DESIGN POWER AMPLIFIER FOR GPS APPLICATION

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This Report is Submitted in Partial Fulfillment of Requirements for the Bachelor Degree of Electronic Engineering (Telecommunication Electronics)

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Universiti Teknikal Malaysia Melaka

April 2011

UNIVERSTI TEKNIKAL MALAYSIA MELAKA
FAKULTI KEJURUTERAAN ELEKTRONIK DAN KEJURUTERAAN KOMPUTER

BORANG PENGESAHAN STATUS LAPORAN
PROJEK SARJANA MUDA II

Tajuk Projek	:	DESIGN POWER AMPLIFIER FOR GPS APPLICATION BASE ON S-PARAMETER
Sesi Pengajian	:	1 0 / 1 1

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ACKNOWLEDGEMENT

I wish to express sincere, heartfelt appreciation to those involved in the completion of this project.

First and foremost, I wish to express special thanks, appreciation and deep gratitude t my project supervisor, Encik Azahari bin Salleh, who has been there to provide continuous guidance, advice, encouragement, support and generous amount of time in helping me to complete this project. His remarkable unique ways and professionalism of handling my weaknesses has turned my simplistic mind to see think in more rational and critical view. It has been a great pleasure and privilege tp learn from someone who is professional like him.

Sincere appreciation of course goes to my friends who give me unselfish support and special thanks to my parents, Md Nayan bin Md Isa and my mother Zauyah binti Mat Isa because always support me.

Above all, I would like to offer my deepest appreciation and thanks giving to Allah S.W.T. There is ni way to measure what You’ve worth. You are The One who has made things possible. You deserve all glory and honor.

ABSTRACT

This thesis is analyzing the Power Amplifier for GPS Application. The power amplifier is in the transmitting chain of the GPS system. They are the final amplification stage before the signal is transmitted. Its must produced enough output power to overcome channel losses between the transmitter and receiver signal gain. The ultimate goal is to design a Power Amplifier which covers range of GPS L1 frequency at 1.575 GHz. The design will focus on designing of matching network base on three difference types of matching network which is single stub element, quarter-wave element and lumped element. Matching is important because to maximize power delivery and minimize power loss and to improve signal to noise ratio as in sensitive components. This power amplifier design is to achieve high power output, gain, noise figure, and insertion loss through the GPS frequency range. The stability analysis of power amplifier is one of the most critical and the most challenging aspects of power amplifier design. This work shows an analysis technique, which accurately predicts the oscillations in power amplifier. Using the technique, different matching techniques and circuits are design and implementation. The transistor was choosing is NPN Bipolar power transistor (AT-41533). The frequency for AT-41533 power transistor is up to 5 GHz. The power amplifier is design based on simulation using AWR Software and the output gain is 15.921 dB using single stub element, 15.13 dB by using quarter wave element and 14.953 dB by using lumped element. From the analysis, we know that single stub element is the good impedance matching because it can fulfill the requirement parameter of the GPS application.

ABSTRAK

Tesis ini menganalisis Penguat Kuasa untuk Aplikasi Sistem Kedudukan Global (GPS). Penguat kuasa dalam rantai penghantaran dari Sistem Kedudukan Global. Ia adalah tahap amplifikasi terakhir sebelum isyarat ini dihantar kepada penerima. Kuasa keluaran yang dihasilkan perlu cukup untuk mengatasi kerugian saluran antara pemancar dan penerima isyarat keuntungan. Tujuan utamanya adalah untuk mereka bentuk sebuah Penguat Kuasa yang merangkumi frekuensi L1 GPS di 1.575 GHz. Rekaan akan fokus pada perancangan yang sesuai pangkalan rangkaian pada tiga jenis perbezaan rangkaian pencocokan yang tunas elemen tunggal, unsur suku gelombang dan elemen lumped. Pencocokan ini penting kerana untuk memaksimumkan penghantaran kuasa dan meminimumkan kerugian daya dan untuk meningkatkan nisbah isyarat terhadap hingar seperti dalam komponen-komponen sensitif. Rekaan power amplifier ini adalah untuk mencapai keluaran yang tinggi, gain, noise figure, dan insertion loss melalui julat frekuensi GPS. Analisis kestabilan power amplifier adalah salah satu yang paling kritikal dan aspek yang paling mencabar dari mereka bentuk power amplifier. Karya ini menunjukkan sebuah teknik analisis yang tepat memprediksi ayunan di power amplifier. Dengan menggunakan teknik ini, teknik pencocokan yang berbeza dan litar adalah rekaan dan pelaksanaan. Transistor yang dipilih adalah Bipolar NPN transistor kuasa (AT-41533). Frekuensi untuk AT-41533 transistor kuasa hingga 5 GHz. Penguat kuasa rekaan berdasarkan simulasi menggunakan perisian AWR ialah 15,921 dB gain keluaran menggunakan elemen stub tunggal, 15.13 dB dengan menggunakan elemen gelombang suku dan 14.953 dB dengan menggunakan elemen lumped. Dari analisis, kita tahu bahawa elemen tunas tunggal adalah pencocokan impedansi baik kerana dapat memenuhi keperluan parameter dari aplikasi GPS.

