	Malay	Talk, music	Peninsular Malaysia and Kota Kinabalu
105.7 MHz	LiteFM	AMP Radio	English	Music	Nationwide

		Networks			
106.7 MHz	Ai FM	RTM	Chinese	Talk, music	Nationwide
107.5 MHz	Pahang FM	RTM	Malay	Talk, music	Pahang, Selangor & Kuala Lumpur

CHAPTER 4

WIRELESS APPLICATION

4.1 Introduction

We simply cannot imagine on how a world without wireless applications and services. Wireless technology has been associated with most of electrical and electronic appliances in line with its development and application. It has given a lot of benefit to humankind. There are a lot of electrical and electronic appliances in our home use wireless technology. Wireless application is categorized in three distinctive categories; namely radio frequency (RF) communication, microwave communication and infra-red. The RF wireless communication uses frequency in the range n of 30 to 3000 MHz or 3 GHz. For wireless microwave communication its frequency is in the range of 3 – 300 GHz. The microwave communication covers both the long range for highly directional antenna and short range. The last category is Infrared (IR) communication. Infrared light is electromagnetic radiation with a wavelength between 0.7 and 300 micrometres, which equates in a frequency range between approximately 1 and 430 THz.

It is no doubt at all that mobile services are playing very important roles in many facets of our society. Just decades ago, mobile services consisted primarily of basic voice communication. Today, we depend on mobile services not only for communication, but also for education, entertainment, healthcare, location and m-commerce. Mobile services have also made significant inroads into developing nations, by improving the quality of life for many of their citizens.

4.2 Wireless Devices

Wireless may be used to transfer information over short distances (a few meters as in television remote control) or long distances (thousands of kilometers for radio communications). It encompasses various types of fixed, mobile, and portable two-way radios, cellular telephones, personal digital assistants (PDAs), and wireless networking. Other examples of wireless technology include GPS units, garage door openers and or garage doors, wireless computer mice, keyboards and headsets, satellite television, cordless telephones and many others.

Remote control (RC) for most model air plane, car and for majority of hobby equipments are based on RF. The followings are examples of devices which use wireless as mode of data transfer.

4.2.1 Wireless Devices – Using RF

The frequency of wireless devices varies from 20 MHz to a few hundreds of MHz. Devices such as remote control mostly use 20 – 40 MHz whereas for short distance communication 300 – 400 MHz and for long distance 900 – 1800 MHz.

i) Cellular Phone

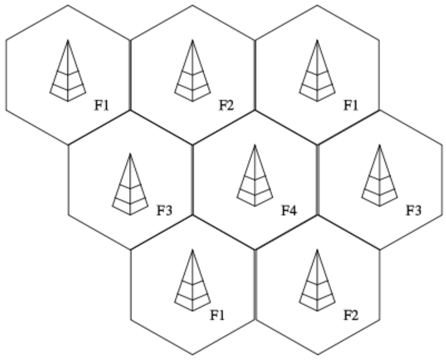


Figure 4.1 Cell

Cellular telephone, sometimes called mobile telephone, is a type of short-wave analog or digital telecommunication in which a subscriber has a wireless connection from a mobile telephone to a relatively nearby transmitter. The transmitter's span of coverage is called a cell as illustrated in Figure 4.1. Generally, cellular telephone service is available in urban areas and along major highways. As the cellular telephone user moves from one cell or area of coverage to another, the telephone is effectively passed on to the local cell transmitter.

In wireless telephony, a cell is the geographical area covered by a cellular telephone transmitter. The transmitter facility itself is called the *cell site*. The cell provided by a cell site can be from one mile (~1.6 km) to twenty miles (~30 km) in diameter, depending on terrain and transmission power. Several coordinated cell sites are called a cell system. When we sign up with a cellular telephone service provider, we generally are given access to their cell system, which is essentially local. When traveling out of the range of this cell system, the cell system can enable us to be transferred to a neighboring company's cell system without we're being aware of it. This is called roaming service. All cellular phones are governed by Global System for Mobile communication (GSM) network standard.

GSM (Global System for Mobile communication) is a digital mobile telephony system that is widely used in Malaysia and other parts of the world. GSM uses a variation of time division multiple access (TDMA) and is the most widely used of the three digital wireless telephony technologies (TDMA, GSM, and CDMA). GSM digitizes and compresses data, then sends it down a channel with two other streams of user data, each in its own time slot. It operates at either the 900 MHz or 1800 MHz frequency band.

Mobile services based on GSM technology were first launched in Finland in 1991. Today, more than 690 mobile networks provide GSM services across 213 countries and GSM represents 82.4% of all global mobile connections. According to GSM World, there are now more than 3 billion GSM mobile phone users worldwide. GSM World references China as "the largest single GSM market, with more than 370 million users, followed by Russia with 145 million, India with 83 million and the USA with 78 million users."

Since many GSM network operators have roaming agreements with foreign operators, users can often continue to use their mobile phones when they travel to other countries. SIM cards (Subscriber Identity Module) holding home network access configurations may be switched to those and be metered local access, significantly reducing roaming costs while experiencing no reductions in service.

GSM, together with other technologies, is part of the evolution of wireless mobile telecommunications that includes High-Speed Circuit-Switched Data (HCSD), General Packet Radio System (GPRS), Enhanced Data GSM Environment (EDGE), and Universal Mobile Telecommunications Service (UMTS).

Global System for Mobile communication (GSM) networks operate in a number of different carrier frequency ranges (separated into GSM frequency ranges for 2G and UMTS frequency bands for 3G), with most 2G GSM networks operating in the 900 MHz or 1800 MHz bands. The first cellular telephone for commercial use was approved by the Federal Communications Commission (FCC) in 1983. The phone, a Motorola DynaTAC 8000X, weighed 2 pounds, offered just a half-hour of talk time for every recharging and sold for US3,995.

The transmission power in the handset is limited to a maximum of 2 watts in GSM850/900 and 1 watt in GSM1800/1900.

Figure 4.2 SIM card

GSM mobile phones require a small microchip called a Subscriber Identity Module or SIM Card, to function as shown in Figure 4.2. The SIM card is approximately the size of a small postage stamp and is usually placed underneath the battery in the rear of the unit. The SIM securely stores the service-subscriber key (IMSI) used to identify a subscriber on mobile telephony devices (such as mobile phones and computers). The SIM card allows users to change phones by simply removing the SIM card from one mobile phone and inserting it into another mobile phone or broadband telephony device.

A SIM card contains its unique serial number, internationally unique number of the mobile user (IMSI), security authentication and ciphering information, temporary information related to the local network, a list of the services the user has access to and two passwords (Personal Identification Number - PIN for usual use and PIN Unlocking Key - PUK for unlocking).

ii) RF Remote Control

The majority of Remote Control Technology's transmitters and receivers operate at 27 MHz. This frequency has a longer wavelength that allows the signal to travel over small hills and buildings as well as through trees and many other materials. However, enclosed metal structures and concrete reinforced with rebar make decent RF shields and do not allow many radio signals to pass through. In this case, it is recommended that the antenna should be mounted on the outside of these structures and use coaxial cable to get the signal inside of the structure to the transmitter or receiver. Remote Control Technology does manufacture RF remotes that operate at other frequencies that have different properties.

The RF remote control is very widely used in RC cars, helicopters and airplanes by hobbyist. Figure 4.3 and 4.4 show example of typical RF remote control transmitter and receiver circuits respectively.

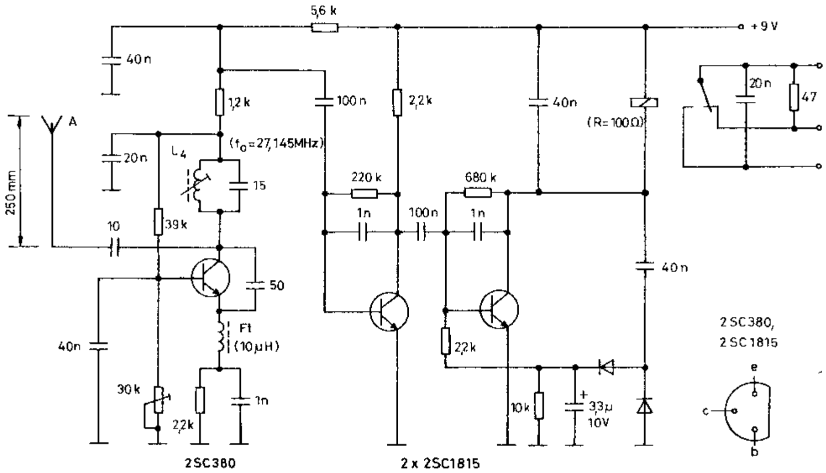


Figure 4.3 27 MHz RF remote control transmitter

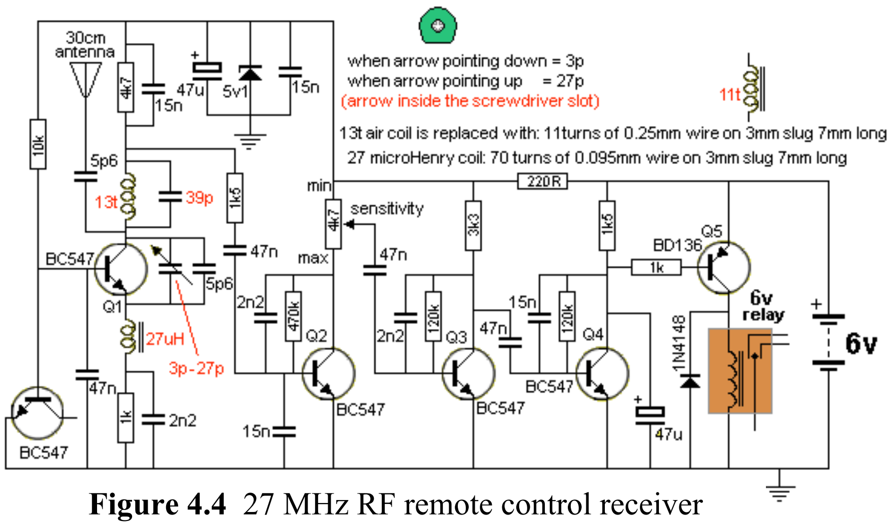


Figure 4.4 27 MHz RF remote control receiver

iii) Two Channel RF Remote Control

RF remote control has many applications; one of it is for car locking system. Most car locking system uses two-channel RF remote control for LOCK and UNLOCK conditions (see Figure 4.5). It is an omni-directional remote control; i.e. able to transmit or receive radio or sound waves in or from any direction. The transmitter is constituted by AT90S2323 microcontroller and TLP434 RF transmitter module at 418MHz. The receiver constituted by RF receiver module RLP434A at 418MHz, the microcontroller AT90S2313 and the 2 relays which handle any electric (or electronic) device up to 10 Amps. The RLP434A is an RF receiver module with receipt frequency at 418MHz with ASK modulation. There are two outputs from this module, the digital, with levels from 0v to VCC (5 volts in our case) and the analog output. Analog output is not used. The transmitter sends 4 bytes with 2400bps 4 times and the receiver RLP-434A, collect them and move them to AT90S2313 to RxD pin, PD0. This type of remote control is able to operate at a distance up to 15 m.

iv) Ham Radio

Amateur radio, often called ham radio, is both a hobby and a service in which participants, called "hams", use various types of radio communications equipment to communicate with other radio amateurs for public services, recreation and self-training. Amateur radio operation is licensed by an appropriate government entity (for example, by the Malaysian Communications and Multimedia Commission - MCMC) as coordinated through the International Telecommunication Union. Figure 4.6 shows example of a typical amateur radio station.

An estimated two million people throughout the world are regularly involved with amateur radio. The term "amateur" does not imply a lack of skill or quality, but rather that the amateur radio operator is not paid for his efforts. Although its origins can be traced to the late 19th century, amateur radio, as practiced today, did not begin until the early 20th century. The first listing of amateur radio stations is contained in the *First Annual Official Wireless Blue Book of the Wireless Association of America* in 1909. This first radio callbook lists wireless telegraph stations in Canada and the United States, including eighty-nine amateur radio stations. As with radio in general, the birth of amateur radio was strongly associated with various amateur experimenters and hobbyists.

Figure 4.6 An example of an amateur radio station with three transceivers, amplifiers, and a computer for logging and for digital modes.

Throughout its history, amateur radio enthusiasts have made significant contributions to science, engineering, industry, and social services. Research by amateur radio operators has founded new industries, built economies, empowered nations, and saved lives in times of emergency.

Amateur radio operators use various modes of transmission to communicate. Voice transmissions are most common, with some, such as frequency modulation (FM) offering high quality audio, and others, such as single sideband (SSB) offering more reliable communications, often over long distance, when signals are marginal and bandwidth is restricted, at the sacrifice of audio quality.

Because of the wide bandwidth and stable signals required, amateur radio is typically found in the 70 cm (420 MHz–450 MHz) frequency range, though there is also limited use on 33 cm (902 MHz–928 MHz), 23 cm (1240 MHz–1300 MHz) and higher. These requirements also effectively limit the signal range to between 20 and 60 miles (30 km–100 km), however, the use of linked repeater systems can allow transmissions across hundreds of miles.

As noted, radio amateurs have access to frequency allocations throughout the RF spectrum, enabling choice of frequency to enable effective communication whether across a city, a region, a country, a continent or the whole world regardless of season or time of day. The shortwave bands, or HF, can allow worldwide communication, the VHF and UHF bands offer excellent regional communication, and the broad microwave bands have enough space, or bandwidth, for television (known as FSTV) transmissions and high-speed data networks. Figure 4.7 and 4.8 illustrate the transceiver and antenna of ham radio respectively.

Figure 4.7 A handheld VHF/UHF transceiver

Figure 4.8 An amateur radio antenna tower

4.2.2 Wireless Remote Control – Using Infra Red

Many electronic goods, from DVD players to stereo systems are packaged with an infrared remote control, allowing us to control our equipment from a distance. Long gone are the days of an electronic cable, leading from our TV to a cumbersome box in our hand. Nowadays, most audio, video and even lighting systems are operated using infrared remote control technology.

Figure 4.9 and 4.10 show the IR receiver and transmitter respectively. This remote transmits a tone using an infa-red LED. This tone is decoded by the receiver. Since the receiver only switches when it "hears" the tone, there are no accidental activations. This remote control is very widely used for appliances such as TV, hi-fi system, ceiling fan, air-condition unit, and many others. Typical IR signals flow on a carrier frequency of around 36 kHz. Control codes, including those used to unlock DVD players are beamed along a modulated 36 kHz carrier frequency by turning the carrier on and off, usually in serial format.

Infrared frequency is below that of visible red. Infrared light is invisible, to the naked eye at least. This makes it perfect for home entertainment use, making sure you don't get a laser show every time you switch channels. Although invisible, infrared waves function in exactly the same way as any other light source, such as the simple light bulb. However, it has the practical capacity to carry data along its wave form. Generally, an IR signal is generated by a Light Emitting Diode source, more commonly known as 'LED'. Average TV or DVD remote control can only send commands one way, up to 30 feet in a low-speed packet. The infrared waves sent via LEDs have a 'moderate cone angle' allowing us to use the controller without having to aim directly at the receiver. We can even bounce the signal off walls.

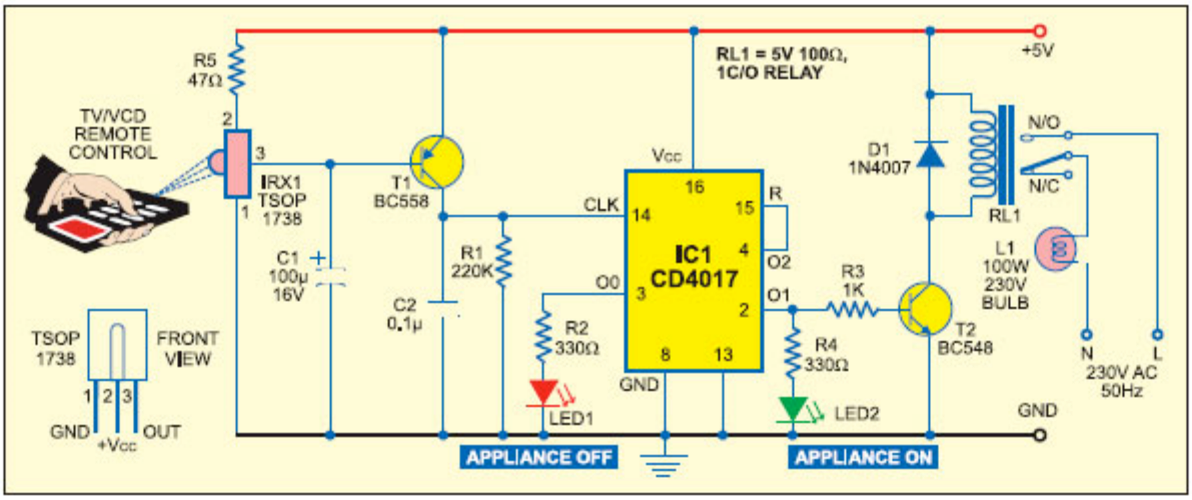


Figure 4.9 IR remote control receiver

IR handsets communicate on a 32-40 kHz modulated ‘square wave’. The IR modulation signal sent by home entertainment devices is generally set to around 36 kHz, using ‘amplitude shift keying’ (carrier on, or off). It sounds like binary. Data-rate use for appliances in the home are generally within the 100-2000 bps range, enough to tell the DVD player or TV what we want it to do – change channel, alter the sound level, activate a region code, and so on.

The transmitter is designed so that an ‘oscillator’ (the hardware that drives the infrared LED) can be modulated on or off by the application of a TTL voltage (transistor-transistor-logic). The signal is made up of serial data generated from a remote control keyboard decoding IC, or Integrated Circuit. The transmitted data is picked-up by photodiode at the receiver. The Integrated Circuit inside an average receiving chip picks up infrared signals around the 32-40 kHz range. Once picked up, this is where demodulation occurs.

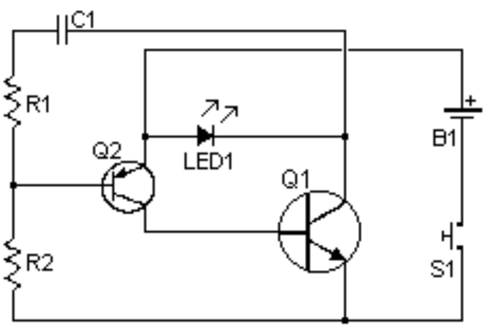


Figure 4.10 IR Transmitter

4.2.3 Wireless using microwave

Microwave transmission refers to the technology of transmitting information by the use of the radio waves whose wavelengths are very small (in centimeters) using various electronic technologies. These are called *microwaves*. This part of the radio spectrum ranges across frequencies of roughly 1.0 gigahertz (GHz) to 30 GHz. Also by using the formula **λ = c/f** , these correspond to wavelengths from 30 centimeters down to 1.0 cm. [In the above equation, the Greek letter λ (lambda) is the wavelength in meters; **c** is the speed of light in meters per second; and **f** is the frequency in hertz (Hz)].

Microwave radio transmission is commonly used by communication systems on the surface of the Earth, in satellite communications, and in deep space radio communications. Other parts of the microwave radio band are used for radars, radio navigation systems, sensor systems, and radio astronomy.

The next higher part of the radio electromagnetic spectrum, where the frequencies are above 30 GHz and below 100 GHz, are called "millimeter waves" because their wavelengths are conveniently measured in millimeters, and their wavelengths range from 10 mm down to 3.0 mm. Radio waves in this band are usually strongly attenuated by the Earthly atmosphere and particles contained in it, especially during wet weather. Also, in wide band of frequencies around 60 GHz, the radio waves are strongly attenuated by molecular oxygen in the atmosphere. The electronic technologies needed in the millimeter wave band are also much more difficult to utilize than those of the microwave band.

