UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DEVELOPMENT OF GPRS SIGNAL AMPLIFIER

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor's Degree of Electronics Engineering Technology (Telecommunication) with Honours

by

MOHAMAD HAKIM BIN ABDUL RANI

B071410110

920805-08-5155

FACULTY OF ENGINEERING TECHNOLOGY

2017

DECLARATION

I hereby, declared this report entitled “PSM Title” is the results of my own research except as cited in references.

Signature	:	
Author’s Name	:	MOHD HAKIM BIN ABDUL RANI
Date	:	……..

APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Electronic Engineering Technology (Telecommunication) with Honours. The member of the supervisory is as follow:

……

(Project Supervisor: Win Adiyanshah Indra)

ABSTRAK

Selular mudah alih telah menjadi peranti yang paling banyak digunakan di dunia kerana mobiliti dan kemudahan penggunaannya. Ini disebabkan oleh rangkaian tanpa wayar yang menghubungkan setiap telefon mudah alih ke rangkaian dan menyediakan akses pantas kepada komunikasi suara dan internet. Walau bagaimanapun, telefon bimbit hanya sebaik signal yang diterima. Pada zaman kini hampir setiap individu perlu sentiasa online, mempunyai isyarat yang lemah adalah masalah yang sangat besar. Kebanyakan produk yang tersedia di pasaran agak mahal, bernilai beratus-ratus hingga ribuan Ringgit tetapi bersaiz besar dan harus dipasang. Oleh itu, tujuan projek ini adalah untuk mengkaji General Packet Radio Service (GPRS) dan signal amplifier dengan tujuan untuk mereka alat amplifikasi signal GPRS dengan kos rendah dan mudah alih. Di samping itu, projek ini bertujuan untuk menyiasat liputan isyarat GPRS keseluruhan Factory 1 di Kampus Teknologi UTeM. Penemuan utama penyelidikan adalah, GPRS menggunakan 'band' 800 dan 900 MHz untuk menyampaikan isyarat untuk kedua-dua rangkaian selular serta telefon bimbit. Band 800 MHz telah digunakan dalam projek ini kerana kebanyakan service provider di Malaysia menggunakan 'band' 800 MHz untuk menghantar isyarat GSM, GPRS dan EDGE. Litar amplifier LM386 digunakan untuk menguatkan signal yang diterima oleh antena GSM dan kemudian akan dihantar ke antena yang lain. Analisis pada liputan Kilang 1 menunjukkan kekuatan isyarat yang sangat rendah, secara purata signal adalah sekitar -80 hingga -90 dBm. Isyarat ini hanya menguatkan isyarat dengan 3-5 dB kerana batasan amplifier pada frekuensi tinggi. Kesimpulannya, prototaip ini dapat berfungsi dan maklumat penyelidikan sebagai maklumat yang diperolehi akan membantu penyelidik seterusnya untuk memperbaiki projek ini. Disyorkan untuk melaksanakan amplifier yang lebih baik seterusnya, gunakan duplekser untuk menggunakan antena lebih baik dan gunakan bekalan kuasa yang lebih kompleks seperti bateri lithium ion.

ABSTRACT

Mobile cellphones have become the most used device in the world due to its mobility and ease of use. This is due to the wireless network that connects each mobile phone to a network and provides quick access to voice communication and internet. However, the mobile phone can only be as good as the signal it receives. In this day and age where almost every needs to remain connected, having poor signal is a very big problem. Most of the market-available solutions are quite expensive, ranging hundreds to thousands of Ringgit but tend to bulky and fixes into place. Hence, the intent of this project is to study on General Packet Radio Service (GPRS) and signal amplification with the aim of designing a low cost and mobile GPRS signal amplification device. In addition, this project aims to investigate the overall GPRS signal coverage of Factory 1 in the Technology Campus of UTeM. The major finding of the research is that, GPRS uses the 800 and 900 MHz band to communicate the signals for both the cellular network as well as the cell phone. Each band covers two different ranges of frequency. The 800 MHz band was used in this project as most service providers in Malaysia use the 800 MHz band to send GSM, GPRS and EDGE signals. A circuit of amplifiers using the LM386 were used to amplify the signals that were received by GSM antennas and would then be sent to the other antenna. The analysis on the coverage of Factory shows a very low signal strength, on average the signal is at around -80 to -90 dBm. The signal is only capable of amplifying the signals by 3-5 dB due to the limitation of the amplifiers at high frequency. To conclude, the prototype was able to function and the research information as the information derived would be helpful to next researcher for improving this project in the near future. It is recommended that the next implement better amplifiers, use a duplexer to better make use of antennas and use a more complex power supply such as lithium ion battery.

