DEPARTMENT OF ELECTRICAL ENGINEERING

DELHI TECHNOLOGICAL UNIVERSITY

(Formerly Delhi College of Engineering)

Bawana Road, Delhi-110042

CERTIFICATE

This is to certify that the Project entitled **"Realization of wave active filter using Voltage Differencing Buffered Amplifier"** submitted by **Sandeep Rana** in completion of major project dissertation for Master of Technology degree in **Control and Instrumentation** at Delhi Technological University is an authentic work carried out by him under my supervision and guidance.

This is to certify that the above statement made by the candidate is correct to the best of my knowledge.

Place: Delhi

(PROF. PRAGATI KUMAR)

Professor

Department of Electrical Engineering

ACKNOWLEDGEMENT

It gives me immense pleasure to express my sincere gratitude to all people who helped and inspired me during my dissertation work.

I sincerely acknowledge the earnestness and patronage of my supervisor **Prof. Pragati Kumar**, Department of Electrical Engineering, Delhi Technological University, New Delhi, for his invaluable guidance, support and motivation throughout this project work. It has been a great experience to get a basic training of research under his rich experience, exemplary patience and exceptional capabilities of reducing complexities to simpler form. In spite of his busy schedule, he was always available whenever I needed help.

I would like to extend my sincere thanks to **Prof. Madhusudan Singh**, Head, Department of Electrical Engineering, Delhi Technological University, New Delhi, for his persistent effort in mobilizing the resources and clearing the visions to work on the project. I also wish to thank all faculty members for their constant guidance and support.

I would like to express heartful thanks to my parents, siblings and friends for their understanding and endless love. Thank you for always being there for me.

Above all, thanks to Almighty God blessing and guiding me throughout my life. May your name be exalted, honored and glorified.

SANDEEP RANA

ABSTRACT

Analog filters play a key role in any modern communication, instrumentation and electronic system. Though today the entire signal processing world seems to be digital, the presence of continuous time filters can be found at every interface with analog world.

With the evolution of several new active building blocks in open literature, there is a great advancement in active filter design. Voltage Differencing Buffered Amplifier (VDBA) is a recently proposed voltage mode active block which has been widely used for filtering as well as signal generation circuits. VDBA combines the features of transconductance amplifier and buffered amplifier.

To meet the stringent sensitivity requirements, higher order analog filters are designed by simulating resistively terminated LC ladder. Active simulation of LC ladder is done primarily by three techniques Element replacement method, Operational simulation and wave active approach. The present work deals with the realization of higher order analog filters using wave active approach. Wave active approach offers several advantages over other techniques such as modular structure, use of lossy integrators etc. This approach is quite similar to the element replacement approach for the design of higher order filters. In this approach wave port terminator equivalents of shunt arm and series arm of a doubly terminated LC ladder are designed with the help of different active building blocks. In the present work, Voltage differencing buffered amplifier has been used to derive series and shunt arm wave equivalents. The workability of the discussed method is shown by implementing 4^{th} order Butterworth low pass filter. Due to virtue of wave active approach a complementary high pass output response is also obtained. All the circuits presented in the dissertation have been simulated on PSPICE.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF SYMBOLS, ABBREVIATIONS

S.No.	Symbols/ Abbreviations	Descriptions
1.	g_m	Transconductance
2.	ω_0	Natural Frequency
3.	Q	Quality Factor
4.	V_{SS}	Source Supply Voltage
5.	V_{DD}	Drain Supply Voltage
6.	R_m	Trans-resistance
7.	I_B	Bias Current
8.	ASP	Analog Signal Processing
9.	DSP	Digital Signal Processing
10.	ABB	Active Building Block
11.	CMOS	Complementary Metal Oxide Semiconductor
12.	Op-Amp	Operational Amplifier
13.	VDBA	Voltage Differencing Buffered Amplifier
14.	FDNR	Frequency Dependent Negative Resistance
15.	OTA	Operational Transconductance Amplifier
16.	CC	Current Conveyor
17.	CFOA	Current Feedback Operational Amplifier
18.	CDBA	Current Differencing Buffer Amplifier

19.	DVCCTA	Differential Voltage Current Conveyor Transconductance Amplifier
20.	DVCCCTA	Differential Voltage Current Controlled Conveyor Transconductance Amplifier
21.	CCDDCCTA	Current Controlled Differential Difference Current Conveyor Transconductance Amplifier
22.	OTRA	Operational Trans-Resistance Amplifier
23.	VDTA	Voltage Differencing Transconductance Amplifier
24.	WAF	Wave Active Filter
25.	WAE	Wave Active Equivalent
26.	VD-DIBA	Voltage Differencing Differential Input Buffered Amplifier
27.	DO-VDBA	Dual output Voltage Differencing Buffered Amplifier
28.	FB-VDBA	Fully Balanced Voltage Differencing Buffered Amplifier