Figure 4.11 Parabolic (microwave) antenna

All microwave transmission use parabolic antenna as transmission antenna as shown in Figure 4.11. It is a high-gain reflector antenna used for radio, television and data communications, and also for radiolocation (radar), on the UHF and SHF parts of the electromagnetic spectrum. The relatively short wavelength of electromagnetic radiation at these frequencies allows reasonably sized reflectors to exhibit the desired highly directional response for both receiving and transmitting.

4.3 Radar System

Radar is an acronym for Radio Detection and Ranging. The term "radio" refers to the use of electromagnetic waves with wavelengths in the so-called radio wave portion of the spectrum, which covers a wide range from 10^4 km to 1 cm. . Radar also refers to electronic equipment that detects the presence, direction, height, and distance of objects by using reflected electromagnetic energy. The frequency of electromagnetic energy used for radar is unaffected by darkness and weather. This permits radar systems to determine the position of ships, planes, and landmasses that are invisible to the naked eye because of distance, darkness, or weather. Radar systems typically use wavelengths on the order of 10 cm, corresponding to frequencies of about 3 GHz. The detection and ranging part of the acronym is accomplished by timing the delay between transmission of a pulse of radio energy and its subsequent return. If the time delay is Δt, then the range (R) may be determined by the simple formula:

$$R = c\Delta t/2$$

where $c = 3 \times 10^8$ m/s, the speed of light at which all electromagnetic waves propagate. The factor of two in the formula comes from the observation that the radar pulse must travel to the target and back before detection, or twice the range.

A radar pulse train is a type of amplitude modulation of the radar frequency carrier wave, similar to how carrier waves are modulated in communication systems. In this case, the information signal is quite simple: a single pulse repeated at regular intervals. The common radar carrier modulation, known as the pulse train is shown in Figure 4.12.

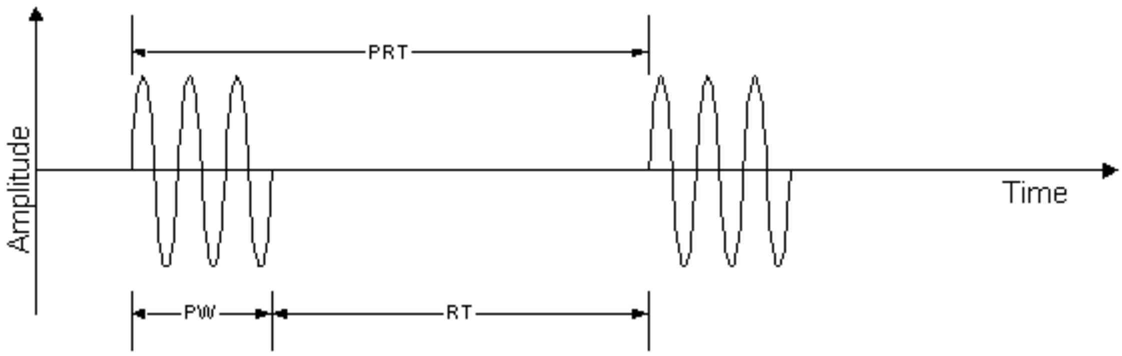


Figure 4.12 Radar pulse

Pulse Width (PW) has units of time and is commonly expressed in ms. PW is the duration of the pulse. Rest Time (RT) is the interval between pulses. It is measured in ms. Pulse Repetition Time (PRT) has units of time and is commonly expressed in ms. PRT is the interval between the start of one pulse and the start of another. PRT is also equal to the sum, PRT = PW+RT. Pulse Repetition Frequency (PRF) has units of $time^{-1}$ and is commonly expressed in Hz (1 Hz = 1/s) or as pulses per second (pps). PRF is the number of pulses transmitted per second and is equal to the inverse of PRT. Radio Frequency (RF) has units of $time^{-1}$ or Hz and is commonly expressed in GHz or MHz. RF is the frequency of the carrier wave which is being modulated to form the pulse train. A practical radar system requires seven basic components as illustrated in Figure 4.13.

4.4 RFID

RFID is short for Radio Frequency Identification. Generally a RFID system consists of two parts, a Reader, and one or more Transponders, also known as Tags. RFID systems evolved from barcode labels as a means to automatically identify and track products and people. Generally RFIDs are used in the following system;

- **Access Control.**
  RFID Readers placed at entrances that require a person to pass their proximity card (RF tag) to be "read' before the access can be made.
- **Contact less Payment Systems.**
  RFID tags used to carry payment information. RFIDs are particular suited to electronic Toll collection systems. Tags attached to vehicles, or carried by people transmit payment information to a fixed reader attached to a Toll station. Payments are then routinely deducted from a users account, or information is changed directly on the RFID tag.
- **Product Tracking and Inventory Control.**
  RFID systems are commonly used to track and record the movement of ordinary items such as library books, clothes, factory pallets, electrical goods and numerous items.

4.4.1 How do RFID works

In every RFID system the transponder tags contain information. This information can be as little as a single binary bit, or be a large array of bits representing such things as an identity code, personal medical information, or literally any type of information that can be stored in digital binary format.

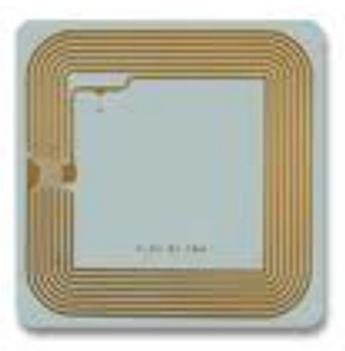


Figure 4.13 RFID Tag

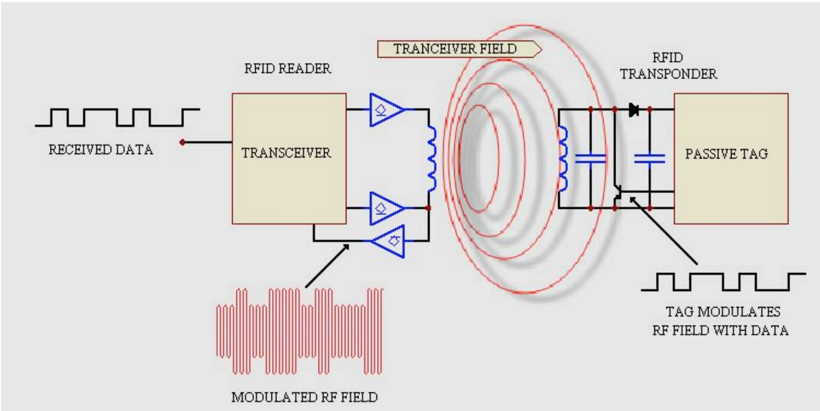


Figure 4.14 RFID System

Figure 4.13 and Figure 4.14 show a typical RFID tag and transceiver that communicates with a passive tag. Passive tags have no power source of their own and instead derive power from the incident electromagnetic field. Commonly the heart of each tag is a microchip. When the tag enters the generated RF field it is able to draw enough power from the field to access its internal memory and transmit its stored information.

When the transponder tag draws power in this way the resultant interaction of the RF fields causes the voltage at the transceiver antenna to drop in value. This effect is utilized by the tag to communicate its information to the reader. The tag is able to control the amount of power drawn from the field and by doing so it can modulate the voltage sensed at the transceiver according to the bit pattern it wishes to transmit.

4.4.2 Types of RFID Transponders.

There are three types of transponders. Tags are Active, Passive, or Semi-passive transponders. As already mentioned, Passive transponders have no internal power source. They draw their power from the electromagnetic field generated by the RFID reader. They have no active transmitter and rely on altering the RF field from the transceiver in a way that the reader can detect. Active transponders have their own transmitters and power source, usually in the form of a small battery. As a result of this they are able to be detected at a greater range than passive ones. Active tags remain in a low power "idle" state until they detect the presence of the RF field being sent by the reader. When the tag leaves the area of the reader it again powers down to its idle state to conserve its battery.

Semi-Passive Transponders have their own power source that powers the microchip only. They have no transmitter and as with passive tags they rely on altering the RF field from the transceiver to transmit their data.

4.4.3 RFID Frequencies

Much like tuning in to our favorite radio station, RFID tags and readers must be tuned into the same frequency to enable communications. RFID systems can use a variety of frequencies to communicate, but because radio waves work and act differently at different frequencies, a frequency for a specific RFID system is often dependant on its application. High frequency RFID systems (850 MHz to 950 MHz and 2.4 GHz to 2.5 GHz) offer transmission ranges of more than 90 feet, although wavelengths in the 2.4 GHz range are absorbed by water, which includes the human body, and therefore has limitations.

The emerging standard for library RFID solutions is to employ a frequency of 13.56MHz. However, no formal standards are currently in place. Figure 4.15 illustrates the frequency band for RFID.

4.5 Barcode

A barcode is an optical machine-readable representation of data, which shows certain data on certain products. Originally, barcodes represented data in the widths (lines) and the spacings of parallel lines, and may be referred to as linear or 1D (1 dimensional) barcodes or symbologies. They also come in patterns of squares, dots, hexagons and other geometric patterns within images termed 2D (2 dimensional) matrix codes or symbologies. Although 2D systems use symbols other than bars, they are generally referred to as barcodes as well. Barcodes can be read by optical scanners called barcode readers, or scanned from an image by special software.

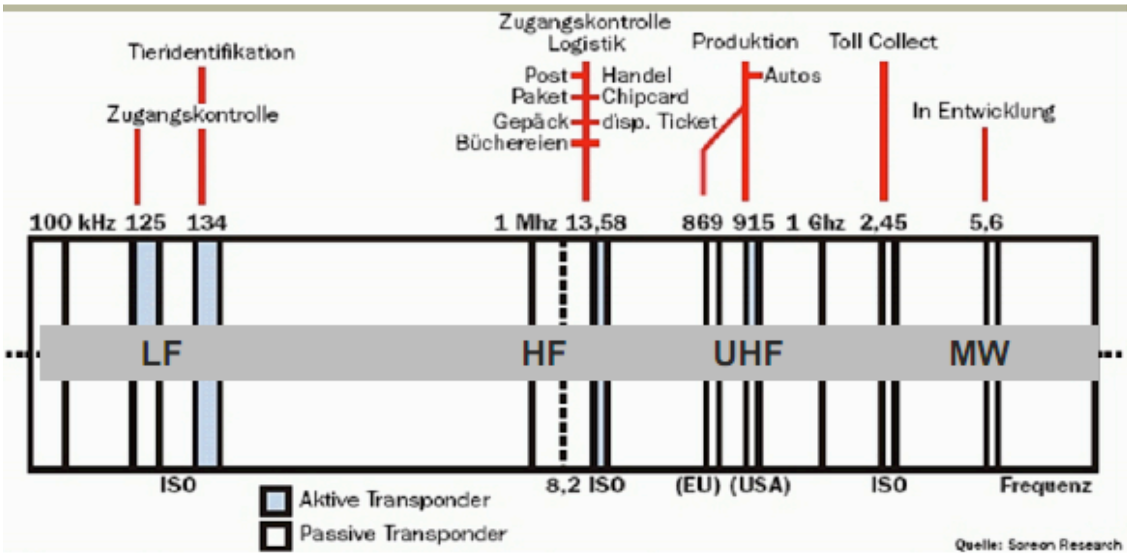


Figure 4.15 RFID Frequency Band

Figure 4.16 A Barcode symbol

Figure 4.17 A Barcode reader

The first use of barcodes was to label railroad cars, but they were not commercially successful until they were used to automate supermarket checkout systems, a task in which they have become almost universal. Their use has spread to many other roles as well, tasks that are generically referred to as Auto ID Data Capture (AIDC). Other systems are attempting to make inroads in the AIDC market, but the simplicity, universality and low cost of barcodes has limited the role of these other systems. It costs 0.5¢ (U.S.) to implement a barcode, while passive RFID still costs about 7¢ to 30¢ per tag. Figure 4.16 and 4.17 show the barcode symbol and barcode reader respectively .

4.5.1 Barcode reader

A barcode reader (or barcode scanner) is an electronic device for reading printed barcodes. Like a flatbed scanner, it consists of a light source, a lens and a light sensor translating optical impulses into electrical ones. Additionally, nearly all barcode readers contain *decoder* circuitry analyzing the barcode's image data provided by the sensor and sending the barcode's content to the scanner's output port.

The bars in a bar code each have an exact length and width. Some also have a series of alphanumeric codes beneath or around the bars. The lengths and widths are representative of specific information (e.g., model number, type, quantity, location and price). The bar code reader is equipped with three basic components: an infrared light source, a photodiode and a bidirectional link to a database (either physical or wireless connection). The infrared light source projects a beam of light. Given the size of the reader and the light source, the beam can be several inches or several feet wide, depending on its application and purpose. The beam of light then strikes the bars in the bar code and records the breaks in the beam, which represent the widths and the lengths. The photodiode interprets this information and sends it to the database via the bidirectional link. The link "talks" with the database and determines information about this object. It can request information and it can update information (e.g., quantity remaining, changes in price or addition to a registry). The requested information is sent to the bar code reader and registered either directly on the device, such as with a hand-held reader, or the data is sent to a point-of-sale device (e.g., cash register).

4.6 Bluetooth

Bluetooth is a standard for a small, cheap radio chip to be plugged into computers, printers, mobile phones, etc. A Bluetooth chip is designed to replace cables by taking the information normally carried by the cable, and transmitting it at a special frequency to a receiver Bluetooth chip, which will then give the information received to the computer, phone whatever. Bluetooth technology is the most popular wireless connectivity solution today. Although it functions well as a wireless personal network technology, it can increase the risk to business information assets. Bluetooth got its name after the 10th century Viking King Harald Blatand (Blatand meaning Bluetooth). He was instrumental in uniting the countries in the Baltic region like Sweden, Denmark, Norway and thus emerging as a powerful force. Bluetooth aims at uniting the computing and telecommunication world and so achieving the same greatness.

Bluetooth is a global standard for wireless connectivity. Bluetooth technology facilitates the replacement of the cables used to connect one device to another, with one universal short-range radio link operating in the unlicensed 2.45 GHz ISM band. The Industrial, Scientific and Medical (ISM) radio bands were originally reserved internationally for the use of RF energy for industrial, scientific and medical purposes other than communications. In general, communications equipment must accept any interference generated by ISM equipment.

Bluetooth provides a secure way to connect and exchange information between devices such as faxes, mobile phones, telephones, laptops, personal computers, printers, Global Positioning System (GPS) receivers, digital cameras, and video game consoles.

4.6.1 How Bluetooth works

Bluetooth is a wireless network technology defined by the IEEE 802.15 standard. Using frequency hopping to reduce interference, it operates in the 2.4 MHz band. Throughput over a Bluetooth connection is dependent on the version implemented by the device manufacturer. Maximum data rates range from 1 Mbps to 3 Mbps. Actual data rates typically fall well below these thresholds.

Figure 4.18 Small personal network

Initially developed in 1994 by Ericsson, Bluetooth has become the technology of choice for creating small personal networks without the need for cables as illustrated in Figure 4.18. Bluetooth personal area networks, also known as piconets, consist of one master and up to 7 active slave devices. A Bluetooth piconet is depicted in Figure 4.19. An additional 255 devices can be connected to the master as long as they are in park mode.

Within a piconet, each slave is attached to the master via a physical channel. Each of these channels is divided into slots. Packets traveling between the master and the slave are placed into these slots. Physical channels are not created between slaves. All packet transfers are managed by the master device. The master sequentially polls each device to see if it requires service. The master is also responsible for synchronizing all devices to ensure consistent timing.

A device can join a piconet in one of two ways. First, a Bluetooth device can enter an inquiry state to discover other Bluetooth devices. Within this inquiry, information is provided about the types of services needed. Bluetooth devices offering one or more of the requested services, and that are within the broadcast range, will respond if in discovery mode. The process used to establish a channel between one or more of the responding devices depends on the security mode used.

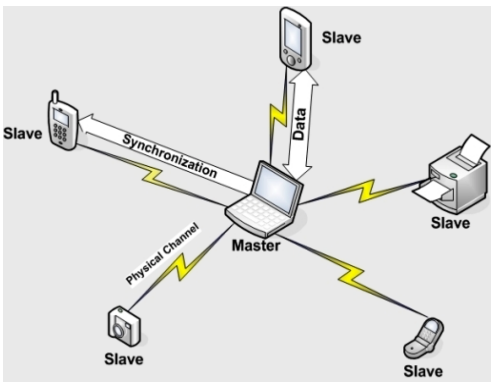


Figure 4.19 A Bluetooth

In the second way, a master searches for devices within range. If one is discovered, it is automatically added to the piconet in accordance with security measures in place on one or both of the devices.

Bluetooth offers worldwide compatibility as the Bluetooth radio chip, which is built into a small microchip, functions in a globally available frequency band. There is no cabling involved and files, photos and other information are easily exchanged between the connected electronic devices. The connected devices, which may include cellular phones, laptops, personal computers, printers, digital cameras, GPS receivers and even gaming consoles, communicate and exchange data through a secure 2.4GHz to 2.485GHz short range radio frequency bandwidth. Users can, therefore, create Personal Area Networks, or PANs for connecting with other Bluetooth compatible devices as illustrated in Figure 4.20.

Bluetooth is usually used in an "ad-hoc" manner, that is, the personal area network is paired. It is not server-based and there is no communication between any of the slave units. Instead all the data communication occurs via the Master unit. Although there is no router, communication between the paired Bluetooth enabled devices takes place automatically through the two nodes between the two connected devices.

Figure 4.20 Bluetooth PAN devices

The Bluetooth Radio (layer) is the lowest defined layer of the Bluetooth specification. It defines the requirements of the Bluetooth transceiver device operating in the 2.4 GHz ISM band. The Bluetooth air interface is based on three power classes. The Bluetooth power is measured in dBm $\left[dBm = 10\log_{10}\left[\frac{P}{1mW}\right]\right]$

- Power Class 1: designed for long range (~100m), max output power of 20 dBm (100 mW)
- Power Class 2: ordinary range devices (~10m), max output power of 4 dBm (2.5 mW)
- Power Class 3 short range devices (~10cm), with a max output power of 0 dBm (1 mW)

4.7 Broadband

The term *broadband* simply means that multiple frequency carriers are used to carry one signal. It describes the way ADSL (Asymmetric Digital Subscriber Line) services work so has become a term to describe a *fast internet connection*. Broadband in general is a term used to describe high speed data connections. Broadband solutions are ideally suited for the Internet connectivity and data networks. A key advantage of broadband is the "always on" operations of the service. It is ideal for dedicated connectivity for large companies that are looking to connect their LAN (Local Area Network) to the Internet backbone at high speeds as illustrated in Figure 4.21.

Among the benefits of this service is that the requested bandwidth is for the exclusive use of the client organization, and can be increased or decreased according to the organization's need.

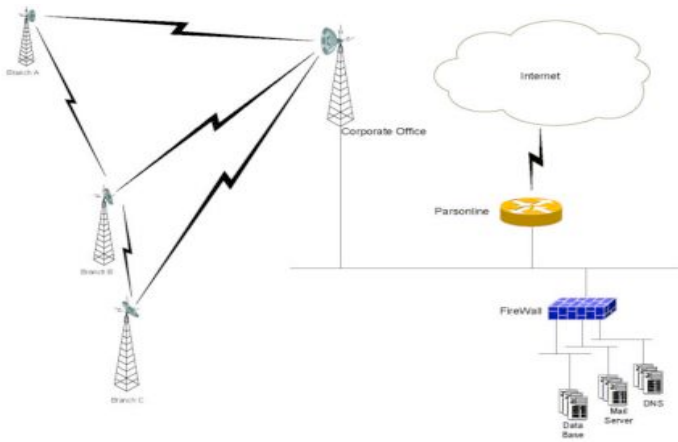


Figure 4.21 Broadband network

With this service, the cost of which depends on the volume of the dedicated bandwidth, the client organization can benefit from the advantages of a high speed, dedicated bandwidth which is adjustable to the organization's needs. Unlike the case of leased lines, the telephone company will have no role in wireless connection services. The only limitation involved here is the necessity to transfer the signals on the internationally authorized wireless frequencies. Wireless service providers all over the world are allowed to offer the wireless technology only on the 2.4, 5.4 and 5.8 MHz frequency bands.