DEDICATIONS

This thesis is dedicated to:

My beloved family,

My Mother, Rohani binti Mohamad;

My Father, Abdul Rani bin Mohamad Hanifa

My Supervisors,

My Lectures,

My housemates,

And all my friends,

Thank you for your support and encouragement.

ACKNOWLEDGMENT

"Rome wasn't built in a day". This idiom appropriately describes the process of creating this thesis. The success and outcome of this project required a lot of guidance and assistance from many people and I am extremely grateful to the support I received for the beginning to the completion of my project. Firstly, I would like to express special thanks En. Win Adiyanshah Indra for taking accepting me under his supervision for the final two semesters. I extremely thankful to him for spending precious time and energy to guide me on completing this project, eventhough he was busy with his own academic affairs.

Secondly, I would like to extend my sincere esteems to both examiners En. Khanapiah bin Nor and Madam Niza binti Mohd Idris. Their experience and dedication help me to write the best thesis I could through their comments and feedback on my project.

Thirdly, I wish to express my deepest appreciation to my family members especially my brother, who kept on supporting me till the end. Next, my housemates who kept my spirits high and my morale ever rising. They even shared their knowledge to help make this thesis. Likewise, I heartily thank my course-mates for their timely support and most of all patience throughout the entire process. Then, I would like to acknowledge all the people that gave their support directly and indirectly during the progress on the project. Last but not least, thank Allah for blessing me with much more than I deserve.

Table of Contents

List of Tables

List of Figures

LIST OF ABBREVIATIONS

A, Amp	Ampere
dB	decibel
dBm	decibel-miliwatts
EDGE Enhanced	Data Rate for GSM Evolution
F	Farad
G	Gain
GSM	Global System for Mobile
H	Henry
P	Power
Xc	Reactive Capacitance
Xl	Reactive Inductance
V	Voltage
W	Watt

CHAPTER 1
Introduction

1.1 Introduction

As far back as human history could be traced, communications have always been an integral part of human civilization. As social creatures, humans require the ability to connect with one another, conveying facts, opinions and ideas. For many centuries, humanity relied on verbal communication to exchange information. Then came writing. In the 1830's, Samuel Morse along with several others developed the telegraph which revolutionized long-distance communication (Bellis, 2017). Sending mail and news no longer took weeks or days, with the telegraph communication could be done in the matter of minutes. Afterward came the wireless telegraph invented by Gugliemo Marconi in 1901 (Simkin, 2014). No longer bound to the constraints of cable length or geographical limitations, Marconi's advancement allowed the telegraph to become a scientific sensation that propelled the field of communication technology for the next century.

Marconi's invention quickly made the telegraph and the radio an indispensable form of communication in the western world. Soon afterwards more and more communication platforms were being introduced and wireless communication quickly spread far and wide throughout the world. In the early 1970s, the general public had access to television sets that receive signals through antenna, radios that required minimal power through the use of batteries and bulky mobile phones that were used for wireless communication. When the internet started to gain popularity in the mid-1970s (Zimmermann, 2012), the world clamored to take hold of technology to connect more and more people and share vast amounts of data together. Data communication has been energized by this and as such have been developed to such an extent that it has eclipsed the original

analog communication system. Data transfer technology has improved other communication systems as well such as the PSTN or telephone network. This have brought about the invention of the wi-fi or wireless internet.

