Faculty of Electronic and Computer Engineering

INTEGRATION OF WIDEBAND LOW NOISE AMPLIFIER WITH NOTCH FILTER USING DEFECTED MICROSTRIP STRUCTURE

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DECLARATION

I declare that this thesis entitles "Integration of Wideband Low Noise Amplifier with Notch Filter using Defected Microstrip Structure" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature :…………………………………………………...

Name :NASRULLAH BIN SAIFULLAH……………...

Date :…………………………………………………..

APPROVAL

I hereby declare that I have read this thesis and in my opinion, this thesis is sufficient in terms of scope and quality for the award of Master of Science in Electronic Engineering.

Signature	:	....
Name	:	ASSOC. PROF. DR. ZAHRILADHA BIN ZAKARIA
Date	:	....

DEDICATION

To my beloved mother and father

ABSTRACT

Low noise amplifier is a crucial device in microwave wireless communication system which typically located in receiver parts. Wider bandwidth of low noise amplifier is theoretically much harder to be designed compared with narrowband. There are some designs has been presented in this thesis which covers wideband and ultra-wideband produced using Advanced Design System (ADS). Besides that, this research presents new methods designing low noise amplifier at wideband (4 GHz – 7 GHz) and ultra-wideband (3.1 GHz – 10.6 GHz) which cover 3 GHz and 7.5 GHz of bandwidth respectively. The first design operated at UWB frequencies implementing negative feedback which provide gain flatness throughout the frequency band. Furthermore, resistive matching provides good input and output matching for wide frequency range. The second design introduces inductive source degeneration which provides an improvement on S11 and S22 with very small degradation of noise figure. This design being supported by multi - section quarter wave transformer matching which provides wideband characteristic to the design. The third design is an improvement of second design by introducing balanced topology that provides good S11 and S22. The forth design implemented a wideband amplifier which designed using distributed amplifier with inductive source degeneration and multi-section quarter wave transformer matching. However, when designing wider bandwidth low noise amplifier, some existing standard such as IEEE 802.11 WLAN which operate at 5 GHz may cause an interference at the particular frequency band. As a way to prevent the interference from the current system that operates in the frequency band, a defected structure was presented to produce a notch response. Several designs of DMS was made which is G – Shaped, C - Shaped and U - Shaped to provide the best attenuation with desired rejection band. The best design which is U – Shaped DMS which has 15 dB attenuation and 1 GHz of rejection band. The integration of U – Shaped DMS ha been done for all of the design and the best design achieved is the second design which provide S11 and S22 of less than -8 dB from 3.1 GHz – 5 GHz and 6 GHz – 10.6 GHz. This design provide gain of more than 10 dB and noise figure of less than 4 dB. The achieved attenuation ratio is 26 dB with nearly 1 GHz rejection bandwidth. The benefit of integration of low noise amplifier with notch filter is the reduction of overall size while providing amplification and attenuation function simultaneously. This design is considered appropriate and a different solution for wireless and radar application without any additional or external connection between low noise amplifier and band – stop filter.

