

# **LOW COST WIRELESS SURFACE EMG ACQUISITION SYSTEM**

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**A report submitted in partial fulfillment of the requirements for the degree of  
Bachelor in Electrical Engineering (Control, Instrumentation and Automation) with  
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**Faculty of Electrical Engineering  
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**2015**

I declare that this report entitle “Low Cost Wireless Surface EMG Acquisition System” is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature :

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Date :

*Dedicated, in thankful appreciation for support, encouragement and  
Understandings to my beloved mother and father,  
Khalijah bt Suid,  
Ahmad Shobani b Haji Ibrahim  
and those people who have guided and inspired me throughout my journey of  
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## ABSTRACT

A low-cost wireless surface EMG acquisition system has been designed for general purpose human-machine interaction. The system includes disposable surface EMG sensors, wireless communication using Bluetooth modules and signal analysis unit. Surface EMG acquisition system has been developed for the measurement of electrical activity of muscles and validates the design prototype of lowest wireless acquisition system. Generally, Bluetooth has an advantage which is almost ubiquitous technology and universally compatible and a wide variety of devices employ it. In this study, the system uses three channels of electrodes that sense muscles activity potential in microvolt and was wireless to transferred to the device with limitation 1kb per seconds. The low cost wireless was design using Bluetooth module. Its EMG signal is friendly and also reliable for users with high flexibility in being significant proposition in modern biomedical engineering surrounding. All through the process, the signal was acquired from muscle activity. Besides that, the implementation of designing the command to configure the signal obtains to be transmitted to the computer's software using MATLAB and software of ARDUINO.

## ABSTRAK

Satu rangkaian tanpa wayar direka untuk mengambil data Electromyography (EMG) dan bertujuan sebagai alat interaksi antara manusia dengan mesin (manusia-mesin). Sistem ini menggunakan alat pengesan EMG serta modul Bluetooth tanpa wayar dan isyarat analysis sebagai perantaraan untuk menunjukkan graf EMG tersebut. Dalam tajuk ini membincangkan kaedah untuk menghasilkan prototaip tanpa wayar kos rendah serta mengambil ukuran arus elektrik yang dihasilkan pada pergerakan otot. Bluetooth mempunyai kelebihan teknologi yang bersifat universal dan mendapat perhatian daripada peranti-peranti lain. Dalam projek ini, sistem ini menggunakan tiga sensor (*disposable electrode*) mikrovolt dan rangkaian komunikasi tanpa wayar menggunakan Bluetooth. Sistem ini merupakan salah satu cara yang digunakan dalam bidang kejuruteraan serta mempunyai fleksibiliti pengguna yang tinggi disebabkan sistem ini adalah mesra pengguna. Secara keseluruhan, sistem ini dibina untuk mengambil data EMG di dalam otot dan menghantar isyarat ke komputer menggunakan kaedah tanpa wayar dan di klasifikasikan menggunakan perisian didalam komputer iaitu MATLAB serta ARDUINO.



## TABLE OF CONTENTS

CHAPTER	TITLE	PAGE
	<b>ACKNOWLEDGEMENT</b>	<b>iv</b>
	<b>ABSTRACT</b>	<b>v</b>
	<b>ABSTRAK</b>	<b>vi</b>
	<b>TABLE OF CONTENTS</b>	<b>vii</b>
	<b>LIST OF FIGURE</b>	<b>x</b>
	<b>LIST OF TABLE</b>	<b>xi</b>
	<b>LIST OF APPENDICES</b>	<b>xii</b>
<b>1</b>	<b>INTRODUCTION</b>	<b>1</b>
	1.1 Background	1
	1.2 Problem Statement	2
	1.3 Objective	2
	1.4 Scope of Project	3
	1.5 Thesis Overview	3
<b>2</b>	<b>LITERATURE REVIEW</b>	<b>4</b>
	2.1 Introduction	4
	2.2 Principle of Electromyography	4
	2.3 Anatomy and physiology of the muscle contraction	5
	2.4 Type of muscles in the hand	7
	2.5 Generation of EMG	7
	2.6 Advantages and disadvantages of EMG signal	7
	2.6.1 Advantages of EMG signal	7
	2.6.1 Disadvantage of EMG signal	7
	2.7 Bluetooth Wireless Communication	8
	2.8 Advantages of Bluetooth Communication	9
	2.9 Architecture Overview of Bluetooth Communication	9
	2.10 Related work done is EMG based low cost wireless surface EMG acquisition system	11
	2.10.1 Surface Electromyography (EMG)	11
	2.10.2 Low-cost wireless	12