By 1991, the IEEE (Institute of Electrical and Electronics Engineers) had begun to standardize WLAN (wireless LAN) technologies (Gunther, 2015). This showed how widespread wireless communication had become. By 2011, most of the world's population has owned at least one manner of wireless device used for instantaneous communication such as the smartphone or laptop. America alone had more wireless subscribers than its current population (Tinar, 2011). As the wireless communications technology continues to advance, the number of users also increase at a steady rate. Nowadays, it is considered strange not to own at least one wireless data communication device. It would not be surprising to see the path of future communications to rely heavily or solely on the

1.2 Problem Statement

Wireless telecommunications have always been plagued with signal transmission problems. Over long distances, signals attenuate or lose power. Certain weather conditions may affect signal transmission, causing the signal to distort and project false or incorrect data. The most apparent problem however, is that signals may encounter obstacles before reaching the receiver, further reducing the signal strength (Oh, 2012). In a metropolitan area, buildings of various sizes dominate the skies, towering over the city area. Considering that most people that use any wireless communication devices are on street level or inside the large buildings, the signal strength that these users would receive is poor and inefficient at best. Many telco companies have placed repeaters and signal in many areas that were either blocked by high-rise buildings or centered at densely populated areas. This does not solve the problem faced by the telco companies however.

In Malaysia, there are 4 carriers that provide cellular service, Digi, Celcom, U mobile and Maxis. All of these companies use the same frequency for 2G and GPRS, which is GSM 900 and GSM 1800 (DCS) (Poole, 2014). GSM 900 operates at a frequency of 900 Mhz while GSM 1800 operates at 1800 Mhz. Both are capable of GPRS services and have been used as such for quite

some time. However, both are not the same in terms of signal penetration and coverage. The laws of physics rule that higher frequencies have less wavelength and as such will not cover as wide of an area. Thus the 1800 Mhz frequency is at a disadvantage. Not only that, the 900 Mhz is also much better at signal penetration (Justice, 2015). Even so, the 900 Mhz spectrum is just not big enough to fit all the radio signals, cellular network signals and other private or government signaling usage. Below is a table that lists the amount of attenuation a signal would face when passing through a certain object.

Table 1 Obstacle attenuation, obtained from "The Basics of Attenuation" website.

Human body	3
Cubicles	3 to 5
Window, Brick Wall	2
Brick Wall next to a Metal Door	3
Glass Window (non tinted)	2
Clear Glass Window	2
Office window	3
Plasterboard wall	3
Marble	5
Glass wall with metal frame	6
Metal Frame Glass Wall Into Building	6
Metal Frame Clear Glass Wall	6
Metal Screened Clear Glass Window	6
Wired-Glass Window	8
Cinder block wall	4
Dry Wall	4
Cinder Block Wall	4
Sheetrock/Wood Frame Wall	5
Sheetrock/Metal Framed Wall	6
Office Wall	6
Brick Wall	2 to 8
Concrete Wall	10 to 15
Wooden Door	3
Metal door	6
Metal Door in Office Wall	6
Metal door in brick wall	12 to 13

From the table above, it is obvious that GSM and GPRS frequency bands are not able to efficiently carry cellular signals in a densely-populated area. The channels in the 900 Mhz band would quickly be congested with user traffic thus bogging down the network, costing the service provider it's revenue. The 1800 Mhz band could fit in more channels but any service provider using it would need much more cell towers and signal repeaters placed in urban areas than they would is using 900 Mhz .

The problem then persists. The users that subscribe to these networks are not capable of accessing their respective communication channels and yet the service providers have done all that could be done on their part (Wills, 2013). The users must then have an economical but no less effective way of boosting cell signal in their immediate vicinity. A personal signal booster would of course be usable but most models of signal boosters and repeaters are too bulky to be carried around. The idea of a mobile device is to have an easy way to move about with the device at hand. Such solutions would force any designs or schematics to become smaller to fit into a constrained space or area.

The second problem would be power. A signal repeater would consume considerably more power than a smartphone in a short amount of time, thus would require a robust energy source. One such source must be simple and robust, as moving about will damage more intricate components and should store an adequate amount of power to allow the signal repeater to operate at any time.

1.3 Objectives

Based on the problem discussed above, the objectives of this study are:

1) To develop a lightweight and mobile GPRS signal amplifier

2) To develop a portable signal booster that can be powered by rechargeable power cells.

1.4 Scope of Research

The scope of this research was established based on the objectives listed. The signal booster will be created according to the stated objectives, using both software and hardware implementation, to create a working signal booster from scratch. The power source of the signal booster will be researched and implemented to complete the prototype device.