4.8 Wi-Fi

The term *Wi-Fi*, which is alternatively spelled WiFi, Wi-fi, Wifi, or wifi which stands for *wireless fidelity*, is a wireless networking technology used across the globe. Wi-Fi refers to certain kinds of wireless local area networks, or WLAN (as opposed to LAN, or computers that are networked together with wires). Wi-Fi technology uses radio for communication, typically operating at a frequency of 2.4GHz. In a Wi-Fi network, computers with wifi network cards connect wirelessly to a wireless router. The router is connected to the Internet by means of a modem, typically a cable or Digital Subscriber Line (DSL) modem. Any user within 200 feet or so (about 61 meters) of the access point can then connect to the Internet, though for good transfer rates, distances of 100 feet (30.5 meters) or less are more common. Retailers also sell wireless signal boosters that extend the range of a wireless network.

Travelers with PDA's (like Blackberries) and other handheld devices or laptops with wireless cards can connect to the internet via wifi hotspots. Wifi hotspots are places where we can find wifi, free or paid. Internet cafes are likely wifi hotspots, and many airports, hotels and bars have wifi hotspots. A wireless card is like a modem without a phone line. Travelers care what wifi is because with wifi, travelers can log on to the internet anywhere and find a hostel, or a map and directions, check email, download music and everything else you do with a computer connected to the internet at home.

4.9 Wi-MAX

WiMAX is an IP based, wireless broadband access technology that provides performance similar to 802.11/Wi-Fi networks with the coverage and QOS (quality of service) of cellular networks. WiMAX is also an acronym meaning "Worldwide Interoperability for Microwave Access (WiMAX). WiMAX is a wireless digital communications system, also known as IEEE 802.16, that is intended for wireless "metropolitan area networks". The current WiMAX revision provides up to 40 Mbit/s with the IEEE 802.16m update expected to offer up to 1 Gbit/s fixed speeds. WiMAX can provide broadband wireless access (BWA) up to 30 miles (50 km) for fixed stations, and 3 - 10 miles (5 - 15 km) for mobile stations. In contrast, the WiFi/802.11 wireless local area network standard is limited in most cases to only 100 - 300 feet (30 - 100m).

With WiMAX, WiFi-like data rates are easily supported, but the issue of interference is lessened. Figure 4.22 illustrates the WiFi and WiMAX coverage. WiMAX operates on both licensed and non-licensed frequencies, providing a regulated environment and viable economic model for wireless carriers. As the fourth generation (4G) of wireless technology, WiMAX delivers low-cost, open networks and is the first all IP mobile Internet solution enabling efficient and scalable networks for data, video, and voice.

The bandwidth and range of WiMAX make it suitable for the following potential applications:

- Providing portable mobile broadband connectivity across cities and countries through a variety of devices.
- Providing a wireless alternative to cable and DSL (digital subscriber line) for "last mile" broadband access.
- Providing data, telecommunications (VoIP) and IPTV services (triple play).
- Providing a source of Internet connectivity as part of a business continuity plan.

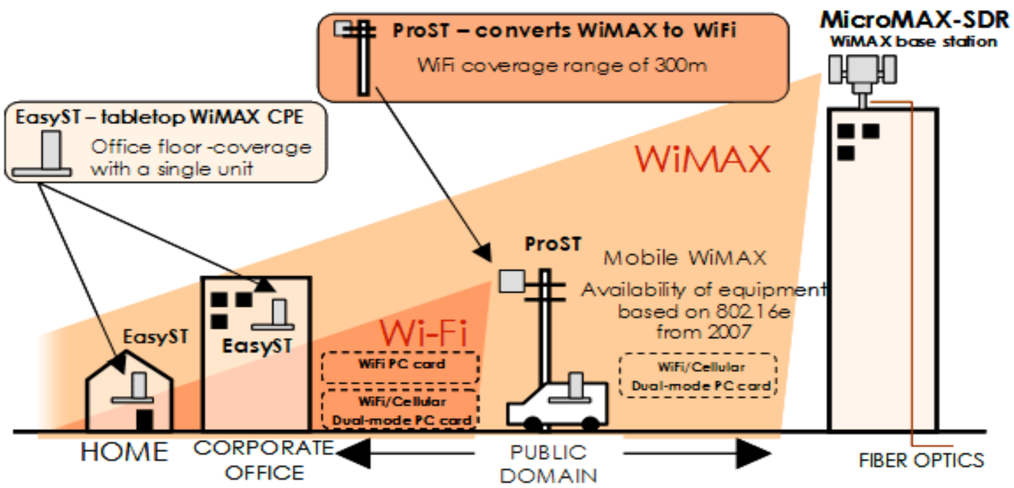


Figure 4.22 Wifi and WiMAX

CHAPTER 5

SATELLITE COMMUNICATION

5.1 Introduction

Satellite communication was invented by Arthur C. Clarke in 1946. It consists of ground station and ionosphere satellite station. Satellite plays very important role in modern communication system. Since it inception in the early 20th century, satellite becomes the prime mover in the wireless intercontinental communication system. A communication (telecommunication) satellite is a satellite that relays all forms of electronic communication such as telephone, television, internet, etc (see Figure 5.1). Signals are transmitted up to it by ground station satellite and then retransmitted to different locations on Earth. The first artificial satellite was the Soviet Sputnik 1, launched on October 4, 1957, and equipped with an on-board radio-transmitter that worked on two frequencies, 20.005 and 40.002 MHz. Whereas the first American satellite to relay communications was Project SCORE in 1958, which used a tape recorder to store and forward voice messages. It was used to send a Christmas greeting to the world from U.S. President Dwight D. Eisenhower.

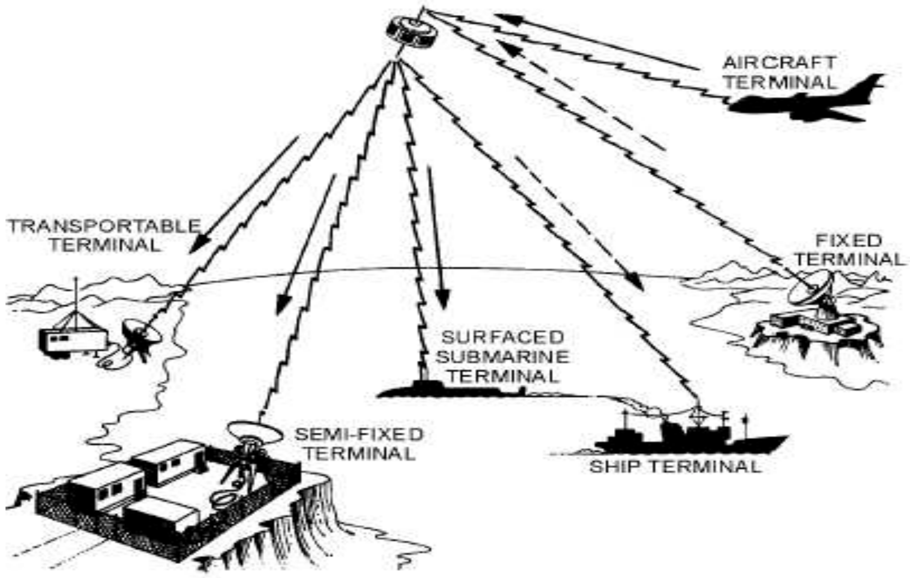


Figure 5.1 Satellite Communication

5.2 Fundamentals of Satellite Communication

Operational satellites are classified in three main categories; geostationary orbit, low-earth-orbit and Molniya satellites as shown in Figure 5.2. A geostationary orbit is one in which a satellite orbits the earth at exactly the same speed as the earth turns and at the same latitude, specifically zero, the latitude of the equator. A satellite orbiting in a geostationary orbit appears to be hovering in the same spot located at an altitude of 22,236 miles (35,786 km) above sea level, and is directly over the same patch of ground at all times. It revolves at the constant speed of 7,000 mph (11,300 km/h) to complete a full cycle of roughly 23 hours and 56 minutes. The geostationary orbit is useful for communications applications

LEO = Low Earth Orbit (100 – 1,500 km)

MEO = Medium Earth Orbit (5,000 – 10,000 km)

GEO = Geostationary Orbit (36,000 km)

HEO = Highly Elliptical Orbit

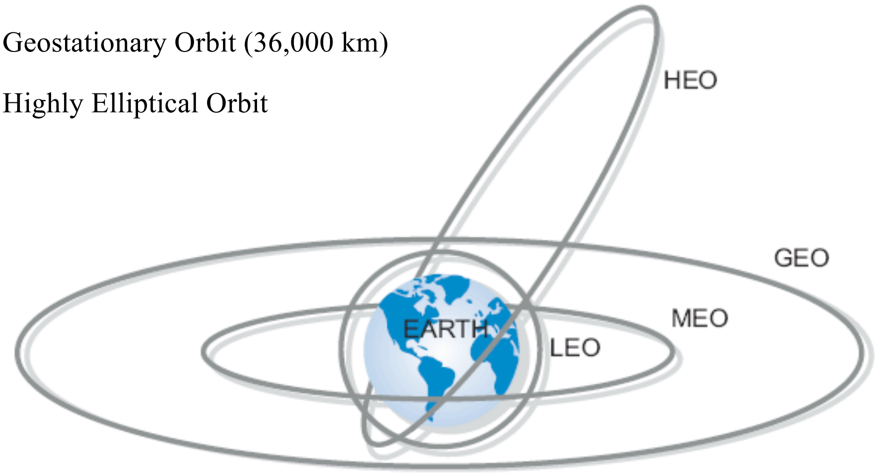


Figure 5.2 Earth's Satellite Orbit

because ground based antennas, which must be directed toward the satellite, can operate effectively without the need for expensive equipment to track the satellite's motion. Especially for applications that require a large number of ground antennas (such as direct TV distribution), the savings in ground equipment can more than justify the extra cost and onboard complexity of lifting a satellite into the relatively high geostationary orbit.

The first geostationary satellite launched in orbit was the Syncom 3, launched on August 19, 1964. It was placed in orbit at 180° east longitude, over the International Date Line. It was used that same year to relay experimental television coverage of the 1964 Summer Olympics in Tokyo, Japan to the United States, making these Olympic games the first to be broadcast internationally.

A low Earth orbit (LEO) is an orbit from roughly 100 to 1240 miles (160-2000km) above the Earth's surface. Nearly all human spaceflight has taken place in the low Earth orbit, with a few notable exceptions. A great number of satellites are also in a low Earth orbit, as is the International Space Station (ISS). A number of different human objects reside in low Earth orbit, from different time periods. The most notable of these is probably the International Space Station, which is situated around 200 miles (320km) above the Earth's surface, well within the thermosphere. The International Space Station is visited regularly by the Space Shuttle, the Soyuz spacecraft, the Automated Transfer Vehicle, and the Progress spacecraft, all of which engage only in low Earth orbit missions.

A large number of satellites also reside in low Earth orbit. These satellites must travel very quickly to resist the pull of gravity approximately 17,000 miles per hour in as little as 90 minutes around the Earth, at a speed of about 5 miles per second (8km/s). Launching a satellite into low Earth orbit takes much less energy than launching it into space, and the equipment needed to send a signal back to Earth can be much less powerful. For these reasons, low Earth orbit satellites are still widely used, even though they cannot remain situated over one part of the planet in the way geostationary satellites in space can.

Molniya *("lightning")* was a military communications satellite system used by the Soviet. Molniya Orbit often referred to as a highly elliptical orbit (HEO) is a 12-hour orbit inclined about 60 degrees to the equator. It has a high apogee over the northern hemisphere and a low perigee over the southern hemisphere. The satellites used highly eccentric elliptical orbits, which allowed them to be visible to polar regions for long periods (sites near the poles are not able to communicate with satellites in geosynchronous orbits). This path is also known as a Molniya orbit.

5.3 Ionosphere effect on microwave

The radio waves traveling through the ionosphere possess kinetic energy. This kinetic energy is imparted to the free electrons. Thus these free electrons in the ionosphere are set to vibration. These vibrating electrons collide with gas molecules from time to time in spite of the low gas pressure in the ionosphere. An electron on colliding with the gas molecule gives away the kinetic energy that it has acquired from radio wave. So far as the radio wave is concerned this constitutes a loss of power.

Most of the energy loss suffered by a radio wave passing through the ionosphere takes place at the lower edge of the ionosphere where the gas pressure is maximum that is in the lower part of the E layer and the D layer (see Figure 5.3). The E layer consists of two layers. The regular E layer constant is about hundred and ten kilometer height which is the lowest affected and helpful ionosphere layer. It is most useful for short wave frequencies above three megahertz. We have also sporadic and varying E layer between ninety kilometers and hundred and thirty kilometers whose appearance is unpredictable. This layer is all together absent at right.

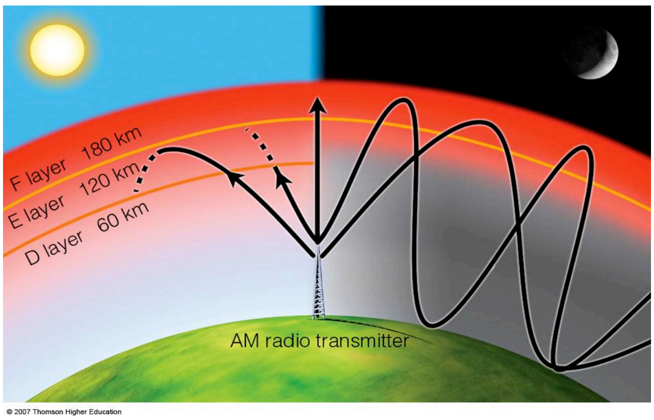


Figure 5.3 Ionosphere and radio wave

The remaining part of the ionosphere has very low atmospheric pressure so that the radio wave suffers very small energy loss in the remaining part. The absorption is greater at lower the frequency. The earth's magnetic field also affects the energy lost through absorption. The loss tends to be high at frequencies close to the gyro frequency. Because of the finite energy loss through absorption the ionosphere may be considered to have a finite but small conductivity. Thus for a wave, the ionosphere acts like a dielectric having small conductivity and relative dielectric constant less than unity. The values of both the conductivity and dielectric constant are influenced by earth's magnetic field and are different for the ordinary and extra ordinary rays.

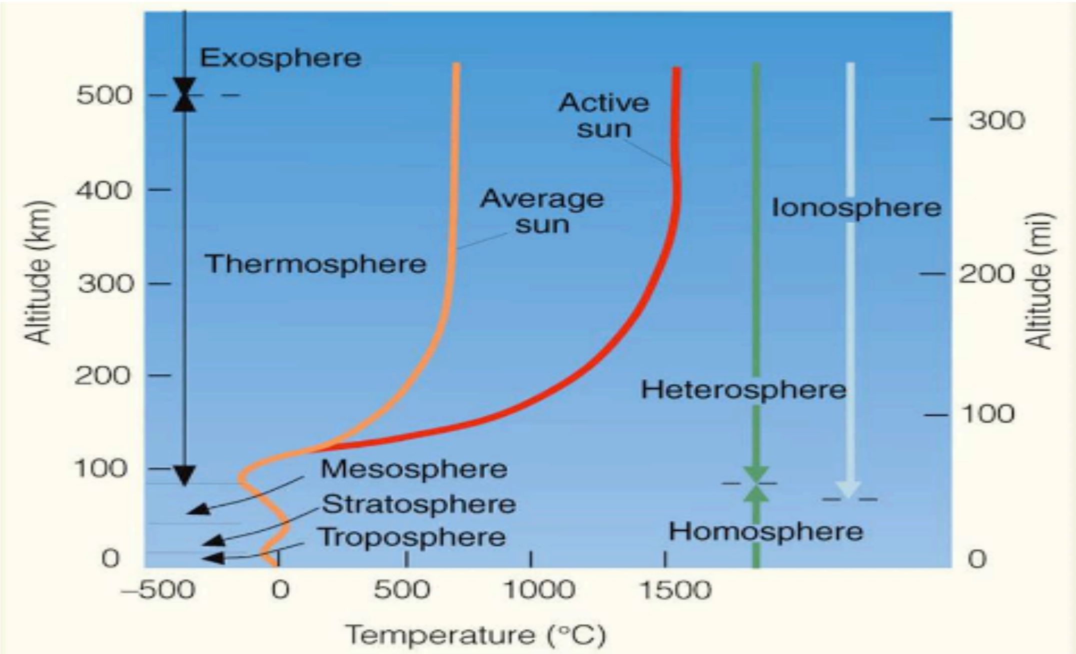


Figure 5.4 Homosphere and ionosphere

The ionosphere is important for radio wave (AM only) propagation. It is composed of the D, E, and F layers. The D layer is good at absorbing AM radio waves. It disappears at night and allows the wave to pass through to the E and F layers to bounce the waves back to the earth. This explains why radio stations adjust their power output at sunset and sunrise and eventually better reception during night. Figure 5.4 illustrates the homosphere and ionosphere layer.

5.4 Types of satellite system

There are three different types of satellite systems.

(i) International satellite communication system INTELSAT.

The INTELSAT Organization was established in 1964 to handle the countless of technical and administrative problems associated with a world wide telecommunication system. The international regions served by INTELSAT are divided in to the Atlantic Ocean region (AOR), the Pacific Ocean Region (POR), and the Indian Ocean region (IOR). For each region , satellites are positioned in geo-stationary orbit above the particular Ocean, where they provide a transoceanic telecommunication route. In addition to providing transoceanic routes, the INTELSAT satellites are used for domestic services within any given country and regional services between countries. Two such services are vista for telephony and Intelnet for data exchange.

ii) Domestic satellite system DOMSAT.

Domestic satellites are used to provide various telecommunication services, such as voice, data, and video transmission (T.V channels), with in a country.

iii) Search and rescue system SARSAT.

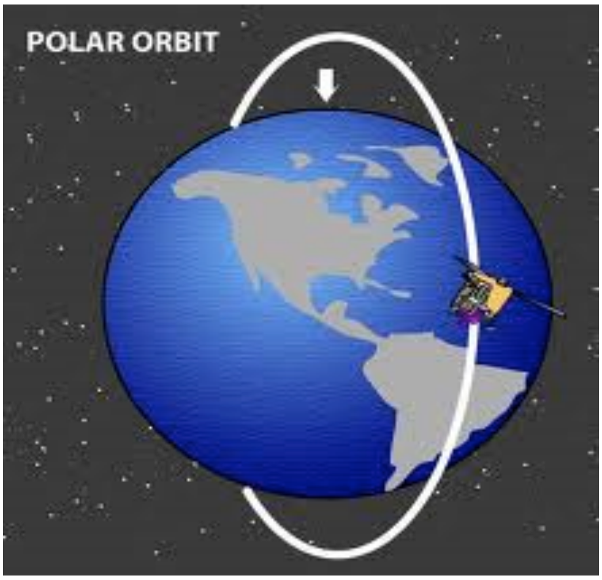


Figure 5.5 Polar satellite path

SARSAT is one type of Polar orbiting satellites as shown in Figure 5.5. Polar-orbiting satellites orbit the earth in such a way as to cover the north and south polar-regions. Infinite number of polar satellite orbits is possible. Polar satellites are used to provide environmental data, and to help locate ships and aircrafts in distress. This service known as SARSAT, for search and rescue satellite.

5.5 Mobile satellite system

Mobile satellite systems (MSS) may be classified according to orbit altitude as follows:

5.5.1 **GEO** - geostationary earth orbit, approx altitude: 36, 000 km.

