

UNIVERSITI TEKNOLOGI MARA

**PERFORMANCE AND ROBUSTNESS
ANALYSIS OF ITERATIVE TURBO
DECODING STOPPING CRITERIA
FOR HIGH DATA RATE
TRANSMISSION**

MOHAMAD YUSUF BIN MAT NASIR

Thesis submitted in fulfillment
of the requirements for the degree of
Master of Science
(Electrical Engineering)

College of Engineering

December 2022

ABSTRACT

In the early termination of turbo-decoding iterations, stopping criteria are used to minimise the decoding delay without sacrificing performance. However, most stopping criteria have been integrated with low-modulation techniques. To adapt the stopping criteria to high-speed networks, they need to be integrated into high-modulation techniques. Hence, to address this requirement, this research aimed to analyse the performance and robustness of stopping criteria with high-modulation techniques for high data rate transmission contexts. Several stopping criteria, including cross-entropy (CE), the sign-change-ratio (SCR), the hard-decision-aided (HDA) approach and improved minimum descriptive length (IMDL), were integrated and tested using quadrature amplitude modulation (QAM). The research also developed a predefined threshold computation technique using MATLAB as the simulation tool to determine suitable thresholds for iterative turbo-decoding stopping criteria. From the performance analysis, it was found that most performances of the CE, HDA and SCR stopping criteria with QAM were close to the fixed stopping criterion. However, IMDL performances tended to suffer from bit error rate (BER) performance degradation. The study also determined suitable thresholds for CE, SCR and IMDL of 0.01, 0.03 and 0.00001, respectively. The robustness results illustrate that the CE threshold of 0.01 is the most robust stopping criterion, and it is capable of coping with signal-to-noise ratio mismatch. In contrast, the IMDL threshold of 0.00001 is less robust. Choosing suitable stopping criteria can minimise the iteration number and provide good BER performance. The findings from the analysis provided will help future researchers choose the most suitable stopping criteria from the existing options.

ACKNOWLEDGEMENT

Firstly, I wish to thank God for allowing me to embark on my Master's study and complete this long and challenging journey. My gratitude and thanks go to my supervisor Dr. Roslina Mohamad, both my co-supervisor, Dr. Murizah Kassim and Prof Dr. Noritawati Md Tahir

My appreciation goes to the School of Electrical Engineering, College of Engineering, who provided the facilities during the simulation. Special thanks to my colleagues and friends for helping me with this project.

Finally, this thesis is dedicated to my father and mother for their vision and determination to educate me. This piece of victory is dedicated to both of you. Alhamdulillah.

TABLE OF CONTENTS

	Page
CONFIRMATION BY PANEL OF EXAMINERS	ii
AUTHOR'S DECLARATION	iii
ABSTRACT	iv
ACKNOWLEDGEMENT	v
TABLE OF CONTENTS	vi
LIST OF TABLES	ix
LIST OF FIGURES	x
LIST OF SYMBOLS	xiv
LIST OF ABBREVIATIONS	xvi
LIST OF NOMENCLATURE	xviii
CHAPTER ONE INTRODUCTION	1
1.1 Research Background	1
1.2 Problem Statement	2
1.3 Objectives	2
1.4 Scope and Limitation of the Study	3
1.5 Significance of Study	3
1.6 Thesis Organisation	4
CHAPTER TWO LITERATURE REVIEW	6
2.1 Introduction	6
2.2 Turbo Code	6
2.2.1 Turbo Encoder	7
2.2.2 Turbo Decoder	8
2.3 Overview of Iterative Turbo Decoding Stopping Criteria	9
2.3.1 Research on Iterative Turbo Decoding for Convergence Output Stopping Criteria	11
2.3.2 Research on Iterative Turbo Decoding for Convergence and Non- Convergence Output Stopping Criteria	13

2.4	Iterative Turbo Decoding Stopping Criteria Algorithm	14
2.4.1	CE	14
2.4.2	HDA	15
2.4.3	SCR	15
2.4.4	IMDL	16
2.5	Research on Turbo Codes with High-Speed Networks	17
2.6	The QAM Technique	18
2.7	Conclusion	20
 CHAPTER THREE RESEARCH METHODOLOGY		21
3.1	Introduction	21
3.2	General Research Methodology	21
3.3	Integration of Iterative Turbo Decoder Stopping Criteria with QAM	22
3.4	Develop the Predefined Thresholds' Computations and Determine Suitable Thresholds	26
3.5	Simulation Parameters for the Robustness Test	27
3.6	Conclusion	28
 CHAPTER FOUR RESULTS AND DISCUSSION		30
4.1	Introduction	30
4.2	Performance Analysis of the Iterative Turbo Decoding Stopping Criteria with QAM	30
4.2.1	Performance of the Stopping Criteria with Different Code Rates	30
4.2.2	Performance of the Stopping Criteria with Different Modulation Sizes	38
4.2.3	Performance of the Stopping Criteria with Different Code Generators	46
4.2.4	Performance of the Stopping Criteria with Different Frame Sizes	54
4.3	The Proposed Threshold Value for Each Stopping Criterion	62
4.4	Robustness Test for the Proposed Threshold Values	66
4.5	Conclusion	75