The project will not research on the signal proficiency of the device on other cellular standards such as 3G, 4G and LTE. The project will also not be researching on the modulation of the GPRS or on data packet transmission, only on the process of RF signal transmission.

CHAPTER 2

Literature Review

2.1 Introduction

The purpose of this chapter is to review recent works that are relevant to this project and have been done by other researchers and teams. The literature reviewed are those that would contribute significantly to this project, including GPRS, Wireless Transmission and Portable Energy cells. The methods and technology of previous papers were compared to produce a much better methodology and process to complete the project.

2.2 Relevant Projects

It has been widely acknowledged that telecommunication devices had a massive technological growth within the past 2 decades and will grow even faster in the coming future. However, one of the more crucial aspects of developing telecommunication device is miniaturization. Miniaturization is a technological endeavor that is a constant struggle for many different fields of electronics, but some more than others. Users and industrial proponents have been clamoring for the miniaturization of cellular components for quite some time now. So far, the effects have been very obvious to the present smartphone market, as the physical size, shape and weight. According to the article Comparison and Analysis of Integrated Passive Device Technologies for Wireless Radio Frequency

Module by (Arun, et al., 2008), the authors have compared and analyzed different IPD (integrated passive device) for RF modules. The various IPD designs that were compared are glass, silicon and LTCC based. The subject matter of this article does not have any major relevance for this project but the miniaturization effort as well as creating integrated circuitry for the prototype will be useful later on when designing schematics, and putting together the various components. The article discusses mainly RF modules, which are of use to this project. While the article itself does not provide an example or design of an RF schematic, the authors do stress that the use of the IPD technique will ensure a more favorable frequency output with less noise.

An amplifier is vital in a signal repeater, as the amplifier would boost a weakened signal to almost full strength. There are of course many other factors that affect signal amplification however, signal amplification is the most crucial process in a signal repeater device. In the article A Fully-Integrated Quad-Band GSM/GPRS CMOS Power Amplifier by (Aoki, et al., 2008) the authors wrote about an IC amplifier using CMOS that utilized Quad-Band signal transmission for GSM/GPRS networks. The aforementioned CMOS chip was created to be efficient for a standard electronic digital circuit, to be more precise, the chip would use between 2.2V and 5.5V during any time that it was switched on. The use of this CMOS chip or any that are like it would positively affect any RF designs as the circuitry would become smaller in size and would need a stable DC voltage to operate. The authors also indicated the CMOS Quad-band chip does not require off-chip components like capacitors and inductors to function in an RF circuit. For those that are not aware, most other IC amplifiers require off-chip components to operate effectively and most manufacturers of those IC would package those components with the IC to reduce needless busy work and waste of resources for the customers.

2.3 Using the General Packet Radio Service(GPRS) As A Cellular Network Standard

At the time of writing, Malaysians had the latest in telecommunications network technology available to them, the most advanced of which was the 4G network. Many attest that to date, mobile data services have been very successful due to its easy use, easy payment system and of course, ease of mobility. A wireless device such as a smartphone or tablet could provide the most basic functions that a laptop computer would offer and have a fraction of the weight. Apps have replaced the need to use cumbersome browsers and allow users to access social media sites, video streaming services and even allow online financial services such as banking and shopping, all on a device that fits in the palm of one's hand. With such ease of access, many would debate the use of dedicated internet services such as Unifi™ and Maxis Home Fiber™, and indeed many have cease to rely on fixed line internet services because of the mobility of wireless data usage. Wireless networks however do have one glaring weakness, and that is unreliable signal reception. If a device is unable to receive signals of sufficient strength, then any telecommunication service is halted. The most reliable frequency band for cellular networks is the GSM 900 which operates at frequencies around 900 Mhz. These