	2.10.3 Hand movement	13
<b>3</b>	<b>METHODOLOGY</b>	<b>14</b>
	3.1 Introduction	14
	3.2 Block Diagram	14
	3.3 Flowchart	15
	3.4 The implementation of ARDUINO interface with shield EKG by using real-time data	17
	3.4.1 Placement of EMG electrode and the technique of signal acquisition	18
	3.4.2 Disposable Electrode	19
	3.4.3 Shield	20
	3.4.4 ARDUINO UNO	22
	3.5 Develop Low Cost Wireless using ARDUINO UNO and Bluetooth	23
	3.5.1 Placement of EMG electrode and the technique of signal acquisition	23
	3.5.2 ARDUINO UNO	24
	3.5.3 Bluetooth modules	24
	3.5.4 Bluetooth Module HC-05	25
	3.6 Chapter Summary	27
	3.7 Key Milestone	28
	3.8 Gantt chart	29
<b>4</b>	<b>RESULT AND DISCUSSION</b>	<b>30</b>
	4.1 Introduction	30
	4.2 Design different gesture	30
	4.3 The processed of EMG Signals	31
	4.4 Data Surface EMG during off-line time with filter	32
	4.5 Chapter Summary	

<b>5</b>	<b>CONCLUSION AND RECOMMENDATION</b>	<b>40</b>
5.1	Introduction	40
5.2	Conclusion	40
5.3	Recommendation	41
	<b>REFERENCES</b>	<b>42</b>
	<b>APPENDIX</b>	<b>44</b>

## LIST OF FIGURE

<b>FIGURE</b>	<b>TITLE</b>	<b>PAGE</b>
2.1	Different body muscles and structures	5
2.2	Generation of EMG	8
2.3	Structures of Bluetooth network	10
2.4	Bluetooth scatternet diagram	10
3.1	Block diagram of wireless surface EMG acquisition system	14
3.2	Flow Chart of Project	16
3.3	Block diagram process of EMG signal	17
3.4	Block diagram of EMG based control system	17
3.5	Muscles and their Architecture	18
3.6	Disposable electrodes with a single 3.5mm plug connector	19
3.7	Alcohol Pad	20
3.8	Top layout of the shield	21
3.9	Bottom layout of the shield	21
3.10	Main parts of the shield board	22
3.11	ARDUINO UNO front	22
3.12	ARDUINO UNO back	22
3.13	USB cable	23
3.14	Connection between ARDUINO UNO and Bluetooth HC-05	24
3.15	Symbols of Bluetooth	25
4.1	Five different gesture of wrist join	30
4.2	Structure Process Low Cost Wireless Surface EMG acquisitions System	31
4.3	Low Cost Wireless Surface EMG acquisition System Hardware	32
4.4	Maximum amplitude for each muscle	38
4.5	Maximum amplitude for each muscle	38
4.6	Maximum amplitude for each muscle	38

**LIST OF TABLE**

<b>TABLE</b>	<b>TITLE</b>	<b>PAGE</b>
3.1	Requirements and Description needed for volunteers	15
3.2	Gain and frequency used	21
3.3	Example of command Test in serial connection	25
3.4	Example of command Reset in serial connection	26
3.5	Example of command Restore default status in serial	26
3.6	Example of command module Bluetooth address in Serial connection	26 26
4.1	Forearm Muscles and Functionality	33
4.2	Signal from gesture Ulnaris Wrist Flexion (UWF)	34
4.3	Signal from gesture Ulnaris Wrist Extension (UWE)	35
4.4	Signal from gesture Wrist Extension	36