ABSTRAK

Penguat hingar rendah merupakan alat penting dalam sistem komunikasi tanpa wayar gelombang mikro yang biasanya terletak di bahagian penerima. Jalur lebar yang lebih tinggi untuk penguat hingar rendah adalah secara teori jauh lebih sukar untuk direkabentuk jika dibandingkan dengan jalur sempit. Di samping itu, kajian ini membentangkan kaedah baru dalam merakabentuk penguat hingar rendah pada jalur lebar (4 – 7 GHz) dan jalur lebar ultra (3.1 – 10.6 GHz) yang masing - masing meliputi 3 GHz dan 7.5 GHz lebar jalur. Terdapat beberapa rekabentuk yang dibentangkan dalam tesis ini yang meliputi jalur lebar dan jalur lebar ultra dihasilkan menggunakan perisian Advanced Design System (ADS). Rekabentuk pertama beroperasi pada frekuensi UWB melaksanakan maklum balas negatif memberikan kerataan keuntungan sepanjang jalur frekuensi. Tambahan pula, pemadanan rintangan menyediakan masukan dan keluaran kehilangan balikan yang baik sepanjang jalur frekuensi. Rekabentuk kedua memperkenalkan kemerosotan sumber induktif yang menyediakan penambahbaikan pada masukan dan keluaran kehilangan balikan dengan kemerosotan kecil pada angka hingar. Ia disokong oleh pelbagai - seksyen gelombang suku pengubah dengan menyediakan ciri – ciri jalur lebar. Rekabentuk ketiga adalah hasil peningkatan rekabentuk kedua dengan menggunakan topologi seimbang yang menyediakan masukan dan keluaran kehilangan balikan yang tinggi. Rekabentuk keempat melaksanakan Satu rekabentuk jalur lebar direkabentuk menggunakan penguat diedarkan dengan sumber degenerasi induktif dan pelbagai seksyen suku gelombang pengubah. Walau bagaimanapun, apabila merekabentuk penguat hingar rendah berjalur lebar tinggi, beberapa standard yang sedia ada seperti IEEE 802.11 WLAN yang beroperasi pada 5 GHz boleh menyebabkan gangguan pada jalur frekuensi tertentu. Sebagai cara untuk menghalang gangguan dari sistem semasa yang beroperasi dalam frekuensi tersebut, struktur hakisan telah diperkenalkan untuk menghasilkan tindakbalas notch. Beberapa rekabentuk DMSs telah dibuat iaitu berbentuk - G, berbentuk – C dan berbentuk - U untuk menyediakan kelemahan yang tertinggi dengan jalur penolakan yang dikehendakki. Rekabentuk DMS yang terbaik berbentuk - U yang mempunyai 15 dB kelemahan dan 1 GHz jalur penolakanReka bentuk terbaik dicapai adalah reka bentuk kedua yang menyediakan S11 dan S22 kurang daripada -8 dB dari 3.1 GHz – 5 GHz dan 6 GHz – 10.6 GHz. Rekabentuk ini juga menyediakan keuntungan lebih dari 10 dB dan angka hingar kurang dari 4 dB. Kehilangan balikan yang dicapai ialah 26 dB dengan jalur penolakan menghampiri 1 GHz. Manfaat integrasi penguat hingar rendah yang rendah dengan penapis takuk adalah pengurangan saiz keseluruhan sambil memberikan penguatan dan fungsi pengecilan serentak. Reka bentuk ini dianggap sesuai dan penyelesaian yang berbeza untuk aplikasi tanpa wayar dan radar tanpa apa-apa sambungan tambahan atau luar Antara penguat hingar rendah dengan perhentian jalur.

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ADC	-	Analog – to – Digital Converter
ADS	-	Advanced Design System
BJT	-	Bipolar Junction Transistor
CMOS	-	Complementary Metal–Oxide Semiconductor
DC	-	Direct Current
DMS	-	Defected Microstrip Structure
DGS	-	Defected Ground Structure
DSP	-	Digital Signal Processing
DS–UWB	-	Direct-sequence Ultra-wideband
FCC	-	Federal Communications Commission
FET	-	Field Effect Transistor
GaAs	-	Gallium Arsenic
GPS	-	Global Positioning System
HBT	-	Heterojunction Bipolar Transistor
IDS	-	Drain-Source Current
IEEE	-	Institute of Electrical and Electronics Engineers
LNA	-	Low Noise Amplifier
LC	-	Inductor Capacitor
LO	-	Local Oscillator
MB-OFDM	-	Multi-Band Orthogonal Frequency Division Multiplexing
MOSFET	-	Metal – Oxide Semiconductor Field Effect Transistor
MESFET	-	Metal–Semiconductor Field-Effect Transistor

NTIA	-	National Telecommunications and Information Administration
pHEMT	-	pseudomorphic High Electron Mobility Transistor
RF	-	Radio Frequency
SNR	-	Signal to Noise Ratio
TEM	-	Transverse Electromagnetic
TSMC	-	Taiwan Semiconductor Manufacturing Company
UWB	-	Ultra – Wideband
VDS	-	Drain-Source Voltage
VGS	-	Gate-Source Voltage
VNA	-	Vector Network Analyzer
VSWR	-	Voltage Standing Wave Ratio
WLAN	-	Wireless Local Area Network

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