Of all the cellular networks that have been developed, 2G networks are the most simple but robust standards of wireless telecommunication. GPRS (General Radio Packet Service) is an extension or improvement of the standard GSM cell network. The GPRS cell network is capable of faster data transmission than GSM, theoretically achieving 170 kbps while GSM could only transmit about 14.4 kbps as stated by (Ghribi & Logrippo, 2000) in the journal Understanding GPRS: The GSM Packet Radio Service. This is due to the way a data packet is transmitted through the network. While GSM used circuit-switching to allocate data to and from a subscriber, GPRS used packet switching which allowed more data transfers for any one subscriber and helped distribute frequency channels more efficiently While GSM formed the foundation for future cellular networks, GPRS made data transmission for mobile devices a reality. The authors also stated that GPRS networks could provide basic internet access such as low-capacity internet browsing, emails and basic transactions like credit card purchases. The 2G networks are still in use today but

only for voice capacity and simple data transfers such as SMS. In areas where 4G and 3G are not available, GPRS could still be accessed as both GPRS and GSM operate under the same frequency band.

GPRS is also considered to be better than GSM in terms of location management. Location management is a mechanism or method that a cellular network may discover, and afterwards connect with, a cellular device. In the journal, Location Management for GPRS by (Ning, et al., 2005), the GPRS network was compared to the GSM in terms of its capability and capacity of tracking mobile devices within an area. The importance of GPRS as a cellular network is evident in this situation, as GSM networks use static LA while GPRS use LA, CA and RA. LA stands for Location Area, in which an area is designated and a number of devices are stated to be included in said area. This is known as static registration, where the number of devices do not change unless a mobile device moves from one LA to another. CA and RA are abbreviations of Cell Area and Routing Area respectively. CA is a cell and RA is a group of cells. These differ from LA as GPRS uses packet-switching to notify and change the area registration when a mobile device moves from one area to another but the system also updates the cells periodically as well as when mobiles change areas. This shows how much more complex the GPRS network is compared to GSM, moreover the handover procedures are much more accurate.

In terms of bandwidth, the 900 Mhz band has many different uses other than cellular network communication channels. Much of the frequency band is used for research, testing, government usage, industrial development and many other uses. As such, the cellular networks are very limited in terms of bandwidth. According to Channel Allocation for GPRS by (Lin & Yi-Bing, 2001), the GPRS network has better channel allocation than GSM due to its flexibility by using packet-switching. With packet-switching, GPRS users enjoy higher data rates than GSM and shorter access time. GSM uses circuit-switching which prioritizes space in any communication connection. For circuit-switching, a user is given access to one channel for an amount of time. The connection from the caller to the recipient will not be in any way modified or disturbed by the system, except under special circumstances. Because of this, the congestion rate is very high. When one connection occupies a channel, no other user may use that channel. The same could not be said for

packet-switching. Packet-switching does not prioritize space. Instead, packet-switching prioritizes time, more specifically bit allocation for timeslots. In one channel, more than one user may be using a GPRS cell service. This is because packet-switching sends bits from many users in a single frame, simultaneously connecting multiple subscribers at a time. This and further development for packet-switching would allow better management of bandwidth, which is already a strained natural resource.

2.4 Wireless Transmission for GPRS

With any telecommunications network, one of the core components is the transmission medium. The implementation of a specific transmission medium for a specific communication requirement will enhance or degrade the performance of a system. While it is widely acknowledged that using fixed cable lines like copper wire or fiber optic cables are much better in terms of data transfer speed, the fact remains that the line is fixed and therefore unmovable. With wireless networks, users are able to move about without worrying about the connection or having a cable attached to a socket in the wall. According to Quadband GSM/GPRS/EDGE Polar Loop Transmitter by (Sowlati, et al., 2004), EDGE or Enhanced Data GSM Evolution is an improvement over the GPRS cell network standard in terms of data transfer rates. Because of this, EDGE suffers from reduced area coverage as the stringent data transfer protocol requires the SNR ratio to be very low. To counteract this, the authors proposed the use of 8-PSK to improve the SNR and data transfer protocol. The implementation of 8-PSK digital modulation and the feedback loop to the amplifier has increased system efficiency overall. EDGE itself uses the same band of frequency as GPRS, which is 900 Mhz. Due to the frequency band's robust nature for penetrating obstacles and propagating around obstacles, the 900 Mhz band is very much still in demand.

The aim of this project is to relay and amplify the GPRS signal from having a weak signal reception to having a strong or steady signal reception, however any signal would