**LIST OF APPENDICES**

<b>APPENDICES TITLE</b>	<b>PAGE</b>
Appendix A: Bluetooth HC-05	44
Appendix B: Package size information	45
Appendix C: The circuit connect the module to 5V serial port of MCU	46

# CHAPTER 1

## INTRODUCTION

### 1.1 Background

This study is focusing on developing a low-cost wireless system recording for general purpose human-machine interactive control and prosthetic system. The system includes a disposable surface EMG sensor, wireless communication module, and signal analysis unit.

Surface EMG is the comprehensive reflection of biological signal on the skin surface during muscle contraction which contains abundant and accurate motion information.

Generally, Bluetooth is one of an open standard for wireless that using for Personal Computer [PC] to be connected with supporters. In wireless communication, most commonly devices that enable to send and receive communicate are Bluetooth and Wi-Fi. In this project, Bluetooth module was choosing because it are low cost, robustness and have low power. For example, innovative solution which is users can perform include printing or faxing capabilities, laptop or computer making or receiving call from a mobile phone, with many more application available.

The proposed low-cost wireless acquisition system is composed by main three parts. The parts are surface EMG sensor, Bluetooth acquisition module and signal analysis module. Surface EMG sensors amplify the analog signals and filter the surface EMG signal. The wireless acquisition module sends the control instruction from the PC client and transmits the surface EMG signals from sensors to the PC client (desktop). The analysis modules send the control instruction to set the parameters of data acquisition module as well as receive, analyse and display surface EMG signals on the screen.

## 1.2 Problem Statement

The purpose of this study is to develop a low cost wireless as hardware and record the data surface EMG acquisition system. This low cost wireless must be robust wireless communication capable to recorded, transmit and transfer data surface electromyography (sEMG) to personal computer [PC] client. This study also provides the student with experience in the development process from the conceptual to the implementation. The idea to develop this project occurs to:

1. The development surface EMG acquisition system and a low-cost wireless which are trustworthy, comfortable for users and for a minimum cost.
2. Produce general purpose human-machine especially for athletes.
3. Intensive research work on prostheses innovative using for arm surface EMG.

## 1.3 Objective

The goal of this project is to develop a low cost wireless surface EMG acquisition system. The main objectives to ensure the successful of the project are as follow:

- i. To develop a low-cost wireless acquisition system for different gesture of surface EMG signals.
- ii. To validate the design prototype of low cost wireless acquisition system accurately.

## 1.4 Scope of the Project

This project, the overall focus on develops a low-cost wireless system and surface EMG acquisition system. In order to verify the practicability of this project, it was designed a prototype with ARDUINO Uno to test the filter circuit, and acquisition performance. Experimental test will be carried out in three (3) subject average age twenty



one (21), average height on hundred and sixty cm (160), and average weight around sixty kg (60). The limitation range of the Bluetooth connection is between 5-20 meters.

## **1.5 Thesis Overview**

This thesis the design a low cost wireless surface EMG acquisition system. Generally, all the process is done in this project is describing by each chapter. The overview of all chapters can be simplified as follow:

Chapter 2 presents the study that related to previous project. From the study of previous paper improvement to make sure the project completed. This is important in order to make sure this project is satisfied.

Chapter 3 discusses the methodology of the development low cost wireless system and applied data surface EMG in ARDUINO UNO to display at MATLAB (PC). In this chapter, it consists of open block diagram and flow charts which are explained about the process of develop this project. It also discusses briefly how it work properly and designed.

Chapter 4 is discussing and displaying all the result obtained and the limitation of this project. All discussions are concentrated on the result and the overall performance of the wireless communication and real time data EMG signal

Chapter 5 in overall is discussing the conclusion and summary of the development of low cost wireless surface EMG acquisition system. In this chapter also conclude the overall project implementation and its future recommendation.

