WIDEBAND ACTIVE-BALUN VARIABLE-GAIN LOW-NOISE AMPLIFIER FOR MOBILE-TV APPLICATIONS

by

LO KENG WAI

M-A2-6275-3

Master of Science

in

Electrical and Electronics Engineering

April 2010

Faculty of Science and Technology

University of Macau

UNIVERSIDADE DE MACAU
仁義禮知信
澳門大學

WIDEBAND ACTIVE-BALUN VARIABLE-GAIN LOW-NOISE AMPLIFIER FOR MOBILE-TV APPLICATIONS

by

LO KENG WAI

A thesis submitted in partial fulfillment of the
requirements for the degree of

Master of Science (M.Sc.)
in
Electrical and Electronics Engineering

Faculty of Science and Technology
University of Macau

April 2010

Approved by _____
Supervisor

_____
Co-supervisor

_____

_____

Date _____

UNIVERSIDADE DE MACAU
仁義禮知信
澳門大學

In presenting this thesis in partial fulfillment of the requirements for a Master's degree at the University of Macau, I agree that the Library and the Faculty of Science and Technology shall make its copies freely available for inspection. However, reproduction of this thesis for any purposes or by any means shall not be allowed without my written permission.

Signature _____

Date _____

UNIVERSIDADE DE MACAU
仁義禮知信
澳門大學

Wideband Active-Balun Variable-Gain Low-Noise Amplifier for Mobile-TV Applications

ABSTRACT

The rapid development of wireless communications and CMOS technology has facilitated the integration of radio frequency (RF) systems as a System-on-Chip (SOC) for cost and power reductions. One of the applications is the RF TV tuner for Digital Video Broadcasting-Handheld (DVB-H). With the development of digital mobile TV industry the TV tuner system has gained wide attention recently.

Variable Gain Low-Noise Amplifier (VGLNA) is one of the most important modules in the TV tuner system. The main function of a VGLNA is to provide enough gain to suppress the noise of subsequent stages as well as adding as little noise as possible.

Recent works on wideband low-noise amplifiers (LNAs) based on an active-balun structure have shown reliable RF performances such as moderate noise figure (NF), high linearity and broadband input impedance matching. This structure has exhibited great potential in minimizing the required external components of multi-band mobile-TV tuners, i.e., an active-balun LNA requires just one radio frequency (RF) input pin and eliminates the need of external balun for each band, which is necessary in the current design.

This thesis will propose a novel active-balun LNA with forestage and poststage gain controls. With this forestage-poststage gain controls the system noise figure and linearity can be easily traded for different gain levels. In addition, the benefits of this design allow also the decrease in circuit complexity, chip area and the power consumption. In this architecture just one Single to Differential (S2D) amplifier is required.

The first part of this work will introduce the theoretical MOSFET noise model and conventional VGLNA circuits. The second part will present the circuit level design based on the proposed architecture. The VGLNA was designed with two passive attenuators inter-operating with an active core to optimize the RF performances under different reception scenarios. It was implemented in a 0.18μm CMOS process with 1.8V of voltage-supply.

Finally, the simulation results of the whole circuit are presented. The VGLNA supports both VHF-III (170 to 240 MHz) and UHF (470 to 860 MHz) bands while offering low NF and S_{11} <-10 dB at all gain levels. The forestage and poststage gain controls flexibly befit reception at different signal-to-interferer levels. The circuit achieves good performances in the required frequency bands and satisfies the requirements of the mobile TV tuner applications.

UNIVERSIDADE DE MACAU
仁義禮知信
澳門大學

ACKNOWLEDGEMENTS

I would like to take this opportunity to express my gratitude to my supervisor – Dr. Pui-In Mak and co-supervisor – Prof. Rui Martins for their generous guidance and patience throughout my study. Without their support, inspiration, and patience, my work in these years would not be so fruitful. I would also like to take this opportunity to thank the colleagues in the Analog and Mixed-Signal VLSI Laboratory for giving me support and guidance which were essential and valuable in my research work.

Next, I would like to thank my friend, Mr. Sunny Chio, Mr. U-Fat Chio and Mr. Chang-Hao Chen for their technical and non-technical discussions in the past that have enhanced my knowledge quite considerably.

Special thanks should be given to the laboratory technician – Mr. Fan Ng, who helped me to solve numerous problems. Finally, I am deeply indebted to my parents for their unconditional love and support over the years. Without them, I would not have obtained my harvest by now.

Lo Keng Wai (Neo)
April 2010

UNIVERSIDADE DE MACAU
仁義禮知信
澳門大學

LIST OF ABBREVIATIONS

ATT : attenuator

BW : bandwidth

CMFB : common mode feedback

CMOS : complementary metal oxide semiconductor

CG-CS : common gate common source topology

DC : direct current

DVB-H : digital video broadcasting handheld

IC : integrated circuit

IF : intermediate frequency

IIP3 : third-order input intercept point

NF : noise figure

OpAmp : operational amplifier

PSRR : power supply rejection ratio

RC : resistor-capacitor

RF : radio frequency

S2D : single-to-differential

SNR : single to noise ratio

SOC : system-on-chip

TV : television

UHF : ultra high frequency

VGLNA : variable gain low noise amplifier

VHF : very high frequency

UNIVERSIDADE DE MACAU
仁義禮知信
澳門大學

TABLE OF CONTENTS

UNIVERSIDADE DE MACAU
仁義禮知信
澳門大學

LIST OF FIGURES

LIST OF TABLES

UNIVERSIDADE DE MACAU
仁義禮知信
澳門大學