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FACULTY OF ENGINEERING
CAIRO – EGYPT
Electronics and Communications Engineering Department

Design of Wide Band RF Power Amplifier

A Thesis
Submitted in partial fulfillment for the requirements of the degree of **Master of Science in Electrical Engineering**

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STATEMENT

This Thesis is submitted to Ain Shams University in partial fulfillment of the degree of Master of Science in Electrical Engineering.

The work included in this thesis was carried out by the author in the Department of Electronics and Communications Engineering, Ain Shams University.

No part of this Thesis has been submitted for a degree or a qualification at any other university or institute.

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Acknowledgment

All my thanks to Allah, to the successful completion of this work.

I express my deepest gratitude and thanks to Prof. Dr. Esmat A. Abdallah, Former President of Electronics Research Institute, Electronics Research Institute, for her continuous supervision support. Prof.Esmat is behind all analytical, technical and even spiritual actions throughout this work. Without her encouragement, the thesis could not reach this level.

Thanks are also due to Prof. Hadia El Hennawi, Former Dean of the Faculty of Engineering, Ain Shams University, for her understanding, patience, encouragement, besides, overcoming any obstacles that might interfere with my work.

Also, my deepest gratitude and sincerest thanks to Dr. Hany M. Taher for his supervision.

My deepest gratitude and sincerest thanks to Dr. Ahmed S. Mahmoud for his fruitful guidance through the course of the work, encouragement, endless help especially in fabrication and measurements and many illuminating discussions.

Thanks for my colleagues and friends in Microstrip Department and the Electronics Research Institute staff for being around me helping and caring.

Many thanks for my mother, father and brothers for their great hearts which looked after me all these years.

To my mother and my father, who had a great influence on shaping my character

To my family and my friends

To my professors and teachers who had feed me with their fruitful knowledge

ABSTRACT

The power amplifier is the most critical element in the transmitter path because it is the most power hungry block and also affects the total performance of the system. The purpose of power amplifier is to amplify the power of the RF signal before it is fed to the antenna. It is expected to provide a sufficient output power for reliable transmission. High gain reduces the number of amplifier stages required to deliver the desired output power and hence reduces the size and manufacturing cost. High efficiency improves thermal management, better lifetime and operational costs. Good linearity is necessary for bandwidth efficient modulation. However, these are contrasting requirements and a typical power amplifier design would require a certain level of compromise. There are several types of power amplifiers which differ from each other in terms of gain, linearity, output power or efficiency depending on the application in which the communication system is used.

In contrast to the standard GSM, the UMTS standard allows mobile and wireless transmission of broadband signals, e.g. video and internet data. The UMTS standard offers high voice quality, high data rates and high network capacity and thus, accelerates the consolidation of the communication, information and mobile multimedia technology. Despite the roll-out of the UMTS standard, GSM is still an important part of the mobile communication and will remain for some years. UMTS mobile phones are conceived in such a way that they also work in a GSM network (dual mode) and therefore, data transfer is also guaranteed in the areas, similarly multi-standard transceiver base stations which support the UMTS-standard and the GSM-standard are in demand.

The challenge of this thesis is to design a power amplifier with 2 GHz center frequency which is able to operate in the UMTS-frequency band (center frequency around 2.14 GHz) and also in the frequency bands of GSM-1800 (center frequency around 1.8 GHz). This so-called multiband base station concept is also able to handle the variation of the used frequency bands in different global regions. The flexibility of the operating frequency offered by this amplifier concept enables short reaction time for newly-introduced standards.

The thesis introduces the design, simulation and manufacturing of class A power amplifier. The first contribution is designing and realizing 2 GHz high linearity wide band class A power amplifier which serves as a stage in multiple stages power amplifier for UMTS and GSM standards. A ready-

made software package advanced design system (ADS) is used in the design and optimization process of the power amplifier. The measurements results of the power amplifier with 3-dB bandwidth extended from 1.5 to 2.3 GHz are 31.242 dBm output power, 17 dB gain, 30% efficiency, 0.8 dB/dB maximum deviation AM/AM and 0.5 degree/dB maximum deviation AM/PM conversions. The second achievement is implementing a DGS filter at the amplifier output for total elimination of the unwanted harmonics. A ready-made software package Zeland IE3D is used in the design and optimization process of the filters. The DGS filter used is constructed by three units array of the Square head dumbbell shape to be suitable for covering the required stop band from 4 to 10 GHz. The dielectric material used is Teflon with permittivity of 2.33 and dielectric thickness of 0.508 mm. The performance of the DGS microstrip line offers -41.2, -45.6, -56.8 and -41 dB attenuation for the second, third, fourth and fifth harmonic components, respectively, which is sufficient to force the harmonic components beyond -60 dBc. The total system performance which consists of the class A power amplifier followed by the DGS filter at the output has measured results of 31.135 dBm output power, 16.9 dB power gain while the harmonics were almost totally removed.

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List of Symbols

A_V	Voltage gain
$A^2_{V_{loaded}}$	Loaded voltage gain
C	Capacitance
F	Actual noise figure
f	Frequency
G	Power gain
G_T	Transducer gain
h	Dielectric thickness
K	Stability factor
L	Inductance
P_{avail}	Power available from the source
P_{load}	Power delivered to the load
R_L	Load resistance
t	Strip thickness
Z_0	Characteristic impedance
Γ	Reflection coefficient
ε_r	Dielectric constant
η	Efficiency
θ	Electrical length
λ	Wavelength