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CHAPTER I

INTRODUCTION

This chapter will discuss the overview process that involved for this project; the aims and specific objectives of the project, problem statements, work scope, methodology and result. The end of this chapter the thesis outline will be listed.

1.1 Project Background

This project implements the Power Amplifier (PA) for Global Positioning System (GPS) system. It's a software project but lastly must fabricate the result of simulation. Power amplifier is building in satellite transponder on GPS transmission system. Input signal is generally small and needs to be amplified sufficiently to operate an output device. Power Amplifier is design to amplify that signal (RF signal) and provides a large version of the signal that may direct to and antenna. It's also required to amplify the wanted signal without distortions and without other impairments which would decrease the usefulness of the signal. Power Amplifier is design operating in Class A linear mode over range of 1575.42 MHz. In this project, the transistor was use is the power transistor. Figure 1.1 shows the Power Amplifier on GPS system.

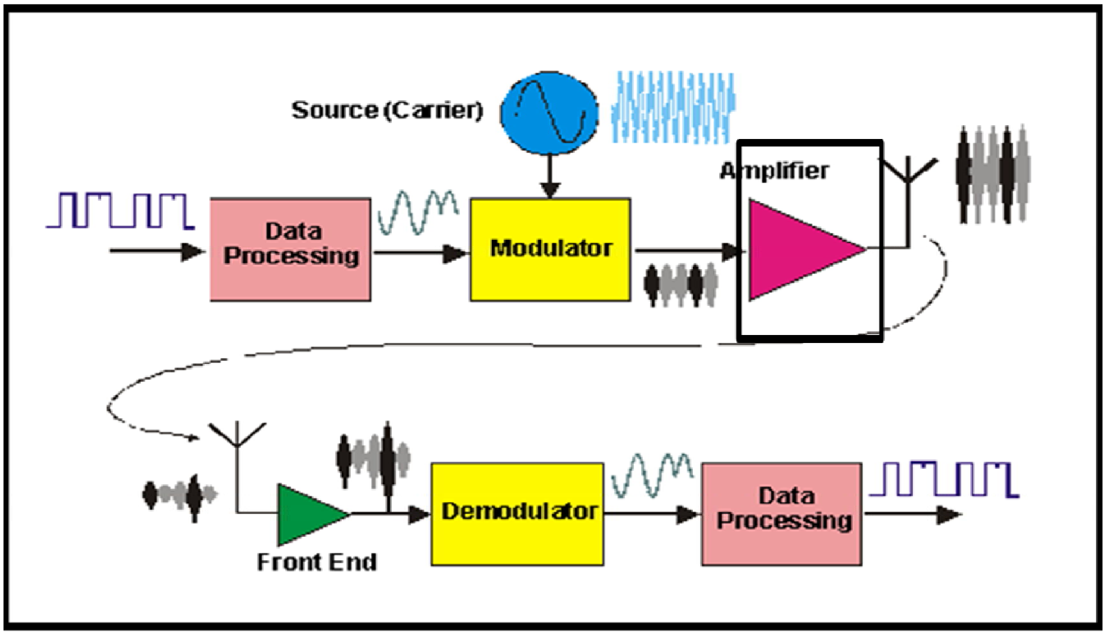

Figure 1.1: Power Amplifier on GPS system

1.2 Objective

Objective of this project is to design,, simulate and analysis the Power Amplifier for GPS application. Design and analyze matching network base on s-parameters for Power Amplifier at L1 Frequency (1575.42 MHz). The power amplifier designed at L1 frequency (1575.42 MHz) for civilian.