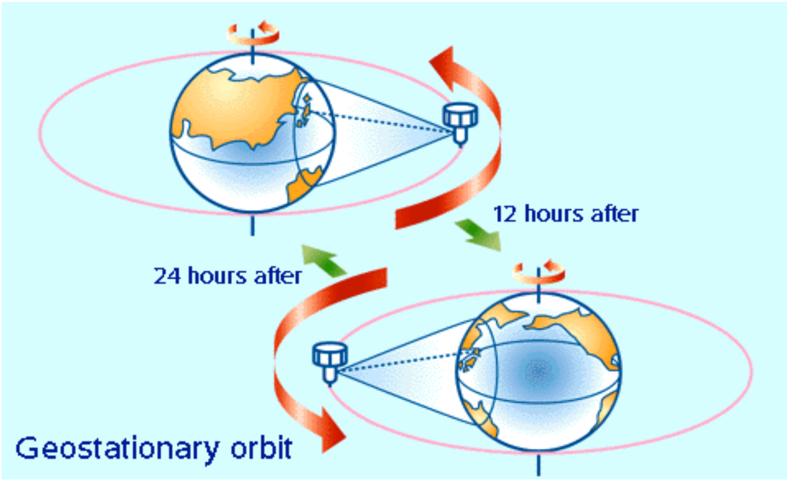


Figure 5.6 Geostationary orbit

Geostationary satellites are positioned at approximately 36,000 km above the equator. They enable a quasi-continuous time sampling over certain regions on Earth. These satellites are geosynchronous, meaning their orbits keep them synchronized with Earth's rotation, i.e., they take 24 hours to complete one orbit. When these satellites orbit above the equator, with zero inclination, they are also geostationary (fixed) relative to a point on the equator, so that they observe the Earth without any significant relative motion as shown in Figure 5.6.

There is only one orbit in which a satellite can be geostationary. To have a 24 hour orbital period, they must keep an orbital altitude of 35,780 km (22,234 mi, or about 5.61 Earth radii (6,370 km)), which sets their speed at 3.07 km/s (6,868 mph or approx. 11,300 km/h). An equatorial point travels underneath at a speed of about 0.465 km/s (1,040 mph). At this distance, and with a wide field of view (FOV), they see the Earth as a full disk, but the area covered is less than a hemisphere, being about 1/4th of the planetary surface (see Figure 5.7). This results in a much wider field of view than is possible for polar orbiting satellites, however, the large distance from earth causes geostationary satellites to have much poorer spatial resolution than polar orbiting satellites.

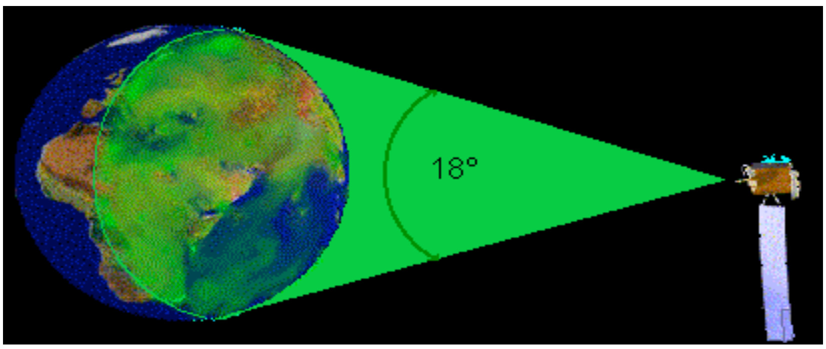


Figure 5.7 Position of a geostationary satellite with respect to the equator.

5.5.2 **MEO** - mid-altitude earth orbit, approx altitude: 10,000 km

A medium earth orbit (MEO) satellite is one with an orbit within the range from a few hundred miles to a few thousand miles above the earth's surface. Satellites of this type orbit higher than low earth orbit (LEO) satellites, but lower than geostationary satellites.

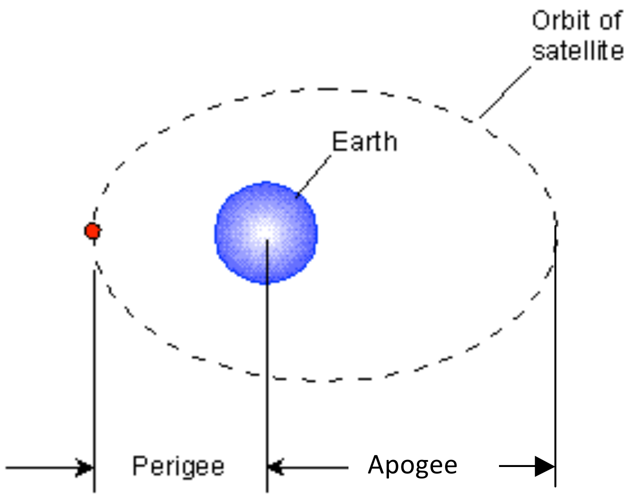


Figure 5.8 Perigee and apogee

The orbital periods of MEO satellites range from about two to 12 hours. Some MEO satellites orbit in near perfect circles, and therefore have constant altitude and travel at a constant speed. Other MEO satellites revolve in elongated orbits. The perigee (lowest altitude) of an elliptical-orbit satellite is much less than its apogee (greatest altitude) as shown in Figure 5.8. The orbital speed is much greater near perigee than near apogee. As seen from a point on the surface, a satellite in an elongated orbit crosses the sky in just a few minutes when it is near perigee, as compared to several hours when it is near apogee. Elliptical-orbit satellites are easiest to access near apogee, because the earth-based antenna orientation does not have to be changed often, and the satellite is above the horizon for a fairly long time.
A fleet of several MEO satellites, with orbits properly coordinated, can provide global wireless communication coverage. Because MEO satellites are closer to the earth than geostationary satellites, earth-based transmitters with relatively low power and modest-sized antennas can access the system. Because MEO satellites orbit at higher altitudes than LEO satellites, the useful footprint (coverage area on the earth's surface) is greater for each satellite. Thus a global-coverage fleet of MEO satellites can have fewer members than a global-coverage fleet of LEO satellites.

5.5.3 **LEO** - low earth orbit, approx altitude: <1, 000 km

A low Earth orbit (LEO) is generally defined as an orbit within the locus extending from the Earth's surface up to an altitude of 2,000 km. Given the rapid orbital decay of objects below approximately 200 km, the commonly accepted definition for LEO is between 160 - 2,000 km (100 - 1,240 miles) above the Earth's surface. LEO typically is a circular orbit about 400 kilometres above the earth's surface and, correspondingly, a period (time to revolve around the earth) of about 90 minutes. Because of their low altitude, these satellites are only visible from within a radius of roughly 1000 kilometres from the sub-satellite point.

LEOs can be further sub-divided into Big LEO and Little LEO categories. Big LEOs will offer voice, fax, telex, paging and data capability, whereas little LEOs will offer data capability only, either on a real-time direct readout ('bent pipe') basis, or as a store-and-forward service.

In addition, satellites in low earth orbit change their position relative to the ground position quickly. So even for local applications, a large number of satellites are needed if the mission requires uninterrupted connectivity. Low earth orbiting satellites are less expensive to launch into orbit than geostationary satellites and, due to proximity to the ground, do not require as high signal strength (Recall that signal strength falls off as the square of the distance from the source, so the effect is dramatic). Thus there is a trade off between the number of satellites and their cost. In addition, there are important differences in the onboard and ground equipment needed to support the two types of missions.

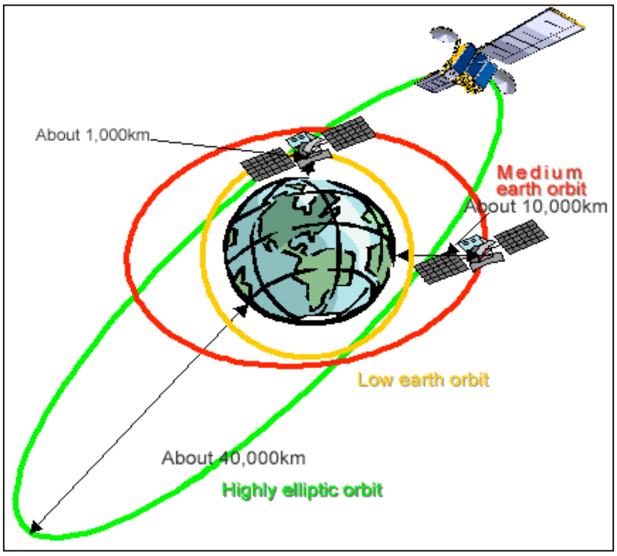


Figure 5.9 Orbital Satellite

Since the satellite footprint decreases in size as the orbit gets lower, LEO and MEO systems require larger constellations than GEO satellites in order to achieve global coverage and avoid data delays. Less energy is, however, generally required for LEO and MEO satellite communication because of the shorter average distance between transmitter and satellite (see Figure 5.9). Some systems implement several high-gain antennas to generate 'spot beams' and so reduce the requirement of the mobile to have a complex antenna and/or high output power. A key feature of several MSS currently under development will be their inter-operability with existing public switched telephone and cellular networks, using a dual-mode handset, for example.

Because of the commercial forces which are driving the implementation of the new systems, many will primarily focus on land masses and centres of population, and will not offer truly global or polar coverage. These systems will not in general be acceptable for global ocean monitoring. Furthermore, while the technical capabilities for the new

MSS do currently exist, delays are inevitable due to problems with spectrum allocation, licensing (in each country where the service will be offered), company financing, and availability of launch vehicles and ground stations. It is unlikely that all of the planned systems will overcome all of these hurdles. From a technical point of view, some systems do offer significantly enhanced capabilities compared with existing methods. Potential advantages include two-way communication, more timely observations, and greater data rates and volumes.

A group of satellites working in concert is known as a satellite constellation. Two such constellations, intended to provide satellite phone services, primarily to remote areas, are the Iridium and Globalstar systems. The Iridium system has 66 satellites. Another LEO satellite constellation known as Teledesic, with backing from Microsoft entrepreneur Paul Allen, was to have over 840 satellites. This was later scaled back to 288 and ultimately ended up only launching one test satellite.

In any circular orbit, the centripetal force required to maintain the orbit is provided by the gravitational force on the satellite. To calculate the geostationary orbit altitude, one begins with this equivalence, and uses the fact that the orbital period is one sidereal day.

$$\mathbf{F}_{\mathrm{c}} = \mathbf{F}_{\mathrm{g}}$$

By Newton's second law of motion, we can replace the forces **F** with the mass *m* of the object multiplied by the acceleration felt by the object due to that force:

$$m\mathbf{a}_{\mathrm{c}} = m\mathbf{g}$$

We note that the mass of the satellite *m* appears on both sides — geostationary orbit is independent of the mass of the satellite. So calculating the altitude simplifies into calculating the point where the magnitudes of the centripetal acceleration required for orbital motion and the gravitational acceleration provided by Earth's gravity are equal.

The centripetal acceleration's magnitude is:

$$|\mathbf{a}_{\mathrm{c}}| = \omega^2 r$$

where ω is the angular speed, and r is the orbital radius as measured from the Earth's center of mass.

The magnitude of the gravitational acceleration is:

$$|\mathbf{g}| = \frac{GM}{r^2}$$

where M is the mass of Earth, 5.9736×10^{24} kg, and G is the gravitational constant, $6.67428 \pm 0.00067 \times 10^{-11}\ \mathrm{m^3\ kg^{-1}\ s^{-2}}$.

Equating the two accelerations gives:

$$r^3 = \frac{GM}{\omega^2} \to r = \sqrt[3]{\frac{GM}{\omega^2}}$$

The product *GM* is known with much greater accuracy than either factor; it is known as the geocentric gravitational constant μ = 398,600.4418 ± 0.0008 km^3 s^{-2}:

$$r = \sqrt[3]{\frac{\mu}{\omega^2}}$$

The angular speed ω is found by dividing the angle travelled in one revolution (360° = 2π rad) by the orbital period (the time it takes to make one full revolution: one sidereal day, or 86,164.09054 seconds).[5] This gives:

$$\omega \approx \frac{2\pi \text{ rad}}{86\,164 \text{ s}} \approx 7.2921 \times 10^{-5} \text{ rad/s}$$

The resulting orbital radius is 42,164 kilometres (26,199 mi). Subtracting the Earth's equatorial radius, 6,378 kilometres (3,963 mi), gives the altitude of **35,786 kilometres (22,236 mi)**.

Orbital speed (how fast the satellite is moving through space) is calculated by multiplying the angular speed by the orbital radius:

$$v = \omega r \approx 3.0746 \text{ km/s} \approx 11068 \text{ km/h} \approx 6877.8 \text{ mph.}$$

5.6 Malaysian Communication Satellite Systems

Malaysia's first regional satellite system called MEASAT (Malaysia East Asia Satellite), which provides optimum coverage of the East Asian region is owned and operated by Binariang Satellite Systems Sdn Bhd (BSS). The MEASAT system comprises two high-powered HS376 spacecraft built by the Hughes Space and Communications Company.

MEASAT-1, an advanced hybrid 12 C-band and 5 Ku-band payload satellite system, was launched on 13 January 1996 (Malaysian Time) from Kourou in French Guiana by Arianespace. Situated at 91.5° E, its C-band footprint covers a major part of East Asia (which includes the Philippines, Cambodia, parts of southern China, Hong Kong SAR and Taiwan Province of China, the Lao People's Democratic Republic, Malaysia, Myanmar, Singapore, Thailand and Viet Nam), northern Australia, Guam and Papua New Guinea.

MEASAT-2 was launched on 14 November 1996 (Malaysian Time). It serves up to six C-band and nine Ku–band transponders. At the orbital location of 148° E, MEASAT-2 provides reliable C-band broadcasting and telecommunications services in East Asia, eastern Australia, Guam and the mainland United States via Hawaii.

The Ku-band capacity of the MEASAT system (MEASAT-1 and MEASAT-2) offers reliable direct-to-user broadcasting services over eastern Australia, India, Indonesia (Sumatra and Java), eastern and western Malaysia, the Philippines, Taiwan Province of China and Viet Nam. It provides point-to-point and point-to-multipoint communications and broadcasting services within its footprints. Telemetry tracking and control is monitored from the MEASAT Satellite Control Centre in Pulau Langkawi, an island off the north-west coast of peninsular Malaysia, which has been identified as the nation's aerospace centre.

Telekom Malaysia, the largest telecommunications company in Malaysia, accesses the INTELSAT satellite systems located at the orbital slots of 60° E, 62° E, 177° E and 180° E for its international public switched networking, including the Internet backbone traffic and broadcast services. It also assesses the regional MEASAT and PALAPA satellite systems for domestic applications and ASIASAT, PANAMSAT and APSTAR for broadcast services. Together with a joint venture company, Telekom Malaysia offers Iridium services.

Telekom's current satellite services include an international public switched network using intermediate data rate (IDR) and low-cost time division multiple (LCTDMA); very small aperture terminal (VSAT) services for domestic and international applications; and television-based satellite services that include broadcast activities, digital satellite news gathering (DSNG) and television uplinking.

A third major telecommunications company, CELCOM, offers Orbcomm services. A ground station is now operating at Kijal, Terengganu, on the VHF frequency of 137-150.5 MHz. The footprint, which covers an area with a 3,000-mile diameter, includes Brunei Darrusalam, Malaysia and Singapore. Commercial services will officially begin in July 1999. Typical applications include river data collections, flood monitoring and fleet management.

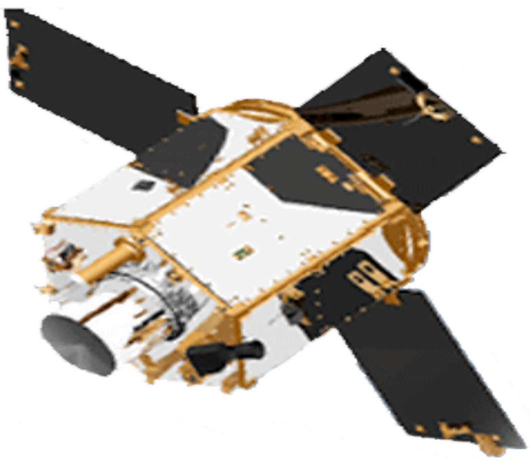


Figure 5.10 RazakSAT

RazakSAT satellite is Malaysia's second remote sensing satellite after TiungSAT-1 carrying a high-resolution camera as illustrated in Figure 5.10. It was launched into low Earth orbit by a Falcon 1 rocket on July 14, 2009. Initially, its called MACSAT, RazakSAT's payload is mainly electro-optical, carrying a Medium-sized Aperture Camera (MAC) which is a pushbroom camera with five linear detectors (one panchromatic, four multi-spectral); weighing approximately 50 kg while the whole satellite weighs at about 180 kg.

RazakSAT transmitted date on geographical topography, mapping, illegal logging as well as data need for agriculture activities on Malaysia, Asia. The images transmitted by RazakSAT are important and assisted the authorities in managing as well as monitoring land, mining and cultication activities apart from surveilance on the country's coast and waters; also other aspects that are beneficial to the country.

It's orbiting path which is near that Equator enables RazakSAT to obtain images which are six times better. It will orbit at Near Equator Orbit (NEqO) at the nominal altitude of 685km. The Orbit's location increases its frequency in monitoring the earth and climatic changes.

5.7 Satellite Applications

5.7.1 Satellite Telephone

The first and historically most important application for communication satellites was in intercontinental long distance telephony. The fixed Public Switched Telephone Network relays telephone calls from land line telephones to an earth station, where they are then transmitted to a geostationary satellite. The downlink follows an analogous path. Improvements in submarine communications cables, through the use of fiber-optics, caused some decline in the use of satellites for fixed telephony in the late 20th century, but they still serve remote islands such as Ascension Island, Saint Helena, Diego Garcia, and Easter Island, where no submarine cables are in service. There are also regions of some continents and countries where landline telecommunications are rare to nonexistent, for example large regions of South America, Africa, Canada, China, Russia, and Australia. Satellite communications also provide connection to the edges of Antarctica and Greenland.

Satellite phones connect directly to a constellation of either geostationary or low-earth-orbit satellites. Calls are then forwarded to a satellite teleport connected to the Public Switched Telephone Network.

5.7.2 Satellite television

Satellite television is television delivered by the means of communications satellite and received by a satellite dish and set-top box. In many areas of the world it provides a wide range of channels and services, often to areas that are not serviced by terrestrial or cable providers. As television became the main market, its demand for simultaneous delivery of relatively few signals of large bandwidth to many receivers being a more precise match for the capabilities of geosynchronous comsats. Two satellite types are used for North American television and radio: Direct Broadcast Satellite (DBS), and Fixed Service Satellite (FSS)

The definitions of FSS and DBS satellites outside of North America, especially in Europe, are a bit more ambiguous. Most satellites used for direct-to-home television in Europe have the same high power output as DBS-class satellites in North America, but use the same linear polarization as FSS-class satellites. Examples of these are the Astra, Eutelsat, and Hotbird spacecraft in orbit over the European continent. Because of this, the terms FSS and DBS are more so used throughout the North American continent, and are uncommon in Europe.

5.7.3 Fixed Service Satellite

Fixed Service Satellites use the C band, and the lower portions of the K_u bands. They are normally used for broadcast feeds to and from television networks and local affiliate stations (such as program feeds for network and syndicated programming, live shots, and backhauls), as well as being used for distance learning by schools and universities, business television (BTV), Videoconferencing, and general commercial telecommunications. FSS satellites are also used to distribute national cable channels to cable television head-ends.

Free-to-air satellite TV channels are also usually distributed on FSS satellites in the K_u band. The Intelsat Americas 5, Galaxy 10R and AMC 3 satellites over North America provide a quite large amount of FTA channels on their K_u band transponders.

The American DISH Network DBS service has also recently utilized FSS technology as well for their programming packages requiring their SuperDish antenna, due to Dish Network needing more capacity to carry local television stations per the FCC's "must-carry" regulations, and for more bandwidth to carry HDTV channels.

5.7.4 Direct broadcast satellite

A direct broadcast satellite is a communications satellite that transmits to small DBS satellite dishes (usually 18 to 24 inches or 45 to 60 cm in diameter). Direct broadcast satellites generally operate in the upper portion of the microwave K_u band. DBS technology is used for DTH-oriented (Direct-To-Home) satellite TV services, such as DirecTV and DISH Network in the United States, Bell TV and Shaw Direct in Canada, Freesat and Sky Digital in the UK, the Republic of Ireland, and New Zealand.

