LOW-POWER RF PREDISTORTION FOR BROADBAND MM-WAVE POWER AMPLIFIERS

By

Maysara Mohamed Mohamed Hamada

A Thesis Submitted to the
Faculty of Engineering at Cairo University
in Partial Fulfillment of the
Requirements for the Degree of
MASTER OF SCIENCE
in
Electronics and Communications Engineering

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Under the Supervision of

Prof. Ahmed N. Mohieldin
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Title of Thesis:

Low-Power RF Predistortion for Broadband mm-Wave Power Amplifiers

Key Words:
Power Amplifier; Linearization; Predistortion; Broadband; Translinear

Summary:
The 5G standard is expected to impose several tough challenges on RF transceivers due to its high 28-GHz carrier frequency, extremely large 1-GHz channel bandwidth, and multicarrier modulation scheme with high PAPR. This is particularly important for the PA because the required linearity and bandwidth force a huge power consumption and very low efficiency, and most linearization and efficiency enhancement techniques are difficult to utilize within these constraints. This work presents two ideas utilizing the predistortion principle to linearize a broadband millimeter wave PA. Simulation results of two variants of the first idea show a 4.2 dB linearity enhancement to the PA at the worst corner and an insertion loss of 7.25 dB in the first variant, or a 2 dB enhancement with an insertion loss of 2.9 dB in the second variant. The second idea achieves a linearity improvement of 3.5 dB at the worst corner with an insertion loss of 2.1 dB.

Dedication

To my beloved parents,

Mohamed Hamada & **Mervat Badr**

My dear brothers,

Nader Hamada & **Amr Hamada**

My beautiful nieces,

Nelly Nader & **Dorra Nader**

My cute nephews,

Selim Nader & **Mourad Amr**

Acknowledgements

I was definitely gifted by an amazing professor, Dr. Ahmed Nader Mohieldin, who was an excellent mentor and a great supporter throughout this work. It's extremely rare to work with a professor who's willing to contribute to literature research and mathematical derivations with students. He definitely set the standard for the kind of professor I want to be when I get my PhD degree.

A lot of credit goes to the Analog Devices Inc. Egyptian Design Center for providing the technology PDK and licensed simulation platforms, as well as funding tapeouts. Most engineers have been very helpful throughout the course of this work.

A token of gratitude goes to my research companion, Youssef Abdelkader, without whom this work would have never been accomplished. His enthusiasm, dedication, and exemplary work ethic have been extremely inspiring to me. His technical creativity has also been an integral factor towards the work we've finalized.

Also, special thanks go to my dear friend Mohamed Badr, who has been extremely helpful and dedicated a considerable amount of his time to help me understand Latex and get the thesis documentation done in time.

Last but not least, my deepest appreciation goes to my family, particularly my parents, who have been extremely tolerant and encouraging. This work wouldn't have been done if it hadn't been for them.

Table of Contents

List of Tables

List of Figures

List of Symbols and Abbreviations

Symbol	Description
Π	Product
Σ	Summation
Ω	Ohm
α	Power Series Gain Coefficient
β	Bipolar Transistor Current Gain
λ	Wavelength
ω	Frequency in rad/sec

Abbreviation	Description
OFDM	Orthogonal Frequency Divison Multiplexing
LTE	Long-Term Evolution
HSPA	High Speed Packet Access
DSP	Digital Signal Processing
RF	Radio Frequency
PAPR	Peak-to-Average Power Ratio
PA	Power Amplifier
THD	Total Harmonic Distortion
AM	Amplitude Modulation
IM	Intermodulation
C/IM	Carrier-to-IM
IP	Intercept Point
IIP	Input-Referred IP
OIP	Output-Referred IP
PM	Phase Modulation
MOS	Metal-Oxide-Silicon

BER	Bit Error Rate
EVM	Error Vector Magnitude
ACPR	Adjacent Channel Power Ratio
QAM	Quadrature Amplitude Modulation
PSK	Phase-Shift Keying
EER	Envelope Elimination and Restoration
PVT	Process-Voltage-Temperature
LDO	Low Drop-Out
DC	Direct Current
LINC	Linear Amplification of Nonlinear Components
VGA	Variable Gain Amplifier
LNA	Low-Noise Amplifier
ADC	Analog-to-Digital Converter
CMOS	Complementary MOS
MMW	Millimeter Wave
FET	Field-Effect Transistor
HEMT	High Electron Mobility Transistor
PDK	Process Design Kit
GaAs	Gallium Arsenide
CDMA	Code Division Multiple Access
LDMOS	Laterally Diffused MOS
TSMC	Taiwan Semiconductor Manufacturing Company
BiCMOS	Bipolar CMOS
SiGe	Silicon Germanium
BJT	Bipolar Junction Transistor
ADS	Advanced Design System
FBMC	Filter Bank Multicarrier
UFMC	Universal Filtered Multicarrier
MATLAB	Matrix Laboratory
AC	Alternating Current
IC	Integrated Circuit
Wi-Fi	Wireless Fidelity