1.3 Problem Statement

The amplifier is used to increase the signal that drives the signal to the antenna. Without the amplifier, low-power radio-frequency cannot be converting into a large signal of significant power. It's also can't optimized to have a high efficiency, high output power compression, good return loss on the input and output, good gain and optimum heat dissipation for driving a signal to the antenna. Signal also has a loss, wanted signal with distortions and other impairments.

1.4 Project Scope

Scope for this project is analyzing the power amplifier for GPS system at L1 frequency. The frequency is 1575.42MHz. The software that will be use is AWR to simulate the power amplifier. Analyze the power amplifier base on stability, gain, input and output return loss at frequency 1.575 GHz using AWR software. Analyze and comparison on type of matching network base on this element:-

(a) Stub element
(b) Quarter wave element
(c) Lumped element

Table 1.1 shows the parameters that been used in this project:-

Table 1. 1 Parameters requirement

Parameter	Requirement
Operating frequency	1.575 GHz
Gain	>10dB
Bias Point	V_{VE}=2.7V I_C=10mA
Transistor	AT-41533

1.5 Thesis Outline

Chapter 1 is about an introduction of project which includes an explanation of project background, a brief introduction of Global Positioning System (GPS) and Power Amplifier (PA), method used in Power Amplifier design, objectives of project, and project scopes.

Chapter 2 of background study defines in detail about GPS and PA , and also about method and type of matching used in the design work.

Chapter 3 contains a research methodology which includes the steps to design power amplifier and a brief explanation of methodology flow chart.

Chapter 4 contains a details explanation of an amplifier design technique which consist a single stage amplifier design, DC biasing design and input output matching design.

Chapter 5 discusses about the selection of transistor and the result from this project, S-parameter analysis, comparison matching network and all gain analysis. Also include the calculation for design.

Chapter 6 reveals the conclusion of this project and future works suggestion on this project.

CHAPTER II

GLOBAL POSITIONING SYSTEM

2.1 Global Positioning System (GPS)

The GPS system consists of three pieces. There are the satellites that transmit the position information, there are the ground stations that are used to control the satellites and update the information, and finally there is the receiver that we purchased. It is the receiver that collects data from the satellites and computes its location anywhere in the world based on information it gets from the satellites GPS is part of a satellite-based navigation system developed by the U.S. Department of Defense under its NAVSTAR satellite program. Figure 2.1 shows the NAVSTAR GPS System Segments.

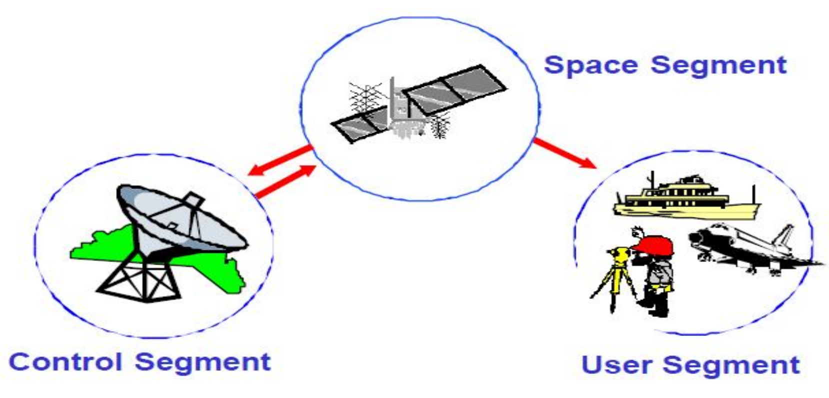

Figure 2. 1 NAVSTAR GPS System Segments

2.2 GPS Orbits

The fully operational GPS includes 24 or more active satellites approximately uniformly dispersed around six circular orbits with four or more satellite each. The orbits are inclined at an angle of 55^o relative to the equator and are separated from each other by multiples of 60^o right ascension. The orbits are no geostationary and approximately circular, with radii of 26,560km and orbital periods of one half sidereal days. Theoretically, there are more GPS satellite will always be visible from most points on the earth's surface and four or more GPS satellite can be used to determine an observer's position anywhere on the earth's surface 24 hour per day.

2.3 GPS signals

Each GPS satellite carries a cesium and/or rubidium atomic clock to provide timing information for the signals transmitted by the satellites. Internal clock correction is provided for each satellite clock. Each GPS satellite transmits two spread spectrum, L-band carrier signal. L1 signal with carrier frequency and an L2 signal with carrier frequency. These two frequencies are integral multiples and of a base frequency . The L1 signal from each satellite uses binary phase-shift keying (BPSK), modulated by two pseudorandom noise (PRN) codes in phase quadrature, designated as the C/A-code and P-code. The L2 signal from each satellite is BPSK modulated by only the P-code. Figure 2.2 shows the GPS signals code and carrier frequencies.