## **CHAPTER 2**

### **LITERATURE REVIEW**

#### **2.1 Introduction**

In this chapter, the theory involved in the design of a low-cost wireless surface EMG acquisition system has been studied. Other than that, the design has been clearly started with the research work that has been done by previous analysis of this low-cost wireless surface EMG acquisition system. In the past, many strategies and methods have been implemented in solving this surface EMG and how to construct a wireless system.

#### **2.2 Principle of electromyography**

Electromyography (EMG) investigates the capacity of muscle through dissection of the electrical indicators exuded throughout husky compressions. Electromyography is rating the electrical activity that is connected with the enactment of the muscle which happens automatically due to the muscle comprehension. At the depolarization limit, the movement possibilities of the engine nerve will drive the muscle fibre to contract. The happening will cause the production of the electromagnetic field. The depolarization that moves between the films of the muscle is known as the muscle activity potential. The engine unit activity is the spatial and transient summation of the singular muscle movement possibilities for all the filaments of the solitary engine unit. Subsequently, the EMG indicator is the arithmetical summation of the engine unit movement possibilities inside the pick-up zone of the node being utilized [1].

### 2.3 Anatomy and physiology of the muscle contraction

In human body, muscles are the most delicate tissue that lies under most creatures' skin. Biological term, muscle consists of protein, fibre of mission that slide past each one in turn. Handle a constriction that changes both the length and the state of the cell. Essentially, muscles are fundamentally obliged to keep up and derive carriage, momentum and also developing inward organs. As an example, the restriction of heart and also the evolution of livelihood through digestive framework by means of peristalsis. Muscle tissues are inferred from the mesodermal layer of embryonic germ cells in a methodology known as myogenesis. There are three sorts of muscle, skeletal or striated, cardiovascular, and smooth. Muscle movement might be thought-out, being either voluntary or automatic. Heart and smooth muscles contract automatically, while the skeletal muscles contract upon summons. Muscles are transcendently fuelled by the oxidation of fats and carbs, however anaerobic concoction responses are additionally utilized, especially by quick twitch strands [2]. These compound responses produce adenosine triphosphate (ATP) atoms which are utilized to power the development of the myosin heads [2].