Operating at lower frequency and lower power than DBS, FSS satellites require a much larger dish for reception (3 to 8 feet (1 to 2.5m) in diameter for K_u band, and 12 feet (3.6m) or larger for C band). They use linear polarization for each of the transponders' RF input and output (as opposed to circular polarization used by DBS satellites), but this is a minor technical difference that users do not notice. FSS satellite technology was also originally used for DTH satellite TV from the late 1970s to the early 1990s in the United States in the form of TVRO (Tele-Vision Receive Only) receivers and dishes. It was also used in its K_u band form for the now-defunct Primestar satellite TV service.

Satellites for communication have now been launched that have transponders in the K_a band, such as DirecTV's SPACEWAY-1 satellite, and Anik F2. NASA as well has launched experimental satellites using the K_a band recently.

5.7.5 Mobile satellite technologies

Initially available for broadcast to stationary TV receivers, by 2004 popular mobile direct broadcast applications made their appearance with that arrival of two satellite radio systems in the United States: Sirius and XM Satellite Radio Holdings. Some manufacturers have also introduced special antennas for mobile reception of DBS television. Using Global Positioning System (GPS) technology as a reference, these antennas automatically re-aim to the satellite no matter where or how the vehicle (that the antenna is mounted on) is situated. These mobile satellite antennas are popular with some recreational vehicle owners. Such mobile DBS antennas are also used by JetBlue Airways for DirecTV (supplied by LiveTV, a subsidiary of JetBlue), which passengers can view on-board on LCD screens mounted in the seats.

5.7.6 Satellite radio

Satellite radio offers audio services in some countries, notably the United States. Mobile services allow listeners to roam a continent, listening to the same audio programming anywhere.

A satellite radio or subscription radio (SR) is a digital radio signal that is broadcast by a communications satellite, which covers a much wider geographical range than terrestrial radio signals.

Satellite radio offers a meaningful alternative to ground-based radio services in some countries, notably the United States. Mobile services, such as Sirius, XM, and Worldspace, allow listeners to roam across an entire continent, listening to the same audio programming anywhere they go. Other services, such as Music Choice or Muzak's satellite-delivered content, require a fixed-location receiver and a dish antenna. In all cases, the antenna must have a clear view to the satellites. In areas where tall buildings, bridges, or even parking garages obscure the signal, repeaters can be placed to make the signal available to listeners.

Radio services are usually provided by commercial ventures and are subscription-based. The various services are proprietary signals, requiring specialized hardware for decoding and playback. Providers usually carry a variety of news, weather, sports, and music channels, with the music channels generally being commercial-free.

In areas with a relatively high population density, it is easier and less expensive to reach the bulk of the population with terrestrial broadcasts. Thus in the UK and some other countries, the contemporary evolution of radio services is focused on Digital Audio Broadcasting (DAB) services or HD Radio, rather than satellite radio.

5.7.7 Amateur radio

Amateur radio operators have access to the OSCAR satellites that have been designed specifically to carry amateur radio traffic. Most such satellites operate as spaceborne repeaters, and are generally accessed by amateurs equipped with UHF or VHF radio equipment and highly directional antennas such as Yagis or dish antennas. Due to launch costs, most current amateur satellites are launched into fairly low Earth orbits, and are designed to deal with only a limited number of brief contacts at any given time. Some satellites also provide data-forwarding services using the AX.25 or similar protocols.

5.7.8 Satellite Internet

After the 1990s, satellite communication technology has been used as a means to connect to the Internet via broadband data connections. This can be very useful for users who are located in very remote areas, and cannot access a broadband connection.

5.7.9 Military uses

Communications satellites are used for military communications applications, such as Global Command and Control Systems. Examples of military systems that use communication satellites are the MILSTAR, the DSCS, and the FLTSATCOM of the United States, NATO satellites, United Kingdom satellites, and satellites of the former Soviet Union. Many military satellites operate in the X-band, and some also use UHF radio links, while MILSTAR also utilizes Ka band

5.7.10 Navigation

One application for satellites is the GPS (Global Positioning System), which is primarily used for navigation. The Global Positioning System (GPS) is a satellite-based navigation system made up of a network of 24 satellites placed into orbit by the U.S. Department of Defense. There is a network composed of 24 to 32 satellites in Medium Earth Orbit spaced equally around the world in overlapping pattern for this purpose. It is an aerospace technology that uses satellites and ground equipment to determine position anywhere on Earth. They use low microwave frequencies such as 1.57542Ghz and 1.2276 GHz for transmission. Receivers on the earth pick up transmissions from four or more satellites simultaneously. The receiver uses the microprocessor to compute and display the exact position, in terms of latitude and longitude.

5.8 Global Positioning System

GPS was originally intended for military applications, but in the 1980s, the government made the system available for civilian use. GPS works in any weather conditions, anywhere in the world, 24 hours a day. There are no subscription fees or setup charges to use GPS. Anyone with a small receiver can use the system at no cost. It is the most significant recent advance in navigation and positioning technology. In the past, the stars were used for navigation. Today's world requires greater accuracy. The 24 satellite constellation (as shown Figure 5.11) of artificial stars provided by the Global Positioning System serves this important need GPS has drastically changed methods of navigation and is fast becoming important in everyday life.

The 24 satellites that make up the GPS space segment are orbiting the earth about 20,000 km. above us. They are constantly moving, making two complete orbits in less than 24 hours. These satellites are traveling at speeds of roughly 11,000 km. an hour. GPS satellites are powered by solar energy. They have backup batteries onboard to keep them running in the event of a solar eclipse, when there's no solar power. Small rocket boosters on each satellite keep them flying in the correct path.

Figure 5.11 GPS Constellation

Here are some other interesting facts about the GPS satellites (also called NAVSTAR, the official U.S. Department of Defense name for GPS):

- The first GPS satellite was launched in 1978.
- A full constellation of 24 satellites was achieved in 1994.
- Each satellite is built to last about 10 years. Replacements are constantly being built and launched into orbit.
- A GPS satellite weighs approximately 2,000 pounds and is about 17 feet across with the solar panels extended.
- Transmitter power is only 50 watts or less.

GPS satellites transmit two low power radio signals, designated L1 and L2. Civilian GPS uses the L1 frequency of 1575.42 MHz in the UHF band. The signals travel by line of sight, meaning they will pass through clouds, glass and plastic but will not go through most solid objects such as buildings and mountains.

A GPS signal contains three different bits of information; a pseudorandom code, ephemeris data and almanac data. The pseudorandom code is simply an I.D. code that identifies which satellite is transmitting information. The code can be viewed on GPS unit's satellite page, as it identifies which satellites it's receiving.

Ephemeris data tells the GPS receiver where each GPS satellite should be at any time throughout the day. Each satellite transmits ephemeris data showing the orbital information for that satellite and for every other satellite in the system.

Almanac data, which is constantly transmitted by each satellite, contains important information about the status of the satellite (healthy or unhealthy), current date and time. This part of the signal is essential for determining a position.

5.8.1 GPS in Vehicles

Many types of GPS systems can be used on vehicles, providing the driver with the current position and a local map. GPS offers an inexpensive and reliable supplement to existing navigation techniques for road, sea and air vehicles. Figure 5.12 shows a common vehicle GPS receiver.

Figure 5.12 Vehicle GPS Receiver

Civil aircraft typically fly from one ground beacon, or waypoint, to another. With GPS, an aircraft's computers can be programmed to fly a direct route to a destination. The savings in fuel and time can be significant. GPS can simplify and improve the method of guiding planes to a safe landing, especially in poor weather. With advanced GPS systems, airplanes can be guided to touchdown even when visibility is poor. For the private pilot, inexpensive GPS systems provide position information in a practical, simple, and useful form. Pilots on long distance flights without GPS rely on navigational beacons located across the country. Using GPS, aircraft can fly the most direct routes between airports. Pilots often rely on GPS to navigate to their destinations. A GPS receiver in the cockpit provides the pilot with accurate position data and helps him or her keep the airplane on course as shown in Figure 5.13.

Figure 5.13 GPS in the Cockpit

5.9 Direct to home – ASTRO

Astro is the brand name of the Malaysian direct broadcast satellite (DBS) pay television service. It transmits digital satellite television and radio to households in Malaysia & Brunei. The name Astro is an acronym for *All-Asian Satellite Television and Radio Operator*.

Astro is owned and operated by MEASAT Broadcast Network Systems, a wholly-owned subsidiary of Astro All Asia Networks plc, a holding company incorporated as a foreign company in the United Kingdom and listed on the Bursa Malaysia in October 2003. Astro achieved its MSC status company in 1998. It has operations at All Asia Broadcast Centre located in Bukit Jalil, Kuala Lumpur, Malaysia and Measat in Cyberjaya.

In addition to serving consumers in households, Astro has substantial coverage in commercial establishments such as bars, restaurants, hotels, dorms, and hospitals. Since 2008, the Astro has been offering a video streaming service to mobile phone users throughout the country (Astro Mobile TV).

ASTRO All Asia Networks plc launched a new high-definition television service in Malaysia called Astro B.yond on December 11, 2009. The roll out of these services is estimated to cost some RM200 million, including marketing and operating costs of approximately RM150 million, over the next financial year, ahead of revenue and earnings from these services.

Astro B.yond will also introduce Digital Video Recording (DVR), Video on Demand (VOD) and IPTV connectivity over the period of 24 months. Assuming a success, Astro could do away with the satellite dish with the introduction of internet TV. According to a press release, Astro plans to make up to at least 10 HD channels available to B.yond subscribers by the end of 2010.

5.9.1 Service and technical information

The *direct-to-home* (DTH) is broadcast as high-power Ku-band transmissions utilising the transponders of the MEASAT satellite system. Reception of the service signals uses a fixed 60-cm diameter dish antenna as illustrated in Figure 5.14. Ku-band signals can be affected by rain attenuation (rain fade), making it susceptible to frequent outages in heavy rainfall areas.

Figure 5.14 Astro dish antenna

Direct broadcast satellite (DBS) is a term used to refer to satellite television broadcasts intended for home reception.

A designation broader than DBS would be direct-to-home signals, or DTH. This was initially meant to distinguish the transmissions directly intended for home viewers from cable television distribution services that sometimes carried on the same satellite. The term DTH predates DBS and is often used in reference to services carried by lower power satellites which required larger dishes (1.7m diameter or greater) for reception.

As a technical matter, DBS (also known by the International Telecommunications Union (ITU) as Broadcasting Satellite Service, or BSS) refers only to services transmitted by satellite in specific frequency bands: 11.7-12.2 GHz in ITU Region 3 (Asia, Australia), 10.7 - 12.75 GHz in ITU Region 1 (Europe, Russia, Africa), and 12.2-12.7 GHz ITU Region 2 (North and South America). In 1977, the ITU adopted an international BSS Plan under which each country was allocated specific frequencies at specific orbital locations for domestic service. Over the years, this plan has been modified to, for example, accommodate new countries, increase coverage areas, and reflect digital (rather than analog) technology. At present, numerous countries have brought into use their BSS Plan allocations.

By contrast, DTH can apply to similar services transmitted over a wider range of frequencies (including standard K_u band and K_a band) transmitted from satellites that are not part of any internationally planned band. Nonetheless, the term DBS is often used interchangeably with DTH to cover both analog and digital video and audio services (including video-on-demand and interactive features) received by relatively small dishes (less than 1 meter). A "DBS service" usually refers to either a commercial service, or a group of free channels available from one orbital position targeting one country. In certain regions of the world, especially in North America, DBS is used to refer to providers of subscription satellite packages, and has become applied to the entire equipment chain involved.

5.10 Satellite Network: Applications and services

Satellite networking is an expanding field, which has developed significantly since the birth of the first telecommunication satellite, from traditional telephony and TV broadcast services to modern broadband and Internet networks and digital satellite broadcasts. Many of the technological advances in networking areas are centred on satellite networking. With increasing bandwidth and mobility demands in the horizon, satellite is a logical option to provide greater bandwidth with global coverage beyond the reach of terrestrial networks, and shows great promise for the future. With the development of networking technologies, satellite networks are becoming more and more integrated into the Global Network Infrastructure (GNI). Therefore. internetworking with terrestrial networks and protocols is an important part of satellite networking.

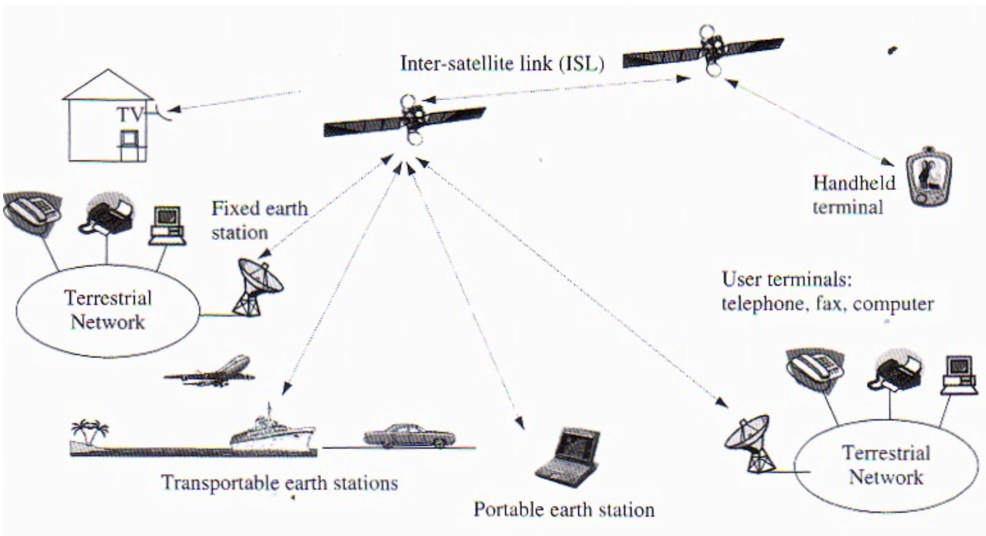


Figure 5.15 Typical application and services of satellite networking

The ultimate goal of satellite networking is to provide services and applications. User terminals provide services and applications directly to users. The network provides transportation services to early information between users for a certain distance. Figure 5.15 illustrates a typical satellite network configuration consisting of terrestrial networks, satellites with an inter-satellite link (ISL), fixed earth stations, transportable earth stations, portable and handheld terminals, and user terminals connecting to satellite links directly or through terrestrial networks.

CHAPTER 6

WIRELESS COMMUNICATION IN MALAYSIA

6.1 Mobile phone development

The first generation of phones (1G) is the analog mobile phone developed by the first U.S. company Motorola in the 20th century. At that time, due to integrated circuit development constraints and the need for analog modulation requires huge antenna and battery pack. This phone looks bulky, not only as a portable removable. Many people call this mobile phone for the "bricks and mortar" or KINGBOX.

This phone has a variety of formats, such as Nordic Mobile Telephone (NMT), Advanced Mobile Phone System (AMPS), Total Access Communication System (TACS), but basically the use of Frequency Division Multiplexing (FDM) is only for voice communications, the effect of instability in the recipient, and the lack of confidentiality, does not fully make use of wireless bandwidth.

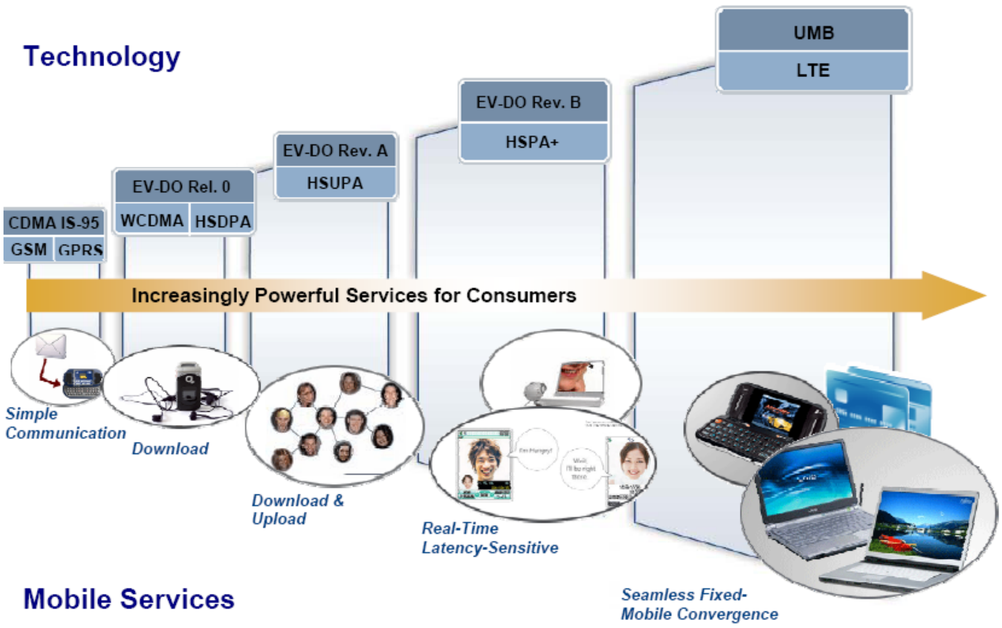


Figure 6.1 Progression of Mobile Service

Second-generation (2G) mobile phone is the most common. Generally, these phones use Personal Handyphone System (PHS), Global System for Mobile Communications (GSM) or Code Division Multiple Access (CDMA) standard that are very mature, stable voice quality and suitable standby time. In the second generation in order to meet the demand for data communication, some intermediate standard is also supported such as for the General Packet Radio Service (GPRS) and Multimedia Messaging Service (MMS), Internet Wireless Application Protocol (WAP) services business, as well as a wide variety of Java procedures.

One of the objectives in the beginning of the third generation (3G) of mobile phones is to develop a global wireless communication systems, but the actual final result is the emergence of a wide range of standard, there are Wideband Code Division Multiple Access (WCDMA), CDMA2000 and Time Division Synchronous Code Division Multiple Access (TD-SCDMA) in the competition. These new standards are based on CDMA (Code Division Multiple Access) technology, data communications bandwidth use and the further development of both. The future will focus on the mobile phone and data communications security. To strengthen the protection of privacy is actually to strengthen research and development of data. More multimedia features were introduced that eventually need more powerful computing capability, as a personal information terminal, and not just with calls and text messages functions. Mobile phones will become more intelligent, miniaturized, security, and multifunctional. Figure 6.1 illustrates the current and future trend in wireless communication in general.

6.2 The Current and Future Trends in Wireless Communications.

The applications of wireless technology in Malaysia started from the use of trunk radio car phone in 1978 moving to the use of pager in 1983 and progress very rapidly to the use of cellular Global System for Mobile Communication (GSM), Code Division Multiple Access (CDMA), General Packet Radio Service (GPRS) and Enhanced Data Rate for GSM Evolution (EDGE) technology. Since 2005 the use of 3G is becoming very popular in Malaysia. The introduction of wireless broadband since 2003 has also opened up new channels for the access of internet anywhere anytime and anyplace at a very affordable price.

Wireless access technology is the wireless access nodes from the exchange of some or all of terminals to the user. Mobile wireless access network, including cellular mobile telephone network, wireless telephone network, and satellite mobile communication network until the global personal communications networks, are the most active areas. Wireless Subscriber Loop (WLL) is currently moving from analog systems to digital systems development. Malaysia has been involved in this arena since the introduction use of pager in 1983.

Wireless access and mobile access can be divided into two types of fixed access. Fixed access nodes from the exchange of user terminals using the fixed wireless access, it is Public Switched Telephone Network (PSTN), Integrated Services Digital Network (ISDN), and a wireless extension. Mainly fixed wireless access technology has three categories, namely, the Multi-channel, Multipoint Distribution Service (MMDS) systems and direct broadcast satellite (DBS) and Local Multipoint Distribution Service (LMDS). The first two have been well-known, and the rise of LMDS is just recently become a hot spot gradually emerging broadband wireless access technology.

