DESIGN OF POWER AMPLIFIER FOR WIMAX APPLICATION

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For the most beloved and supporting parents,

Ahmad Zahrollail Bin Haji Mohd Basri

Rohana Binti Kosri

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ABSTRACT

Broadband technology has rapidly become an established, global commodity required by high percentage of the population. Worldwide Interoperability for Microwave Access (WiMAX) using the Orthogonal Frequency Division Multiple Access (OFDMA) modulation to suit multi-path environments that gives network operators higher throughput and capacity. Without power amplifier (PA), the signal will attenuate itself through the transmission line and resulting receiver can't construct the original signal information. In order to overcome the problem, PA with the ability to achieved high gain and high output power is placed in front of the transmitter to boost the signal high enough to ensure the receiver get all the signal information that it should received and loss can be avoided. This project is basically is to design PA that will operate in the frequency range of 3.3 GHz to 3.8 GHz which licenses frequency allocation for IEEE 802.16 or WiMAX. The aim for this project is to get gain, S_{21} more than 12 dB by comparing several design technique of the PA such as balanced amplifier and feedback amplifier in order to get the best performance of PA after the analysis between the designs. The implementation of the design is based on the AWR Microwave Office software used to perform simulation of the power amplifier design. Analysis will be done by comparing the results of calculations and simulation and between the design techniques. At the end of this project, it is shown that the results nearly the same for both calculation and simulation and feedback amplifier gives the best result of gain, S_{21} which is about 15.60 dB in average.

ABSTRAK

Teknologi jalur lebar dengan pantasnya bertapak di komoditi global yang dikehendaki oleh peratusan tinggi penduduk dunia. Saling Boleh Kendali Seluruh Dunia Untuk Akses Gelombang Mikro (WiMAX) menggunakan modulasi Capaian Berbilang Pembahagian Frekuensi Ortogon (OFDMA) bagi memenuhi keperluan persekitaran pelbagai laluan yang memberi daya pemprosesan dan kapasiti lebih tinggi kepada operator jaringan. Tanpa penguat kuasa (PA), isyarat yang melalui transmisi talian akan mengalami pengecilan yang menyebabkan penerima isyarat tidak dapat menjana isyarat asal yang di hantar. Untuk mengatasi masalah tersebut, PA dengan keupayaan untuk mencapai gandaan yang tinggi diletakkan di bahagian hadapan sistem pemancar bertujuan untuk meningkatkan gandaan isyarat sehingga isyarat asal mampu diterima oleh sistem penerima. Projek ini pada asasnya bertujuan untuk mereka bentuk PA yang boleh beroperasi pada julat frekuensi dari 3.3 GHz sehingga 3.8 GHz dimana ianya adalah julat frekuensi berlesen untuk IEEE 802.16 atau WiMAX. Tujuan utama projek ini adalah untuk mendapatkan gandaan, S_{21} lebih besar daripada 12 dB dengan membuat perbandingan beberapa teknik rekabentuk PA seperti penguat terimbang dan penguat suapbalik bagi mendapatkan hasil PA terbaik selepas membuat analisi antara teknik. Rekabentuk dilaksanakan dengan berasaskan perisian AWR Microwave Office digunakan untuk menjalankan simulasi terhadap rekabentuk PA. Analisis akan dijalankan dengan membandingkan keputusan antara pengiraan dengan simulasi dan antara teknik rekabentuk. Di akhir projek, analisis menunjukkan keputusan antara simulasi dan pengiraan hampir sama dan penguat suapbalik menunjukkan hasil terbaik yang memberikan gandaan, S_{21} dengan purata sebanyak 15.60 dB.

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LIST OF ABBREVIATIONS

SYMBOL	DEFINITION
BS	Base Station
CS	Central Station
BA	Balanced Amplifier
DA	Distributed Amplifier
FCC	Federal Communications Commission
FET	Field Effect Transistor
IF	Intermediate Frequency
IL	Insertion Loss
IMD	Intermodulation Distortion
LNA	Low Noise Amplifier
MAG	Maximum Available Gain
MAN	Metropolitan Area Network
MWO	Microwave Office
NF	Noise Figure
OFDM	Optical Time Division Multiplexing
OTDM	Orthogonal Frequency Division Multiplexing
PA	Power Amplifier
PAE	Power Added Efficiency
QAM	Quadrature Amplitude Modulation
RF	Radio Frequency
SOA	Safe Operating Area