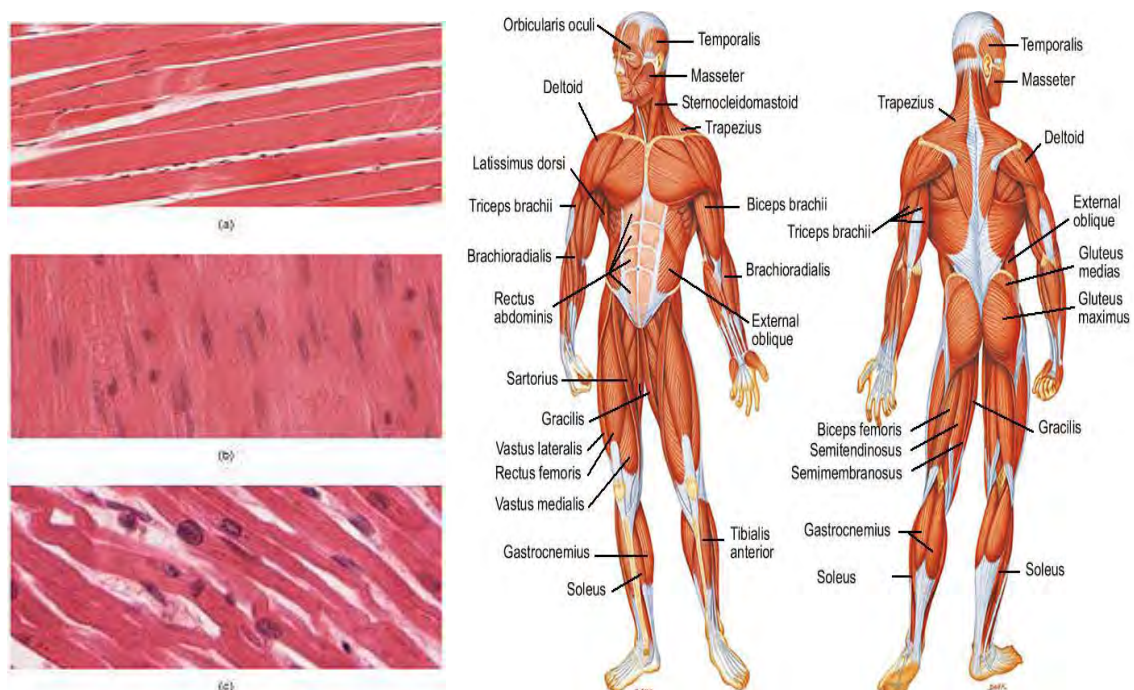


Figure 2.1: Different body muscles and structures [2]

The important contrasts part has three sorts of muscle (skeletal, heart and smooth) which each have noteworthy contrasts. So, that every one of the three utilizes the development of acting against myosin to make constriction. In skeletal muscle, compression is invigorated by electrical driving forces transmitted by the nerves, the motoneurons (engine nerves) especially. Cardiovascular and smooth muscle constrictions are empowered by inner pacemaker cells which customarily contract, and proliferate withdrawals to other muscle cells they the neurotransmitter acetylcholine.

## **2.4 Type of muscles in the hand**

As known, human's hand are the most unpredictable as well as complicatedly structure which are allow to move depends on the brain's development. Biological term, in human body there are 60 different muscles that will work as one to complete the tasks. Flexion and broadening of the hand phalanges of fingers are proficient by extraneous muscles of the hand (of those of the lower arm). Exact finger developments that require the coordination of snatching and adduction with the flexion and expansion are practically the assignment of the little inalienable muscles (those inside) of the hand. The natural muscles of the hand are further separated into the thenar (concerning palm on the thumb side) and hypothenar (concerning palm besides the little finger), and the halfway gatherings. The extensions between the hand and the lower arm is the wrist (or carpus), a gathering of eight little bones fitted together in a cobblestone system and bound set up by solid ligaments. The posterior forearm muscle are basically the muscle that control the movement of the fingers. These muscles works along the tendons at the wrist to help both the wrist and the hand to express movement. Alternately, they join to tendons that stretch out along each one finger are installed in long sheaths on the palm side of the hand. When, the lower arm contracts it pulls on the tendons and the sheath to twist the finger. There are a circle inside the wrist permits the 180 switch on the top to the bottom of the hand is called pronation and supination. For every single fingers of human's hand carries on correspondingly to each other and has comparative musculature. While the thumb is also remarkable itself. The thumb is greatly vital to the hand's adaptability on the grounds that it restricts alternate fingers, which implies we can squeeze a little question between the thumb and finger to lift it up.

## 2.5 Generation of EMG

The EMG is produced when an engine neuron movement potential the spinal line lands at an engine and plate. Its landing causes an arrival of Ach (Acetylcholine) at the synaptic separated (1) with causes a depolarization (Action Potential). This activity potential electrically voyages descending from the surface in a transverse tubule (2). This thusly causes an arrival of  $Ca^{++}$  (3), bringing about cross-extension trying (4) and the sarcomere of the muscle to get (5). An electromyography (EMG) is an estimation of the electrical movement in muscles as a side effect of constriction. An EMG is the summation of movement possibilities from the muscle filaments under the anodes set on the skin [3]. If there more muscles that fire, it will be more amazing the measure of movement possibilities recorded and the more stupendous the EMG perusing.

## 2.6 Advantages and disadvantages of EMG signal

EMG has both advantages and disadvantages

### 2.6.1 Advantages of EMG signal:

- i. EMG is cheaper in comparison to another technique.
- ii. EMG can gives a lot of data which are both scalar and continuous.
- iii. EMG also identify for more muscular activity than visual measurement.