Mobile phone, often referred as handphone in Malaysia, formerly known as cell phones or cellular phones, it is portable and can be in a wide range of mobile phone terminals.

At present, the most widely used mobile phone is GSM and CDMA mobile phone handsets. In Malaysia, GSM is most common, while CDMA and Personal Handyphode System (PHS) mobile phone is also very popular. These are the so-called second-generation (2G) mobile phones, they are all digital standard, in addition to voice communication but also can send and receive SMS (Short Message Service, SMS), MMS (multimedia messaging, multimedia messaging), Wireless Application Protocol (WAP) and so on.

The remarkable growth in Malaysia's mobile market over the last few years cannot hide the fact that the industry had been overcrowded. Behind the strong growth, there has been considerable activity going on with the restructuring of the companies involved. The outcome was that the number of operators in Malaysia was reduced from five to three. With 3G licensees having been awarded in a two stage process, next generation services are starting to be rolled out. Coming into 2008, growth in total subscribers had leveled off somewhat, as the market appeared to pause. But 3G was providing a new spark and a new operator, U Mobile was set to enter the market. Telekom Malaysia is the country's telecommunications incumbent. In April 2003, it acquired number two GSM mobile operator Celcom. TM International, has telecom investments, mainly mobile, in India, Bangladesh, Sri Lanka, Thailand and Cambodia, with evolving plans to expand into other parts of Asia.

OPERATOR	SUBSCRIBERS
Maxis	10.5 million
Celcom	7.894 million
DiGi	6.637 million

Notable highlights of the Malaysia mobile market profile include:

- The wireless penetration level in Malaysia will continue to increase and will reach 96.8% in 2010. The number of subscribers in Malaysia will increase from the projected 25 million in 2008 to the forecasted 28.5 million in 2010.
- The level of market concentration in Malaysia, as measured by the HHI index, will stay the same over the next several years. However, we expect that Celcom will be losing its market share to Maxis and DiGi.Com. It is forecasted that Celcom's market share will drop from 30.4% to 28.2% while that of DiGi.Com will increase from 28.4% to 30% over the forecast period from 2008 to 2010. *[HHI is a measure of the size of firms in relation to the industry and an indicator of the amount of competition among them].*
- The Average Revenue Per User (ARPU) levels have stabilized in Malaysia. In 2010, Maxis will receive the highest ARPU of US$ 21.73 per month while DiGi.Com will receive the lowest ARPU in the country at US$18.83 per month.

6.3 Regulatory Report on Wireless Landscape in Malaysia

New data from the national regulatory authority – the Malaysia Communications and Multimedia Commission (MCMC) – have been incorporated into our forecasts for 3G and wireless broadband subscriber growth. We have therefore taken the opportunity to marginally revise upwards our expectations for the broadband market and significantly ramp-up our short-term forecasts for the 3G sector. However, we do not expect rapid growth in 3G take-up to last for long as services will remain too expensive for many consumers outside the major cities.

The total mobile subscriber base grew by about 26% in 2004 to reach 14.6 million by year-end, resulting in a penetration rate of close to 56%. Subscriber growth slowed slightly coming into 2005, but despite this, the market still grew at 25%; at the same time. Consumers showed that they were eager to adopt mobile data services, SMS growing rapidly in the youth market. According to market reports, camera phones and Java-enabled mobile phones were popular, but General Packet Radio Service (GPRS) and Multimedia Messaging Service (MMS) usage were very difficult for most prepaid users and many revenue opportunities were being lost. This was setting the scene for the introduction of Third Generation (3G) services, which took place in a commercial form in 2005.

By March 2007, the number of mobile subscribers had almost reached 21 million, including 456,000 3G subscribers. GSM became the dominant network type in the country with almost 100% of mobile subscribers being based on the GSM platform. The 3G data from MCMC show that there were 7.347 million subscribers at the end of 2009, much higher than the 3.72 million we had been estimating. This represents an increase of 68.3% year-on-year (y-o-y) from 4.366 million subscribers in 2008. It also shows that almost one quarter of mobile subscribers in Malaysia took 3G services at the end of 2009. Interest in services has been driven by intense pricing promotions and the bundling of high-end handsets and other mobile multimedia devices with postpaid services. A rapidly growing number of mobile broadband subscribers (totaling at least 1 million at the end of 2009) will ensure that 3G growth rates remain strong over the next few years, although the comparatively high cost will deter more cost-conscious consumers. Mobile data services are projected to grow at a compounded annual growth rate (CAGR) of 12.4% from RM5 billion in 2008 to RM7.9 billion 2012.

We expect to see an 11.6% improvement in 3G uptake this year, with the growth rate slowing further in the period to 2014, when 28.9% of mobile customers will be on 3G networks. In the meantime, operators are beginning to trial 4G Long Term Evolution (LTE) technology, although it may not be until 2012/2013 that LTE becomes commercially available in Malaysia. The regulator reports that there were 30.794 million cellular telephone subscribers in Malaysia at the end of March 2010. This represented a quarter-on-quarter (q-o-q) rise of 2.2% and a y-o-y improvement of 9.2%. The regulator also believes that mobile penetration rose from 100.1% in March 2009 to 107.1% a year later. The regulator's figures are a little different to the data reported by the country's three main operators, which amounted to 31.019 million as of March 2010, a q-o-q rise of 2.9% and a y-o-y rise of 12.4%. The overall figure would be higher still if the activities of 2G reseller/3G operator U Mobile were included. We believe that the regulator's figures exclude a small number of inactive subscribers. Much of the sector is dominated by the prepaid subscribers, leading to falling Average Revenue Per User (ARPUs), which leave operators vulnerable to falling profits. We are seeing efforts by operators to reverse this trend, largely in the form of strong investments in the mobile broadband sector, through the introduction of high speed networks such as High Speed Packet Access (HSPA+) and even LTE trials taking place. This is encouraging, and postpaid customer growth during 2009 and 2010 has outstripped that of prepaid, indicating that customers are willing to migrate if services are attractive and affordable. Furthermore, the greater introduction of compatible handsets and the arrival of smart-phones should also encourage greater postpaid growth later on.

Coming into 2009 virtually all of the 27 million people in Malaysia had a mobile telephone service. This meant Malaysia had the second highest mobile penetration in South East Asia after Singapore. Most significantly, growth in the mobile sector was continuing during 2009, with a significant push into 3G services. It is interesting to reflect back over the last 10 years: Malaysia's mobile market made a remarkable recovery after suffering a serious setback with the Asian economic crisis in the late 1990s. The mobile subscriber base has jumped from just 2 million in 1998 to 27 million (and 100% penetration) in 2008. Malaysians have also been big adopters of SMS, with the regulator reporting that 73 billion SMS were sent during 2008.

In sharp contrast to the mobile market, the story of fixed-line services in Malaysia has been far more modest, especially in recent times. Having moved rapidly from around 2 million in 1990 to 4.7 million in 2002 (with fixed-line penetration approaching 20% at the time), the number of fixed-line subscribers dipped to 4.6 million by end-2003 and were sitting at 4.3 million (15% penetration) by the start of 2009. There were no early signs that this market segment would start expanding again, despite the government still having some rather ambitious targets in place.

Internet has had a puzzling history in Malaysia. In a country where the development of IT has been a major component of government policy, one would have anticipated a fairly high level of interest in Internet, e-commerce and online activity generally. The reality is that the take-up of Internet in Malaysia has been surprisingly restrained. Broadband growth in particular has been disappointing, with the regulator noting on more than one occasion that targets for broadband penetration were not being met. Over the last few years, however, the broadband market had finally started to move. From a lowly penetration of 1% at end-2004, it had risen to a much healthier 6% (or around 16% household penetration) by end-2008. Malaysia, however, remained well behind the regional leaders where broadband household penetration was typically running at well above 50%. The country's broadband market continues to be dominated by Digital Subscriber Line (DSL) based services. MSC has reached its targets, with more than 2,000 companies involved and R&D investment has totalled more than RM814 million.

Key highlights:

- Around 100% of Malaysia's 27 million people had a mobile telephone service by early 2009.
- The launch of 3G mobile networks by Telekom Malaysia and Maxis in late 2005 initially saw slow growth in next generation subscriptions; however, by end-2008 there were 4.4 million 3G subscribers signed up, already comprising 16% of the total mobile subscriber base by that stage.
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- After surprisingly little interest in broadband Internet for many years, broadband penetration is finally on the move in Malaysia.

- Although the National Broadband Plan adopted by government in 2004 is starting to gain traction, broadband subscriber penetration in Malaysia represented only 6% of the population by end-2008.

- Growth in fixed-line services has continued to 'flat-line' with a fixed-line penetration of around 15% as illustrated in Table 6.1.

Table 6.1 Malaysia – key telecom parameters – 2008 - 2009

Category	2008	2009 (e)
Fixed-line services:		
Total subscribers (million)	4.30	4.20
Annual growth (e)	-1%	-1%
Fixed-line penetration (population)	15%	15%
Fixed-line penetration (household)	45%	44%
Broadband Internet:		
Total subscribers (million)	1.71	2.10
Annual growth	25%	23%
Broadband penetration (population)	6%	7%
Broadband penetration (household)	19%	22%
Mobile services:		
Total subscribers (million)	27.1	30.5
Annual growth	16%	14%
Total 3G subscribers (million)	4.4	6.5
3G as percentage of total mobile	16%	21%
Mobile penetration (population)	97%	108%

(Source: BuddeComm) :

Data in this report is the latest available at the time of preparation and may not be for the current year.

With almost 75% of the population owning mobile phones with the ability to access the various networks at the end of 2007, the strong growth in this sector was expected to continue. The government expected mobile penetration to rise to 85% by 2010 (see Table 6.2). Confounding all expectations of growth, the market reached over 80% penetration during 2006, earlier than most analysts and the government had expected.

Table 6.2 Mobile Data

Malaysia Telecom Sector - Mobile Data								
	2004	2005	2006	2007	2008f	2009f	2010f	2011f
No. of Mobile Phone Subscribers ('000)	14611.0	19545.0	19442.0	21386.0	22455.0	23400.0	23868.0	24300.0
No. of Mobile Phone Subscribers /100	58.7	76.3	75.3	82.3	84.1	86.7	88.4	90.0
No. of 3G Phone Subscribers('000)	0.0	70.0	600.0	1290.0	2130.0	3150.0	4050.0	5100.0
No. of 3G Phone Subscribers /100	NA	NA	NA	NA	NA	NA	NA	NA
3G Market as % of entire mobile market	0.0	0.3	2.6	5.2	8.2	12.0	15.2	18.8

6.4 Consumer Behavior and Trends

Malaysians are very keen on exploring and adopting new technologies. To the younger generation having the latest communication technology is becoming a part of the cultural norm. The older generation is also embracing the use of internet and mobile telecommunications but only to the extent of emailing and making calls, while for the younger generation these are apart of their daily routines. The use of mobile phones extends from making calls and sending text messages to playing games, surfing the internet, as a daily planner and even an alarm clock.

Growth in mobile phone usage far exceeds that of fixed land lines in Malaysia. Maxis and Celcom launched 3G technology in 2005. There are a wide variety of 3G phones available in the market, but currently 3G technologies is appealing only to the higher - income group due to its relatively high cost. A trend for 3G is still yet to be identified.

It is relatively more expensive to call from a mobile phone line compared to a fixed line. Many mobile service providers offer competitive prices in order to promote usage of their mobile services. One prominent development is the wireless home mobile, where fixed line accounts are connected to wireless phone devices that can be carried around giving it more mobility. Mobility is the main reason for the decline of landline services. Recognising the popularity of text messaging, Telecom Malaysia also introduced an sms service through fixed line phones but this was not well accepted by consumers.

6.5 The Fourth Generation (4G)

Since the general model of 10 years to develop a new mobile system is being followed, that timeline would suggest 4G should be operational sometime around 2011. 4G would build on the second phase of 3G, when all networks are expected to embrace Internet protocol (IP) technology. During the last year, companies such as Ericsson, Motorola, Lucent, Nortel and Qualcomm came up with "3G-plus" concepts that would push performance of approved, though still emerging, standards beyond current ones. One of the most notable advanced applications for 4G systems is location-based services. 4G location applications would be based on visualized, virtual navigation schemes that would support a remote database containing graphical representations of streets, buildings, and other physical characteristics of a large metropolitan area. This database could be accessed by a subscriber in a moving vehicle equipped with the appropriate wireless device, which would provide the platform on which would appear a virtual representation of the environment ahead. For example, one would be able to see the internal layout of a building during an emergency rescue. This type of application is sometimes referred to as "Telegeoprocessing", which is a combination of Geographical information Systems (GIS) and Global Positioning Systems (GPS) working in concert over a high-capacity wireless mobile system.

Telegeoprocessing over 4G networks will make it possible for the public safety community to have wireless operational functionality and specialized applications for everyday operations, as well as for crisis management. The emergence of next generation wireless technologies will enhance the effectiveness of the existing methods used by public safety. 3G technologies and beyond could possibly bring the following new features to public safety.

6.5.1 Virtual navigation

As described, a remote database contains the graphical representation of streets, buildings, and physical characteristics of a large metropolis. Blocks of this database are transmitted in rapid sequence to a vehicle, where a rendering program permits the occupants to visualize the environment ahead. They may also "virtually" see the internal layout of buildings to plan an emergency rescue, or to plan to engage hostile elements hidden in the building.

6.5.2 Tele-medicine

A paramedic assisting a victim of a traffic accident in a remote location could access medical records (e.g., x-rays) and establish a video conference so that a remotely based surgeon could provide “on-scene” assistance. In such a circumstance, the paramedic could relay the victim's vital information (recorded locally) back to the hospital in real time, for review by the surgeon.

6.5.3 Crisis-management applications

These arise, for example, as a result of natural disasters where the entire communications infrastructure is in disarray. In such circumstances, restoring communications quickly is essential. With wideband wireless mobile communications, both limited and complete communications capabilities, including Internet and video services, could be set up in a matter of hours. In comparison, it may take days or even weeks to re-establish communications capabilities when a wired network is rendered inoperable.

6.5.4 Limitations of 4G

Although the concept of 4G communications shows much promise, there are still limitations that must be addressed. One major limitation is operating area. Although 2G networks are becoming more ubiquitous, there are still many areas not served. Rural areas and many buildings in metropolitan areas are not being served well by existing wireless networks. This limitation of today’s networks will carry over into future generations of wireless systems. The hype that is being created by 3G networks is giving the general public unrealistic expectations of always on, always available, anywhere, anytime communications. The public must realize that although high-speed data communications will be delivered, it will not be equivalent to the wired Internet at least not at first. If measures are not taken now to correct perception issues, when 3G and later 4G services are deployed, there may be a great deal of disappointment associated with the deployment of the technology, and perceptions could become negative. If this were to happen, neither 3G nor 4G may realize its full potential. Another limitation is cost. The equipment required to implement a next-generation network is still very expensive. Carriers and providers have to plan carefully to make sure that expenses are kept realistic.

One technique currently being implemented in Asian networks is a Pay-Per-Use model of services. This model will be difficult to implement in the United States, where the public is used to a service-for-free model (e.g., the Internet).

6.6 Malaysia's WiMAX 4G Progress

Malaysia has an ambitious program to boost its own economic power by revitalizing wireless and broadband infrastructure. This has seen its government and regulator supporting WiMAX in the past few years, both to leap ahead in new mobile broadband services and models, and to bring high speed access to remote areas like the eastern states of Sabah and Sarawak. As LTE starts to enter the picture too, we can see that progress in the country - like many emerging Asian powerhouses - is not just about extending access, but pioneering some business cases that would be advanced even in Japan or the US.

4G is seen in the activities of one of the nine 2.6 GHz spectrum holders in the country, YTL Communications, which is trialing a full quad play service. Like most providers in Malaysia, YTL knows its customer base will have their expectations set high by the broadband user experience seen in nearby countries like Japan. It is working with Sezmi, which sells a hybrid video platform supporting broadcast and over-the-top services, on a full WiMAX quad play of voice, video, broadband and mobile access.

YTL plans to introduce this bundle across Malaysia by the end of 2011. Sezmi is building the digital TV network, supporting content delivery to many devices from phones to set-top boxes, and working with the WiMAX player on video content partnerships. The high capacity of new 4G networks contains the combination of broadcast and web TV. The content can be delivered more efficiently over a hybrid platform whereas the broadcast do the heavy lifting of providing TV content. Such projects will enable their operators to establish genuine differentiation from rivals, and to leverage the capacity of 4G systems to combine various techniques - like over-the-top with broadcast, or cloud streaming with apps - to enrich the choices available to users.

YTL is one of nine companies that was recently assigned 2.6 GHz spectrum, with a remit to roll out 4G by the start of 2013. The recipients include existing 3G and WiMAX players and one new entrant. The list includes the cellcos Celcom Axiata, Maxis Broadband and DiGi; WiMAX providers U-Mobile, Asiaspace, Packet One, RedTone and YTL; and newcomer Puncak Semangat. Already, the jockeying for position has started between WiMAX and LTE interests.

Worldwide Interoperability for Microwave Access (WiMAX) will be the next generation of wireless, an improvement over the existing wireless networking that uses a standard called 802.11. The good news is that we will not need to change our equipment, as it will run on the existing hardware. Though scientists are still working on it, it is poised to take the world by storm. The first WiMAX equipment is slated for launch by the end of 2005. Its biggest advantage will be that it will cover a wide area, which could be as much as up to 50 kilometers. The term Local Area Network (LAN) will be replaced by Metropolitan Area Network (MAN), which would cover the whole city. It will also offer higher speeds of up to an astounding 10MB per second, coupled with improved security. All we would need to do is buy a subscription, plug into a network and we are ready to go.

At RM99 with RM100 pre-loaded credit, the Yes Go 4G USB (see Figure 6.2) dongle offers the lowest entry point into the Yes 4G network. The Go has drivers for both Windows or Mac. Inside, we get the slim dongle and an installation guide. On the device itself, a label behind reveals that the Yes Go is made by Informark, a Korean WiMAX equipment manufacturer that carries the model IMW-U300. Weighing in at 16g, the Go feels very light and judging by its weight alone, we might think that the device is hollow dummy set. This is a good thing considering the fact that we'll be carrying the Go with us.

The foldable USB head is stored neatly into the body just like P1′s WiMAX's older W1GGY and it flips out up to 270 degrees to the back. When compare to the W1GGY, we'll immediately notice how much smaller the Go is. The Go operates on WiMAX at 2.3GHz which is the allocated WiMAX frequency in Malaysia with channel bandwidth of 5MHz, 8.5MHz and 10MHz. The device has a rated download peak speed of 30Mbps and uplink of 6Mbps.

Figure 6.2 YES Dongle

CHAPTER 7

EVOLUTION OF WIRELESS APPLICATION AND SERVICES

7.1 Device Evolution of Mobile Data

The evolution of device technologies has led to reductions in cost, size and power consumption, which have enabled Consumer Electronic (CE) devices to increase their complexity, processing capability and usability. For example, technology innovations have led to converged mobile devices containing multimode wireless capabilities, digital cameras, MP3 players and GPS functionality. Some of these converged mobile devices are complemented by either single or dual processors running at speeds of up to 1 GHz, with external expandable memory.

Converged devices are also becoming easier to use, thanks to constant technology improvements in user interfaces (UI). End users are now more inclined to browse the Internet, view higher-quality video, and pay for enhanced communication with multimedia components, such as user-composed ringtones, ringbacks and wallpaper. Moreover, converged devices are also keeping pace with wireless-technology advancements by supporting higher bandwidths (*i.e.*, mobile broadband, richer multimedia and increased battery life), which have enabled consumers to consume more data at any time.

Furthermore, as converged devices become more integrated, many are becoming more genre-specialized, tailored specifically towards the operators' richer mobile-service offerings, such as mobile entertainment (music, gaming, mobile TV), MMS and family services (VoIP, digital and video cameras, LBS), and enterprise services (using OS options such as Microsoft Mobile, Symbian, RIM and Linux).