VSWR	Voltage Standing Wave Ratio
WiMAX	Worldwide Interoperability for Microwave Access
Wi-Fi	Wireless Fidelity
WLAN	Wireless Local Area Network

LIST OF SYMBOLS

C	Capacitor
dB	Decibel
f	Frequency
g	Element Values
G	Giga
h	Height
Hz	Hertz
I	Current
K	Rollet's Stability Factor
km	Kilometer
L	Inductance
M	Mega
m	Meter
mA	Miliampere
mm	Milimeter
mW	Miliwatt
nm	Nanometer
π	Pi
P	Power
R	Resistance
S	Scattering
T	Tera
V	Voltage

ω	Angular Frequency
Y	Admittance
Z	Impedance
Γ	Reflection Coefficient
δ	Fractional Bandwidth
ε_r	Relative Dielectric Constant
η	Efficiency
λ	Wavelength
Ω	Ohm

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CHAPTER I

INTRODUCTION

Wireless communications technology grows rapidly over recent years. Worldwide Interoperability for Microwave Access (WiMAX) can be considered as one of the newest product of the wireless communication system. In Malaysia, there are a lot of interest in developing and implementing this technology in Malaysian community especially by local university and also private sector. In order to fulfill the user's need for high data rate communications, WiMAX has been introduced replacing the previous wireless communication system such as IEEE 802.11-based Wireless – Fidelity (Wi-Fi) systems which belong to the class of Wireless Local Area Network (WLAN) that has a lower data rate and lower scale of coverage.

1.1 Project Background

Worldwide Interoperability for Microwave Access (WiMAX) is a generic name for a wireless digital communications system, also known as IEEE 802.16.It

covers both fixed point to point, fixed point to fixed multi-point and fixed point to mobile multi-point [1]. WiMAX is a complementary for all of the cabled transmission line system such as coaxial cable, fiber optic and others. It covers a whole range of operating frequency bands, both licensed and non-licensed, operating powers and modulation techniques [1]. This wireless technology is based on Orthogonal Frequency Division Multiplexing (OFDM) technology by taking advantage of ever increasing computing power in the digital signal processing development [2].

The requirement for the WiMAX amplifiers are among the toughest as they simultaneously push the boundaries of RF transmit bandwidth, average power out of the antenna, efficiency and linearity. That is where the need for the deployment of the power amplifier in the WiMAX systems. The power amplifier is a key component in WiMAX systems. Its function is to amplify the power energy of the RF signal from the transceiver, which comes from baseband with OFDMA modulation. The power amplifier would then transmit this energy to an antenna, which would radiate this energy to free space.

Large scale coverage bandwidth of wireless communications system makes the circuit design of key RF blocks of front end transceiver such as power amplifier become more difficult task because of its complex circuit design. The challenging aspect that the engineer couldn't take lightly is designing power amplifier for the wide band RF systems which require linearity demand meets. WiMAX power amplifier (PA) has a considerations such as linearity, efficiency, gain, insertion loss, and return loss which can't be overlook because its difficulties. As varied as the system requirements may be, the specific requirements of a given amplifier can also vary considerably. Nevertheless, there are common requirements for nearly all amplifiers, including frequency range, gain/gain flatness, power output, linearity, noise figure/noise power, matching, and stability [3].

Basically, the design of amplifier over a broad frequency range is a matter of properly designing the reactively matched circuit, travelling wave circuit, cascade

single stage distributed amplifier, feedback circuit or loss matched circuit in order to compensate for the variation of frequency [4]. The best technique chosen to get the best required parameters result.

1.2 Problem Statement

Without Power Amplifier in the WiMAX system, the signal information that being transmit by transmitter will attenuate itself which will cause the receiver can't get the full information from the signal or can be called loss. The signal transmits attenuate because of its natural consequence of signal transmission over long distances. Power amplifier boost the signal before being transmitted to ensure the receiver get all the signal information that it should received and loss can be avoided. High losses or lack of bandwidth also have many undesirable effects upon the linearity and noise figure for amplifiers with classic power combining architectures.

By designing the Power Amplifier for the WiMAX application, the RF performance is excellent because its ability to achieve the high gain, high output power and high power added efficiency. Because of that, designing power amplifier for WiMAX application need to find the optimal balance between high power and high efficiency in order to ensure robust links, high data rates, and good range for the WiMAX services.

There are numerous techniques for designing RF power amplifiers. Amplifier design technique such as Distributed Amplifier technique and several other sub-techniques needs to be analyzing in order to get the best method for constant gain along the desired frequency range of 3.3 GHz to 3.8 GHz.