### 2.6.2 Disadvantages of EMG signal:

- i. EMG is very noisy
- ii. Natural expression may alter.
- iii. Surface EMG has channel crosstalk

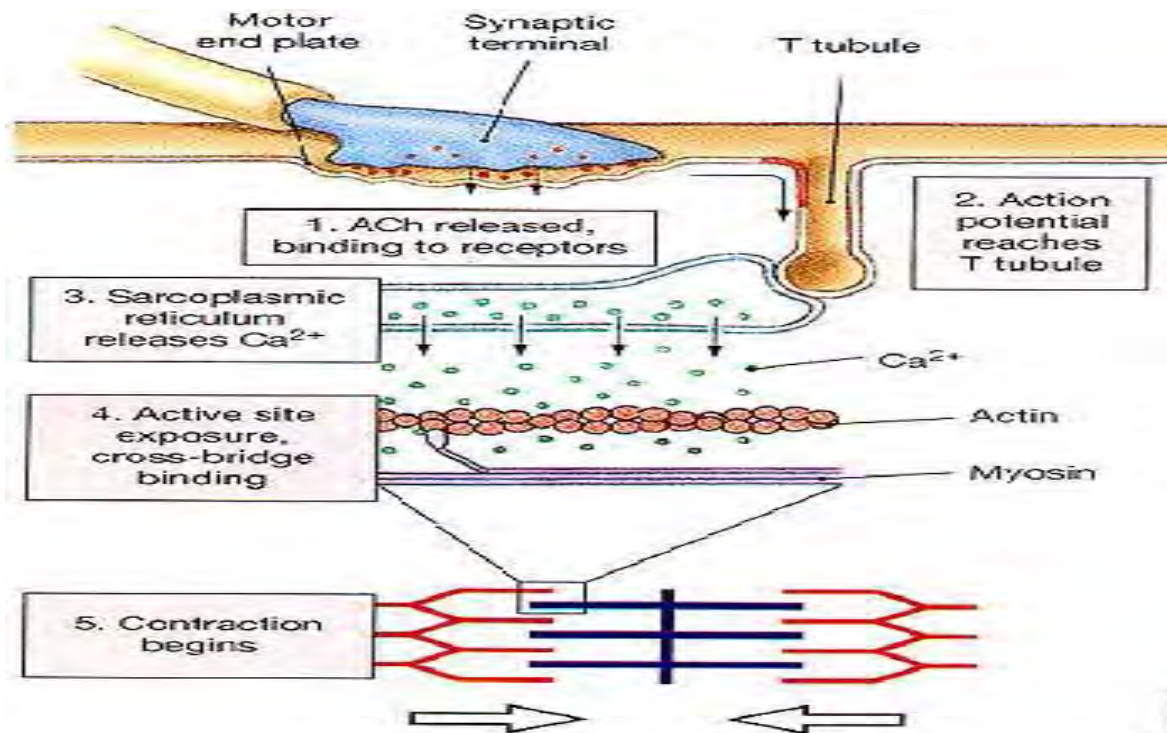


Figure 2.2 Generation of EMG [3]

## 2.7 Bluetooth Wireless Communications

Bluetooth is one of an open standard method for data wireless communication. Mostly Bluetooth are connected with supporters from the PC and the cell phone industries. Generally, Bluetooth is primary market data and voice transfer between communication devices and their connected units. Bluetooth use a method short radio links to take over cable between computer and their connected units. Bluetooth using a similar way with IrDA protocol that using radio frequency (RF) 2.5 GHz industrial, utilizing and medical (ISM) band. Application Bluetooth includes PC peripheral networking, hiding computing and the data synchronizing. Bluetooth is designed to be low cost, however it has a limited connection distance and the transmission speed. Bluetooth can only support 780 kb/s that can used for 721 kb/s unidirectional data transfer (57.6 kb/s return back direction) or it can up until 432 kb/s symmetric data transfer.

## 2.8 Advantages of Bluetooth communication

Bluetooth have several advantages. Advantages of Bluetooth technology are

- i. Bluetooth is using to transfer information between two or more devices such as IrDA and HomeRF,
- ii. Suite to low-bandwidth like transferring data.
- iii. Ability to simultaneous handles both data and transmission.
- iv. Bluetooth have capability to support one asynchronous data channels and voice channels.