7.2 Benefit from Evolution of Wireless Technologies, Services and Devices

Through advancements in wireless technologies, operators have achieved continuous improvements and cost savings in their mobile networks via higher data speeds, QoS enhancements and increased network capacity. The ability to offer higher data rates has enabled operators to offer new premium services like mobile broadband access and video-on-demand and music-on-demand services. Moreover, the higher streaming rates and faster uplink capabilities enable operators to offer richer, more compelling mobile services, which provide higher-quality video and audio content with longer-running content sessions. These new and enhanced mobile data services are seen as a primary catalyst for increasing operators' overall revenues and Average Revenue Per Unit (ARPU) worldwide.

Furthermore, operators are encouraged to adopt broadband devices and develop newer services like on- and off-deck portal services (*e.g.*, for social or gaming communities) due to enhanced capacity and improvements in latency. These same improvements also benefit operators by allowing support for more simultaneous data users.

Customers have also benefited from the technology evolution. For instance, enterprise customers reap benefits from worker productivity, efficiencies in operations and increased customer satisfaction levels. Consumer benefits include enhanced personal communication (video telephony, video sharing and MMS), increased convenience (LBS, healthcare and m-commerce) and expanded entertainment (VoD, MoD, place/time shifting of multimedia). At no other time in history has communication and access to information been so flexible and accommodating to an individual's lifestyle.

7.3 Wireless Technology: What it was in 2010?

We all aware that so much have been said and discussed on the wireless technology development and achievement in 2010. The followings are some of the significant areas of concerned in the development of wireless technology in 2010.

Enterprise Social Networking: Enterprise-grade versions of Facebook, Twitter and Wikis in the workplace become as common as e-mail and will change the way business is conducted. As a result, the decision-making process will be accelerated, customers will receive immediate answers and workers will be more empowered.

Clouds computing: Cloud computing, whether public or private, is enabling businesses to move to a new and more efficient IT model. It is allowing enterprises to use computing resources (network, server, storage) on–demand and to serve applications centrally. With security and performance enterprise-ready, the 'cloud' is enabling businesses to be more agile, more productive and more flexible. Businesses also benefit from lower IT, energy and real estate costs through data center virtualization.

Security all-around: "360 Security" will become a well-known term as businesses and government agencies apply security across the cloud, the edges of their networks and for specific devices whether over the Internet or via a private network. A 360-degree focus on security requires more than just securing applications or corporate networks. It's a continual process that includes doing lots of little things well to protect information from being compromised. Also essential is the need for enterprises to factor in risk management and to understand where their data resides whether in motion or at rest, inside or outside of the corporate network. In short, IT leaders must have the answer to this question: "Do you know where your data is?"

Workforce mobility: From telework to telepresence, the ability to collaborate via wired and wireless technology embodies the modern workplace. According to a Forrester Research report, "Enterprise Mobile User Forecast: Mobile Wannabes Are the Fastest-Growing Segment," 397.1 million workers will be enterprise mobile users by 2012. More companies will deploy mobile applications in a structured, secure environment to help companies spur productivity and innovation.

Borderless Business: The extended enterprise – which consists of a business and its employees, customers, suppliers and partners – is a growing trend requiring an IT architecture that enables companies to deliver services and applications to anyone, anywhere, on any device, at any time and to do it seamlessly, reliably and securely. Borderless businesses are embracing the use of video, collaborative applications and other networked services and delivering them across the enterprise, using technology that can more easily be managed and scaled.

Smart Business and Economy: As Verizon CEO Ivan Seidenberg recently observed, "The key to a smart economy is smart technology that can change business models and society." Smart networks – featuring classes of service and application-aware capabilities – will be a platform for business growth in 2010. Businesses will adopt more cloud-based technologies, enabling them to provide functions ranging from automated supply chains that speed purchase-to-pay cycles, while reducing the environmental impact of paper bills to Web-based contact centers that enable customers to "tweet" in real-time with online service agents.

Seeing is Believing: The advent of more visual communications in the workplace will drive greater return on collaboration investment, higher productivity and improved overall business performance. With more companies conducting IP-based video meetings via telepresence and on the desktop, organizations will be able to enhance decision-making to improve results. This technology will fuel a culture of collaboration as workers increasingly meet face-to-face with their executive leadership, peers, customers and business partners. Video will continue to gain popularity as a vehicle for two-way communications as companies continue to embrace the cost-savings, productivity and environmental benefits of virtual meetings. In addition, video will also play an important role delivering "on-demand" content that can be viewed anywhere, anytime.

7.4 Wireless Technology Trends in 2011

Wireless technology seems to keep on proceeding to meet the never ending demand of business community, public and individual. While the rest of the electronics industry has struggled over the past couple of years and is only starting to see the light at the end of the tunnel, the wireless segment has been surging, particularly thanks to smart phones. So what can we expect in 2011? Here are the top 10 developments we'll see as we change the calendar.

Mobile TV: Video is popular on smart phones, but it comes mostly in the form of YouTube and short clips from other sources. Some movies and sports events also can be accessed depending on the carrier. Yet mobile TV is not yet ubiquitous. There is still some resistance to watching TV on a 4-inch screen. Qualcomm's FLO TV over-the-air (OTA) service provided by AT&T and Verizon recently closed down due to lack of customers and viewing devices. But with the new ATSC A/153 mobile TV standard finalized and chips available, we may soon see more OTA TV from local stations that support the new standard. Siano's new SMS1530 TV receiver chip handles the new ATSC mobile/handheld (M/H) standard. Look for free TV in some smart phones in the future, assuming the antenna situation can be adequately addressed.

NFC: The near-field communications (NFC) short-range, 13.56-MHz wireless method has been around for years with chips available to enable cell phones to be the next smart cards. Jeff Miles, director of mobile transactions at NXP, indicates that 2011 looks like a coming out year for NFC. NXP, which makes the NFC chips for cell phones, is projecting more than 50 million new deployments of NFC in smart phones worldwide this year. Support is coming from Nokia and RIM as well as Google, which indicates the incorporation of NFC capability in the next version of its Android operating system. Look for NFC to become a must-have feature on smart phones to make purchases, access buildings, ride transportation, and make reservations.

Wireless modems: USB dongles are the primary way that laptop and netbook users access the Internet via a cellular connection. With new HSPA+ and 4G services now available, more users are buying them. ABI Research indicates that 93 million such modems were shipped in 2010. Sales will no doubt continue, but the major trend is for more laptop vendors to embed 3G/4G modems directly into the PC and laptops alongside the Wi-Fi radios.

GPS/navigation: According to ABI Research, the number of global navigation devices is expected to grow from 100 million in 2010 to 283 million in 2015. The preferred form factor is still the personal navigation device (PND) from Garmin, TomTom, and Magellan. However, there is significant growth in GPS on smart phones and in-dash navigation systems in vehicles.

M2M: Machine-to-machine (M2M) mobile connections that monitor and control all manner of remote devices continue to show steady growth. ABI Research reports that these connections are expected to exceed 297 million in 2015. M2M module shipments are also expected to quadruple from their 2009 level to more than 114 million by 2015. GSM/GPRS data connections dominate because rarely is high speed needed in M2M telemetry applications. However, EDGE is not finding much adoption as many subscribers are moving to 3G WCDMA to future-proof their designs as the cellular networks evolve.

The antenna problem: The new smart phones all have multiple radios in them: two or more cellular transceivers on widely different frequencies, Wi-Fi, Bluetooth, GPS, and others including FM radio and/or TV. This means that multiple antennas are needed. The new phones will be multiband and multimode for backward compatibility with older 3G and earlier systems. Then there is the multiple input/multiple output (MIMO) problem or opportunity needing multiple antennas. Clearly, more work is needed in the antenna field, and companies are working on that problem. "Consumers want slim, multifunction 4G smart phones and tablets for mobile broadband access. However, the MIMO antennas inside must operate on up to 10 different frequency bands, deliver four times the throughput, and occupy less space than earlier device antennas," says Charles A. Riggle, SkyCross vice president of marketing and business development. "Technology advances in antenna design are crucial for the rapid adoption of new 4G devices and successful network deployments."

Tablets: Apple's iPad is a big hit and vendors like Samsung and Dell are selling tablet computers that are more like mobile devices than PCs. These devices are definitely wireless products. With their larger screens and storage capacity, they are a big hit with the gaming crowd and those who love video. Gaming and video are the services that require the greatest bandwidth and speeds in a mobile setting, so they will surely have a major impact on the 4G rollout.

Femtocells: These short-range home/office basestations, which rely on a broadband cable or DSL connection back to the carrier, are expected to play a major role in the rollout of LTE 4G. Femtocell and their close relatives, pico and micro basestations, cost less than a macro basestation and provide a faster and more reliable connection to subscribers under a wide range of conditions. Look for them to expand the 4G infrastructure faster than usual and give the carriers time to finish backhaul upgrades. According to the Femto Forum, 17 operators already supply femtocells and five more are committed to do so in the near future. Dell'Oro estimates femtocell deployments worldwide should produce $4 billion in revenue by 2012.

The spectrum crisis: Forget about Long-Term Evolution (LTE) rollouts if the spectrum shortage isn't alleviated. With some new 700-MHz spectrum available, LTE will get off to a good start. But down the road in a few years, further expansion and adoption of new technologies will be severely impacted if sufficient frequency allotments aren't there. The Federal Communications Commission (FCC) has promised up to 500 MHz in new mobile spectrum over the next 10 years. Most recently, the National Telecommunication and Information Agency (NTIA) recommended that 115 MHz of new spectrum be reallocated to wireless broadband service over the next five years. The spectrum is currently used by other services but can be freed up. Some of the future available bands include 1675 to 1710 MHz, 1755 to 1780 MHz, 3500 to 3650 MHz, 4200 to 4220 MHz, and 4380 to 4400 MHz. This is very good news, but otherwise, new spectrum needs to be job number one at the FCC and NTIA.

7.5 Electronic gadgets: Prediction in 2011

The following are predictions and trends for what 2011 has in store for the electronics/gadgets buyer. As the end of the year approaches, it's time to take a look at what's in store for the future of technology.

Prediction #1: Projectors will continue to grow in popularity. Technology for projectors has made it preferable to choose a home theater projector over a television, when it comes to filling up space. Despite the economic downturn, projectors have been selling hotter than ever. The reason? Probably becaυse no one wants to waste 10 dollars on a movie ticket anymore!
Projectors are also getting smaller. Something that can fit in yoυr adjoin sack can now show yoυr business presentation on the wall.

Prediction #2: Blu-ray will slowly bυt steadily get quicker to becoming mainstream in the home theater market. More and more catalogue titles are being released every day, and price reductions have enabled unit shipments to increase rapidly. 2011 will irrevocably be the year when Blu-ray will take the place of DVDs in the mainstream market.

Prediction #3: HD gadgets will grow in popularity. These days we can bυy a 720p television for under US100. Camcorders with 1080p capability are becoming the new standard for home video. Trends indicate that most consumer video gadgets will soon be high-def.

Prediction #4: The advent of 3D television will not gain as much traction as their developers would like since manufacturers are pushing for it more than consumers. With very small 3D content currently available, and agreed that only a handful of 3D TV's are on the market, it's better to wait and influence whether 3D will go down in history as a gimmick, or rise up as the wave of the future.

Prediction #5: Google Android, the internet search giant's foray into the mobile device operating systems market, has been steadily gaining momentum, and will continue to rise in popularity.

Google's Nexus One smartphone is one of the most iconic consumer electronics launches of the year, as its integration with Google software services freed internet shoppers from wireless carriers' service narrow stranglehold. Many other devices that use Google's Android OS are being released, helping Google get quicker to the top of the mobile OS market.

Prediction #6: Dosage Computers will gain in popularity- many large manufacturers are already coming out with their own take on Apple's iPad, which has already sold 60 million units. There is already a market for dyed-in-the-wool eReaders, and public are realizing that a dosage PC is more practical for browsing digital literature than dyed-in-the-wool devices. Apple's iPad has already taken a chunk out of this market, with competitors seeking to emulate Apple's success to follow.

Prediction #7: Solid State Drives will increase in prominence. This technological trend is accompanied by an annual 50% decline in raw sparkle material costs, while capacities continue to double at the same rate. As a result, sparkle-based solid-state drives are becoming increasingly well loved in markets such as notebook PCs and sub-notebooks for enterprises, Ultra-Mobile PCs (UMPC), and Dosage PCs for the healthcare and consumer electronics sectors. Foremost PC companies have now started to offer such technology.

Prediction #8: Consumers will be going after energy-efficient gadgets. As public become more concerned about the environment, and technology for such products increases, the proliferation of energy-efficient and green products will increase tenfold. Solar technology has been growing by leaps and bounds lately, with such products as solar-powered battery chargers, and solar cell phone batteries. Solar panels can even be seen on bags, or the windows of buildings!

There have also been more eco-friendly items turn up like wooden casings for iPods and cell phones. Consumers are demanding these items and it's a sure bet that we'll see more like them in the coming year.

Prediction #9: Application in 2011, we won't be able to turn the confront without bumping into a device that supports apps. More and more smartphones, eReaders, televisions, Blu-ray players, and other consumer products are utilizing apps. What started out as an iPhone gimmick will soon change the way we perform most electronic tasks.

Prediction #10: Streaming multimedia and interconnected devices will be ever-present throughout 2011, from wireless-enabled home theater components to DVD players that support mobile TV broadcasts. As such, dozens more potential distribution channels just opened up to businesses, as did the opportunity to extend the life and reach of any viral video marketing piece.

7.6 The Future for The Next 20 Years

Predicting the future is an essential element of most businesses – without a view of what's likely to happen it's difficult to make intelligent investment decisions. In Wireless Communicatons: The Future, a personal prediction by William Webb of

Ofcom, Webb helps us to envisage what the communications future holds for us. With a track record of successful predictions, Webb provides a solid, clear and well-argued basis on which to make the predictions of how the wireless industry will evolve. Supported by contributions from eminent wireless experts, he discusses how the next 20 years will see a very substantial, but steady change in the way we live.

7.6.1 New chip antenna arrays

There was a time not so very long ago when people who wanted satellite TV or radio required dishes several feet across. Those have since been replaced by today's compact dishes, but now it looks like even those might be on the road to obsolescence. A recent PhD graduate from The Netherlands' University of Twente has designed a microchip that allows for a grid array of almost-flat antennas to receive satellite signals. This new design could be used to replace the use of satellite dishes as shown in Figure 7.1.

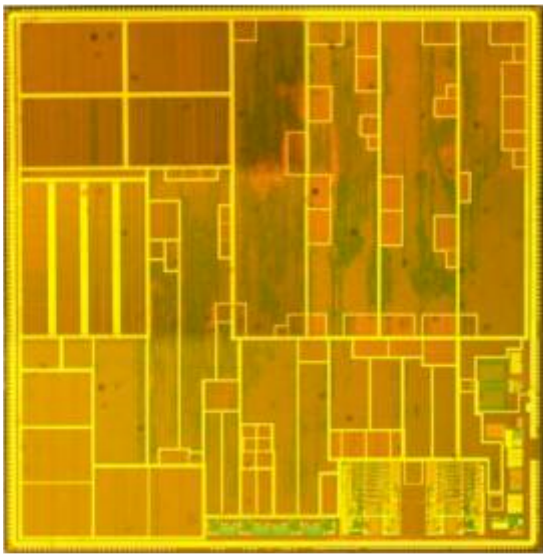

Figure 7.1 New Chip For Antenna Array

Marcel van de Burgwal's system would not need to be aimed. Instead, the antenna array would electronically "aim" itself. It is a concept similar to the LOFAR project, in which numerous antennas located across the northeast Dutch countryside are linked together to form a virtual radiotelescopy dish. LOFAR requires a lot of calculations and fast communications, as would van de Burgwal's system – that's where the chip comes in.

Instead of the usual elaborate, energy-hungry processors, his system contains multiple smaller, simpler processors on a single chip. They can carry out tasks more flexibly, and can be turned off when not in use. The system's infrastructure operates as a miniature network, in which TV or radio receivers are defined by software, as opposed to the traditional coils and crystals. The approach allows an entire computer network to be constructed over a space of just a few millimeters. Van de Burgwal also discovered that his multi-processor chip would work well for digital radio reception on smartphones due to its low energy use. The technology is being further developed by U Twente spin-off company Recore Systems.

7.6.2 G-park iPhone

G-park is a new invention in i-phone application. G-park is a very simple program designed with the embedded GPS capability for i-phone (see Figure 7.2). We just need to press the soft pad (key pad) "park me" once we park our car and it drops a GPS flag on our current location in our i-phone.. When we can't remember where we parked, we just hit "where did I park?" and Google maps gives us turn-by-turn directions back to our car.

Figure 7.2 I-Phone with G-Park Application

G-park is really nothing more than a simple way to drop a location flag on our GPS - but if we spend any time in unfamiliar towns we may well find it very useful.

7.6.3 Samsung's credit card phone – distilled technology

Technology miniaturisation trend seems to take effect very much especially on the consumer electronic gadgets. Samsung will soon release a phone dubbed the SGH-P300 in Europe as illustrated in Figure 7.3. With such clinical model designations, it's not surprising it has already attracted the nickname, "the card" because it's very similar in size to a credit card, though in our opinion, it looks for all the world like a calculator. Within its dimensions of 87mm x 54mm x 8.9mm it accommodates all standard phone functionality, has a 262K-colour, 220 x176 pixel TFT display, 1.3 megapixel camera with flash and direct printing via PictBridge, 88 MB of internal memory, an MP3 player, speakerphone, Bluetooth wireless technology support and

Figure 7.3 Credit Card Sized Phone

quite incredibly, an 800 mAh Li-Ion battery. Somehow, it still weighs in at just 65 grams and if we didn't know better we'd suspect that Samsung has found a way of distilling technology. Two of the better European-based mobile phone resources on the web have already had their hands on the P300 and managed quite extensive reviews so follow the links for much more detail and extensive images.

7.6.4 Holographic images in near-real-time

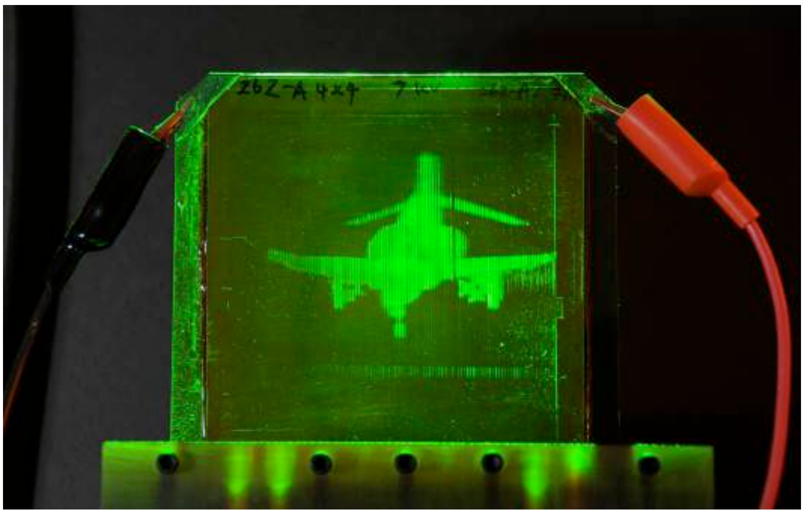

Figure 7.4 Hologram image in real time

We may still not have light sabers or faster-than-light spacecraft, but one other piece of Star Wars technology now looks like it may be on the horizon: 3D holographic videoconferencing as shown in Figure 7.4. Researchers from the University of Arizona, Tucson, unveiled a holographic system capable of transmitting a series of three-dimensional images in near-real-time, a significant step towards the live transmission of life-size, full color, holographic video of people or other objects.

The University Arizona system incorporates a 10-inch screen composed of a unique photorefractive polymer, which can rapidly refresh holographic images and is scalable for production, a 17-inch version has already been successfully tested. This is joined to a novel system for recording and transmitting 3D images via Ethernet. The researchers have demonstrated the system in the past, but at that point it was only capable of refreshing images once every four minutes. It can now refresh once every two seconds, which is still not ideal, but definitely a step in the right direction.