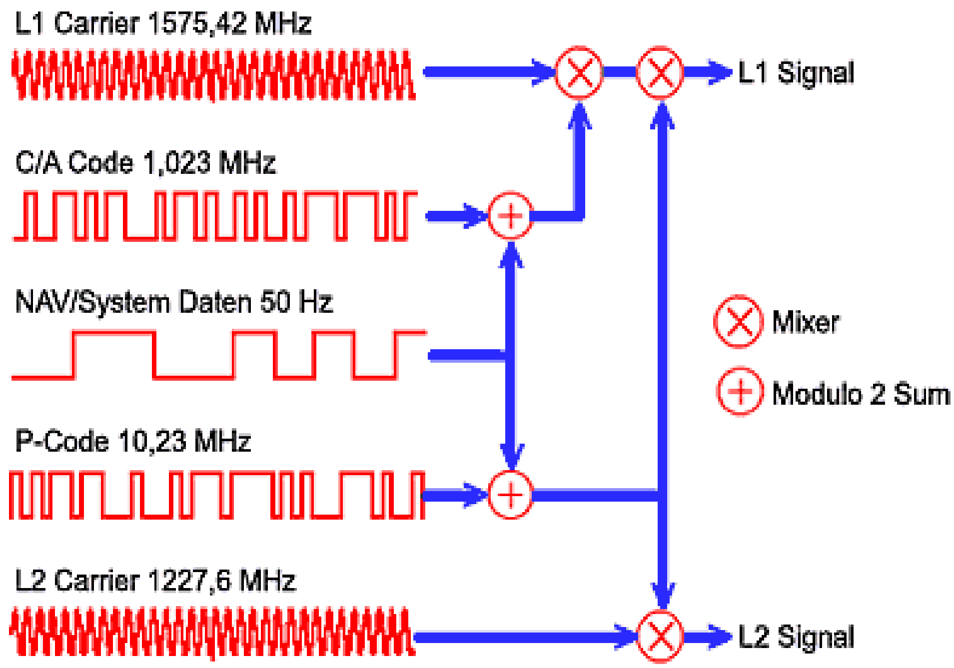

Figure 2. 2: GPS signal code and carrier frequencies

2.4 L1 carrier frequency

L1 is a civilian-use signal, to be broadcast on the same L1 frequency (1575.42 MHz) that currently contains the C/A signal used by all current GPS users. Figure 2.5 shows the demodulating and decoding signals in GPS system Implementation will provide C/A code to ensure backward compatibility assured of 1.5 dB increases in minimum C/A code power to mitigate any noise floor increase. Non-data signal component contains a pilot carrier to improve tracking enables greater civil interoperability with Galileo L1. Figure 2.4 shows the signal that transmits from satellite.

2.5 Demodulation and decoding

Figure 2.3 shows demodulating and decoding signal in GPS System.