## 2.9 Architecture Overview of Bluetooth Communication

Based on the Figure 2.3, it illustrated Bluetooth specification link to control hardware and link manager portions by using integrated as one chip or a radio module and base-band module, implements the RF, baseband. This hardware did not just control reception and radio transmission, but it also need the digital signal processing for the baseband protocol. The function includes establishing connection, support asynchronous (data) and synchronous (voice) link, the connection error and the authentication. This link manager firmware produce with baseband CPU performs low-level device discovery, link setup, authentication, and link configuration. Link manager are provides two devices communication which is utilizes the services of the underlying link controller (baseband) and provide a host controller interface (HCI) as a standard interface to software.



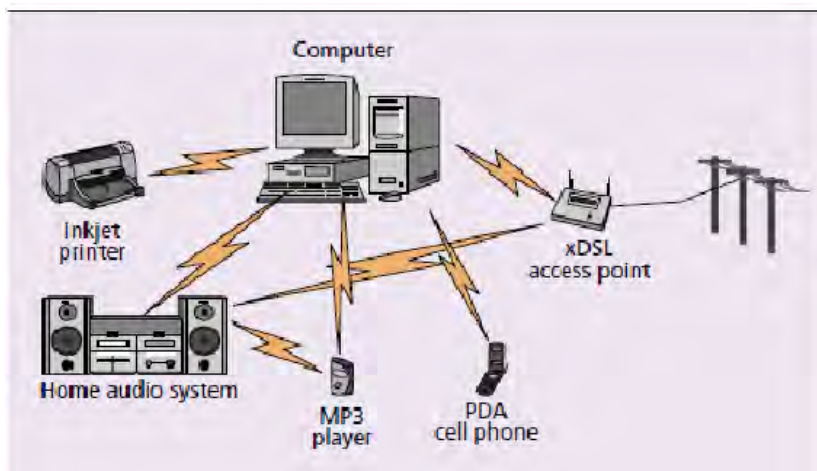


Figure 2.3: Structures of Bluetooth network

From the Figure 2.3 shows the structure of Bluetooth network for the configuration of Bluetooth system through towards numerous applications. This hardware control inkjet printer, home audio system, MP3 player, PDA cell phone and xDSL access point.

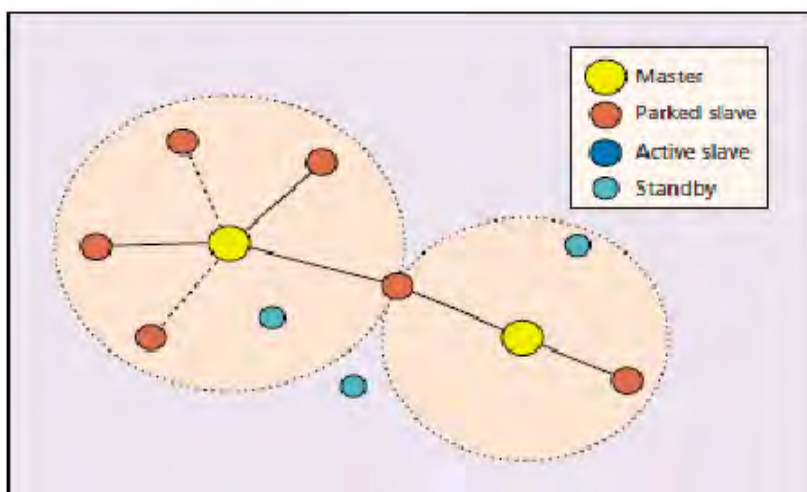


Figure 2.4: Bluetooth scatternet diagram

From the legend in the Figure 2.4 above, the Bluetooth scatternet diagram can be explained groups of two eight devices that called piconets. The colours of yellows is a single master devices, red for parked slave device, blue for active slave devices and light blue for standby. Generally, the was connected between piconets and scatternet.