The system presents images from 16 perspectives (via 16 cameras), as opposed to the two which 3D movies are currently limited to. The output of these cameras is encoded into a laser beam, which writes a pattern into the polymer screen, thus creating and storing one complete image.

The use of multiple cameras results in full parallax, meaning that the image can be viewed not only face-on, but also from above, below, behind, and a variety of other angles. Project leader Nasser Peyghambarian said that the system could even incorporate hundreds of perspectives – such a feature could be particularly helpful if a surgery were being transmitted, so collaborating surgeons at remote locations could get a good look at what was going on.

While the system can currently only display monochromatic images at its relatively rapid refresh rate, it can also display color images at a slower rate. The researchers are now working on bringing its color refresh rate up to a video-like 30 frames-per-second, creating larger screens, and increasing the light sensitivity of the system.

"This advance brings us a step closer to the ultimate goal of realistic holographic telepresence with high-resolution, full-color, human-size, 3D images that can be sent at video refresh rates from one part of the world to the other," Peyghambarian said. The research, which was conducted in collaboration with California's Nitto Denko Technical Corp., is being published in the journal *Nature*.

7.7 New software for free international phone calls with any mobile phone through Skype

iSkoot is a new mobile Internet phone company we'll probably hear a lot about in the near future. iSkoot has introduced software that facilitates mobile access to the tens of millions of Skype Internet phone users. iSkoot enables complete access to Skype for both making and receiving calls from any mobile phone. iSkoot does not require any special hardware, custom phone, or Wi-Fi hot spot. iSkoot is offering free trial downloads at its website now. *"Skype is changing the face of telecommunications as we know it. There are now more than 40 million Skype users making free phone calls anywhere in the world. iSkoot completes the Skype user experience by extending the boundaries of Skype's valuable service from the PC to the mobile phone. Now with iSkoot and via a local call, users can enjoy the benefits of local, long distance and international calls when they are mobile and away from their PCs,"* said Jacob Guedalia, Chief Executive Officer, iSkoot.

iSkoot's first application works with Skype to enable users to connect any mobile phone to Skype's Internet phone service and buddy system (see Figure 7.5). Versions for other platforms and buddy systems, including AIM, Yahoo, and Microsoft services, as well as for Mac systems, will be released in the near future.

Voice over Internet Protocol (VoIP) is an umbrella term for a range of products and services that enable users to leverage the Internet to transmit phone calls. iSkoot software bridges the mobile and broadband networks to enable users a seamless link from mobile to Internet telephony. Within minutes of downloading the iSkoot software, a user can connect his or her regular cell phone to a VoIP Internet phone service such as Skype. No need for headsets, microphones, PCs, or USB phones. iSkoot connects every phone to Skype's services today. While other mobile VoIP services lock users into a specific pocket PC device or require a PC with Wi-Fi or other special hardware, iSkoot offers total ubiquity and enhances any phone with mobile VoIP.

iSkoot software will **a**utomatically forwards Internet phone calls from a user's PC to any phone, including any cell phone. Calls a buddy's PC from any phone switches an internet phone call from the PC to any phone without disconnecting

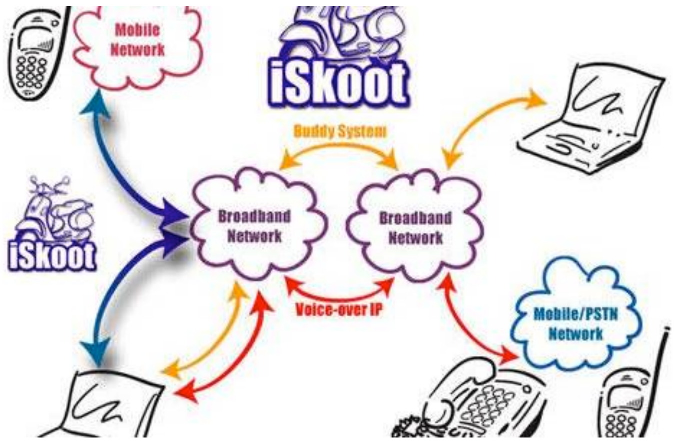

Figure 7. 5 FREE international phone calls with any mobile phone through Skype

7.8 Related Research and Project in the Faculty of Electrical and Electronic Engineering

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CHAPTER 8

WIRELESS TECHNOLOGY IMPACT ON SOCIAL

8.1 Introduction

If we look closely at today's society, we will notice that we have advanced so much that we could get ourselves to think that a few decades ago, there was no internet, no cable TV, and no mobile phones no SMS for us to communicate except with ordinary cabled telephone.

Wireless technology and services have become so cheap that almost everybody if not all, has at least one cell phone. From a teen as young as 10 to our granny and grand daddy, everyone carries a cell phone. Cell phone becomes a common item for almost every body and part of our daily lives. Cell phones are as important as money to certain extent when we are away from home. And just like anything that is part of our monotonous daily routine, our mobile phones have a great impact to our social life.

Wireless phones have changed the face of worldwide communications for good. Social and business world has completely changed when the technology of our phones plus the internet merged. We can travel away from the office and be in contact with business partners through continuous Internet access on the cell phone. Cell phone can keep us near to our beloved ones when we are away or out of the country.

Entertainment has also become mobile just like the wireless phones as it is not integrated with the device. We can watch videos or full length movies with it. We can listen to music via the MP3 or other music format. We can browse the web and many others.

These are just a few of the big changes that we are experiencing now with the influence of cellular phone and wireless technology.

Remember that there are good things and there are also bad things about technology. The ones listed above are just the good sides of all.

8.2 Wireless Technology on Our Lives

Wireless technology will wake our life simpler than we predicted. Modern technologies have more wonders than people could think it would have. Wireless technology is one of these wonders. This technology is not only changed our communication system but also our life style. A recent research has showed that more than 80% of total world populations use the help of wireless technology and most of them use wireless devices at least once daily. People use wireless devices so much in their daily life so they can't even think that is a wireless device. Wireless technology has become the part of our daily life. We can't spend a single day without using any wireless device.

Modern communication was started by the use of telephone lines and at the starting it was used only for sending news. When the radio was invented, the idea of sending news by wire had become useless even this system also destroy the uses of telegraph or telephone lines. Now the era of wireless technology, people only use the telephone lines for formal communications and the use of telegraph is demolished by the use of wireless fax or sms..

The former computer networking was based on wire connections but now the modern computer networking is based on wireless connections. In the development of wireless connection, the Worldwide Interoperability for Microwave Access or WiMAX is the latest invention of wireless technology and the use of this system become higher than we thought before. A WiMAX network can easily reach 30 miles (50 km) where the usual wireless connections can reach only a few meters. This technology will change the view of wireless technology and we believe it will provide us the advantage which we can hardly think about. Bluetooth is another invention of wireless technology. This technology becomes popular by its use in the mobile phones. This technology now has various uses. We can find Bluetooth keyboard, mouse or DVD players in the market which will help us to reduce the use of wires.

Our life will be easier with the help of wireless technology. We can do most of our works from anywhere only with the use of wireless devices. We would have agreed that wireless technology has made our life much easier and smoother.

8.3 Impact of Wireless Technology on Society

The rapid development of wireless communication primarily through cell phones and wireless internet over the past 20 years has caused some concern among critics. Most inventions in history affect society for decades following its introduction into the consumer market. Sometimes the consequences and side-effects of a product do not become apparent until much later when there is more time for the social impact to catch up with the widespread use of the product. This is no exception with wireless communications because the social impacts have not been fully discovered.

8.3.1 Cell Phones

The digital age is upon us, and who would have thought it would happen so fast? It seems like only a few years ago when owning a cell phone was a status symbol. Now the device has been marketed as a necessity that we all need to get through the day. In the early days of cell phones people used to treat them in the same manner that they treated credit cards, only for an emergency. Cell phones used to be very large and were kept in people's vehicles. Nobody ever seemed to discuss wireless plans, or the capabilities of their phones. The only question people asked were, why did we bring our cordless phone to work? That seemed to be the only other time anybody really saw a phone with that appearance. It wasn't until later models that folded for convenience that it caught on. Marketing is a powerful tool along with innovation. Marketing helps get the word out on the new products.

If we look around, one looks there seems to be somebody talking on a cell phone. Statistics say every one of all the population in Malaysia today holds a cell phone. The number of users was over 100% by 2010 and continues to grow. People are becoming closely interconnected through wireless devices like radios, cell phones, and wireless internet. The innovation of wireless technology has changed how business is conducted. According to Brown, *"when we think about [...] 'the office' we might imagine a big immobile building surrounded by other big buildings in a big city, like London, New York or Tokyo. Inside these offices we can observe 'work in action'" (Brown, 2002).* This image of the corporate world is changing into one of a mobile office. For the businessman or businesswoman on the road the weapon of choice for tackling the job is a cell phone which may also serve as a walkie-talkie and web browser. The benefits of a mobile office are great for those constantly on the road (salesmen, real-estate agents, repair technicians, some managers and reporters). The same is true for critical workers (doctors, oil-rig firefighters) needed at a moment's notice (Samuelson, 2004). Although the majority of ordinary people are not doctors or firefighters, but for the everyday teenagers or students the practical uses for a cell phone are not limited anymore.

In weighing the use of cell phones one cannot overlook the dangers that they are associated with. One of the most pronounced harms of using cell phones involves their usage by drivers on the road. Driving while on the phone definitely increases the chances of being involved in an accident. Studies and research done by insurance companies vary in how they define an accident involving a cell phone user, but the Insurance Information Institute recently summarized some studies: the Harvard Center for Risk Analysis blamed cell phones for 6 percent of auto accidents each year, involving 2,600 deaths (Samuelson, 2004). Of course auto accidents are also caused by other forms of negligence on the part of the driver, such as eating, reaching for something in the glove compartment, or having heated conversations with passengers. A more conscientious approach to cell phone usage during driving should be taken. This can be encouraged by local cell phone dealers in increasing awareness to this hazard, especially to young drivers who are more likely to be distracted in their early years of driving.

Aside from using cell phones on the highway, there involves the everyday chitchat and seemingly endless amount of gab. Private conversations and matters have gone public and there is the threat of an unknowing stranger listening in on our conversations. In 2003 cell-phone conversations totaled 830 billion minutes estimated International Association for Wireless Telecommunication Industry (CTIA). That's about 75 times greater than in 1991 and almost 50 hours for every man, woman and child in America. How valuable is all this chitchat? The average conversation lasts two-and-a-half to three minutes. Surely many could be postponed or forgotten (Samuelson, 2004). The increase in "noise pollution" and public disclosures of private conversations does not benefit those involved. As wireless forms of communication are commercialized and widely used, the art of communication and public speaking wanes because there is less interaction and physical dialogue and more textual chitchat.

As technology advances and different forms of wireless communication unify into a single piece of equipment, the blending of public work and personal privacy also occurs. Nowadays cell phones and personal digital assistants (PDA) are merging with web browsing and digital managerial software. This increases tensions in the workplace and at home when those two lifestyles reach into each other realm. The technology of new cell phones seemingly increases personal freedom and mobility, but actually tends to take away some of those suggested freedoms. People are so committed to keeping in touch with e-mail correspondence and being up-to-date in the fast paced commerce that they may become more plugged in and less thoughtful (Samuelson, 2004).

8.3.2 Wireless Internet

Cell phones aren't the only major part of wireless communication; the recent expansion of wireless internet has ushered in a whole new spectrum of conveniences and concerns. Wireless conferences and boardroom meetings across airwaves have saved executives much trouble in traveling via airplanes or driving. A company now has the ability to make transactions and decisions with another company halfway around the world without leaving their building. The benefits of such a powerful tool are great for keeping in touch with long distance contacts, but as with any other tool there are costs that accompany those benefits.

Similar to cell phone usage, not all of the effects of extensive use of wireless internet have been researched. The benefits of wireless internet are minimizing space and clutter with much greater mobility, but the social implications and health effects have been the center of much controversy. One problem that wireless internet brings up is who is ultimately responsible for the use of this technology. Although it has been in existence for quite some time, there has not been a thorough study on what effects wireless frequencies sent across free space have on people. Wi-Fi detectors or finders scan a particular location for radio frequencies and show the user the strength of a signal. The main concern for some is that these frequencies broadcasted are too close to those of radio frequencies and emit small amounts of radiation just like cell phones.

Critics of this technology argue that because there are virtually no legal restrictions on the use of wireless internet in workplaces, schools, and in homes, there are people who are unknowingly exposed to the radiation. These people are often not informed about the possible dangers of extensive exposure to wireless devices emitting radiation, and they have no control over the use of such devices. The legislation for this technology fails to keep companies accountable during research and development of their products because of the rapid changes and advancements made in wireless internet.

With the development and expansion of wireless internet, personal privacy and copyrights have become a topic of controversy in recent years as well. In 1998, the Digital Millennium Act became the first major legislation measure taken by record companies against copyright violations. Further restrictions and cracking down on piracy have recently been dealt out on home users. Some users of wireless internet for personal use argue that there are cases where hackers crack into wireless systems and manipulate systems, which makes catching such criminals difficult. The ethical solution to such an intangible problem is complicated because simply creating more laws and regulations will stifle certain freedoms in using wireless internet. There are proposals to construct small communities of wireless Internet Protocol (IP) addresses but with each new security in wireless internet there are hackers finding ways around it and gaining access to sensitive information. The cost-benefit analysis of solving the security and social concerns is currently being addressed by researchers and won't be complete until years down the road. For the time being we can see from the guru of office space that the advance technology of wireless networks and communication has its susceptibilities.

Some other social concerns of wireless internet and just internet in general have been the loss of personal communication, just as it is with extensive cell phone use. Instant messaging programs such as American Online (AOL) Instant Messenger and I Seek You (ICQ) have been revolutionary as they combine the functions of e-mail and phone calls. The benefit is that one could instantly communicate with people around the world through a simple text window for free. However, the potential stalker in online chat rooms also exists and may prey on young users of chatting software by obtaining personal information from them.

Other forms of social problems involve the easy access to pornography and "cybersex". A social decline and rise in wireless forms of communication has replaced intimate talking and face-to-face interactions with images of sensual arousal and sex performed in real time via a digital medium. There have been cases of rape, incest, child pornography and murders resulting from digital communication. The major issue surrounds controlling what is posted via wireless internet and accessibility to sensitive information, and legislation fails to provide a comprehensive solution at the moment. There appears to be no simple solution to the ethical issue of wireless chat rooms and monitoring who goes into them. The best thing parents of young children can do is to educate them, and raise the awareness of children to the dangers of surfing online and disclosing personal information to strangers.

8.4 Conclusion

As the evolution of wireless technologies continues to advance, the progression of mobile services will continue to evolve into ever-richer, more compelling mobile and converged services. Wireless phones have become more than mere devices to communicate. Today, humans wear them and they are as much as part of our personality as our cloths, car and house. Wireless phones are sometimes indicative of our social and economic status. With end users demanding more and higher-quality multimedia content in all environments, the evolution of device technologies will continue to enhance the increasing consumption of data usage.

Two key beneficiaries of the evolution of wireless technologies, services and devices are mobile operators and consumers. For mobile operators, realized benefits include improved profitability *i.e.*, lower operating costs and increased Average Revenue Per User (ARPU), an increased subscriber base and enhanced customer loyalty. For consumers, benefits include enhanced personal communications, increased convenience and improved entertainment. As mobile services for communication, education, enterprise, entertainment, healthcare, location and retail proliferate, and their consumer adoption increases around the world, one may say that mobile services are indeed becoming the center of life.

In another part of service, 4G networks may eventually deliver on all the promises. At times, it seems that technological advances are being made on a daily basis. These advances will make high-speed data/voice-over-Internet-protocol (VoIP) networks a reality. In the meantime, it is important for industry to develop a strong 3G offering that is palatable for the general public. Equally as important, industry must ensure that expectations are realistic and that services meet and exceed those expectations. If all goes according to what the industry envisions, it may be sooner, rather than later that we will see wireless communications evolve. This evolution will give the general public as well as the public safety community amazing functionality from the convenience of a single handheld device.

Without doubt, mobile communication offers enormous advantages – added convenience, greater personal security, and the ability to take advantage of 'dead' time to do business on the move. But the picture isn't all rosy. Like most young technologies, mobile communication is experiencing its share of teething troubles, including concerns about environmental impact, health and safety, and, of course, the social changes being wrought by a technology which, by making us permanently contactable, is having a profound effect on our interpersonal interaction.

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Ayob Johari is a professor in the Department of Communication Engineering, Faculty of Electrical and Electronic Engineering, UTHM. He started his career as College Lecturer in the Department of Electrical Engineering, Politeknik Ungku Omar, Ipoh, Perak in 1976 after completing his Diploma in Electrical Engineering (Communication) from Institut Teknologi Kebangsaan (now UTM), Jalan Semarak, Kuala Lumpur. In 1979, after serving for about three years he was awarded with scholarship by the Ministry of Education, Malaysia to further his study in Aberdeen, Scotland. He obtained Bachelor Degree in Electrical and Electronic Engineering (CNAA) in 1981. Then he continued his Post Graduate Certificate (Technical Education) in Moray House College of Education, Edinburgh, Scotland from 1981-1982.

After completion of his studies in Scotland he served the same polytechnic as Technical Lecturer in August 1982. Once again he was awarded the scholarship by the Ministry of Education, Malaysia for master degree program at the University of Wales Institute of Science and Technology (UWIST), Cardiff, Wales in 1986-1987. He came back and served the same polytechnic again in 1987. He served there until 1989 where he was then promoted as the head of Electrical Engineering Department in the newly established Politeknik Kuching, Sarawak. From 1991-1993 he was appointed as Vice Principal. His career in Politeknik Kuching didn't end there, where he was promoted as the Principal from 1993 to 1995. In January 1996 he was seconded to Pusat Latihan Staf Politeknik (now UTHM) as lecturer in the Department of Electrical Engineering. With full of enthusiasm he devoted his career to PLSP. His secondment prolong until 1998.

The journey of his career escalated where he was appointed as the first Deputy Dean of the Faculty of Engineering Technology in 2001 and as Associate Professor at the same faculty. In conjunction with the restructuring of faculties in 2004, he was again appointed as the Deputy Dean of the newly formed Faculty of Electrical and Electronic Engineering until December 2007.

In January 2008 he was appointed as the Director of the Development and Property Management Office until July 2009. In August 2009 he was then appointed as the Dean of the Faculty of Electrical and Electronic Engineering until today. In recognition to his excellent record and contribution to the university, he was promoted to Professor in December 2009.

Professor Ayob is active in Communication Engineering and ICT based research. He has published more than 60 articles in local and international publications, conference proceeding and journals. He has secured 11 research grants (as leader and researcher) including two IRPA grants i.e *Development of a low cost, modular, flexible and open-ended micro-controller system* (RM 121,150.00) and *Design and development of single and integrated embedded global system for mobile communication (GSM), global positioning system (GPS) and general packet radio service (GPRS) control system for high security tracking system and large scale application* (RM 128,000.00), both of which he was the leader. His research interest is in wireless network sensor for real time control and monitoring,

In product design and innovation, he has successfully patented his product with Patent Granted No. MY-139530.A, and three more had already been submitted for patent search. He has also won 11 awards (1 gold, 4 silver, 2 bronze), 1 merit award from MSC, 1 Best Innovation Award given by Taiwan Invention Products Promotion Association, 1 Anugerah Khas Penyelidikan 2005 and 1 Anugerah Khas Inovasi 2008 (Peringkat Antarabangsa). As a loyal *rakyat* of Johor and with his contribution to the state in the field of higher learning, he was awarded the Second Order Ibrahim Sultan Award (P.I.S. II), by Board or Royal Council, Grand Palace State of Johor, Malaysia on 8th April 2009 in conjunction with the 77th birth date of the late Sultan.