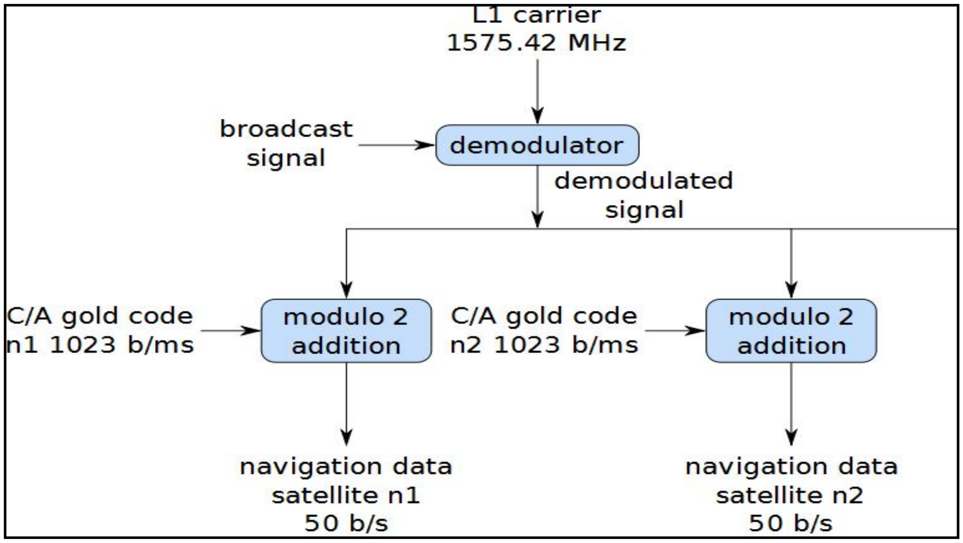

Figure 2. 3: GPS satellite transmissions

Figure 2.4 shows the transmission signal from satellite

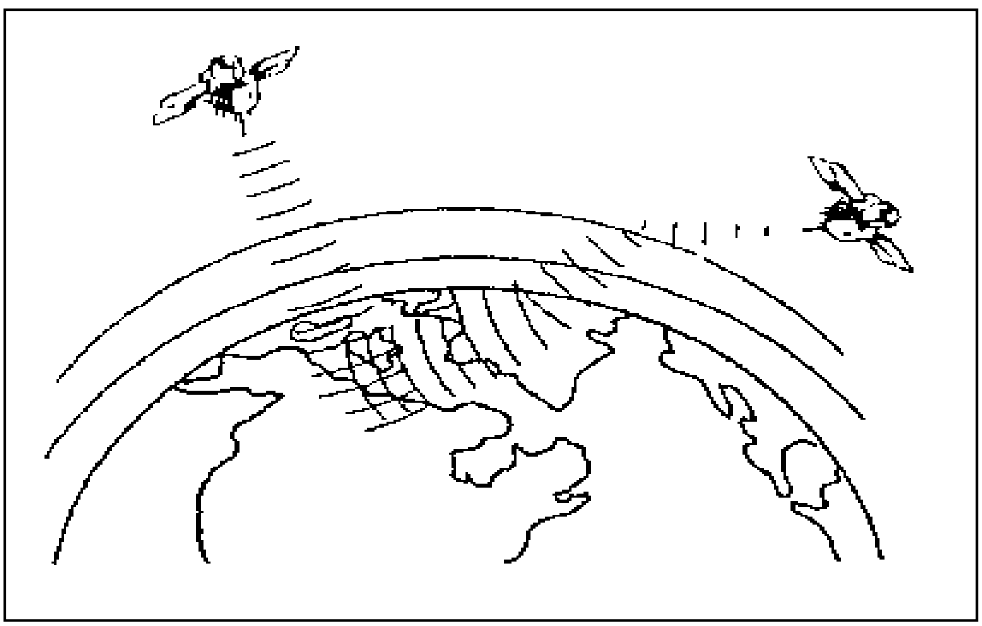

Figure 2. 4: Satellite signals

GPS satellites use the microwave L-band to broadcast three separate radio-navigation signals on two separate RF channels usually called L1 (around 1.6 GHz) and L2 (around 1.2 GHz). These frequencies were chosen as a compromise between the required satellite transmitter power and ionospheric errors. The influence of the ionosphere decreases with the square of the carrier frequency and is very small above 1 GHz. However, in a precision navigation system it still induces a position error of about 50m at the L1 frequency during daylight and medium solar activity. On the other hand, GPS were designed to work with omnidirectional, hemispherical-coverage receiving antennas. The capture area of an antenna with a defined radiation pattern decreases with the square of the operating frequency, so the power of the on-board transmitter has to be increased by the same amount.

GPS broadcast two different signals: a Coarse/Acquisition (C/A) signal and Precision (P) signal. The C/A-signal is only transmitted on the higher frequency (L1) while the P-signal is transmitted on two widely-separated RF channels (L1 and L2). Since the frequency dependence of ionospheric errors is known, the absolute error on each carrier frequency can be computed from the measured difference between the two P-transmissions on L1 and L2 carries.

The L1 C/A- and P-carriers are in quadrature to enable a single power amplifier to be used for both signals. The L1 and L2 transmitter outputs are combined in a passive network and feed an array of helix antennas. These produce a shaped beam covering the whole visible hemisphere from the GPS orbit with the same signal strength.

All three GPS transmissions are continuous, straightforward BPSK modulated carriers. Pulse modulation is not used. The timing information is transmitted in the modulation: the user's receiver measures the time of arrival of a defined bit pattern, which is a known code. If desired, the modulation code phase can be related to the carrier phase in the receiver to produce even more accurate measurements, since both the carrier frequency and the code rate are derived coherently from the same reference frequency on-board the satellite.