CORRECTION OF SHIPS' STEERING ANGLE FOR SAFE MANEUVERING AGAINST STRONG WINDS USING MICROCONTROLLER

Thambugala Athukoralalage Shamen Hansaka Thambugala

228940P

MSc/PG Diploma in Industrial Automation

Department of Electrical Engineering

University of Moratuwa
Sri Lanka

June 2025

CORRECTION OF SHIPS' STEERING ANGLE FOR SAFE MANEUVERING AGAINST STRONG WINDS USING MICROCONTROLLER

Thambugala Athukoralalage Shamen Hansaka Thambugala

228940P

Dissertation submitted in partial fulfillment of the requirements for the degree
MSc/PG Diploma in Industrial Automation

Department of Electrical Engineering

University of Moratuwa
Sri Lanka

June 2025

DECLARATION

I declare that this is my own work and this Dissertation does not incorporate without acknowledgement any material previously submitted for a Degree or Diploma in any other University or Institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text. I retain the right to use this content in whole or part in future works (such as articles or books).

Signature: Date: 13 June 2025

The supervisor should certify the Dissertation with the following declaration.

The above candidate has carried out research for the MSc/PG Diploma in Industrial Automation Dissertation under my supervision. I confirm that the declaration made above by the student is true and correct.

Name of Supervisor: Dr. RM Maheshi Ruwanthika

Signature of the Supervisor: Date: 13 June 2025

ACKNOWLEDGEMENT

I am honored to present this thesis as a student of the MSc/PG Diploma in Industrial Automation. I consider myself fortunate to have had the golden opportunity to pursue this programme, which has significantly enriched my knowledge of Industrial Automation. Although I encountered some challenges in understanding certain concepts, the support from my colleagues and the guidance of well-resourced lecturers enabled me to overcome these difficulties.

First and foremost, I would like to express my sincere gratitude to my supervisor, Dr. RM Maheshi Ruwanthika (Department of Electrical Engineering, University of Moratuwa, Sri Lanka), for her invaluable guidance and support throughout this research. I also extend my heartfelt thanks to Professor AGBP Jayasekara (Course Coordinator of the MSc/PG Diploma in Industrial Automation), Professor WDAS Wijayapala, Professor JP Karunadasa, Professor DP Chandima, Professor SP Kumarawadu, Dr. V Logeeshan, Dr. SDMS Gunawardana, and Eng. JL Wickramasinghe, along with all other lecturers who dedicated their time and effort to enhance our theoretical and practical knowledge.

I am also deeply thankful to the Commander of the Sri Lanka Navy, the Director General of Electrical and Electronic Engineering of the Sri Lanka Navy, and all the officers of the Sri Lanka Navy for supprting me. Furthermore, I extend my special thanks to Ms. Suwini Fernando (Coordinator of the MSc/PG Diploma in Industrial Automation) and the staff of the University of Moratuwa for their support.

Lastly, I am profoundly grateful to my parents and my beloved wife for their unwavering support, guidance, and assistance throughout my academic journey.

ABSTRACT

The maritime industry, responsible for approximately 80% of global trade volume, faces significant challenges posed by adverse weather conditions, particularly strong winds. Over-steering in such conditions increases the risk of capsizing, leading to substantial economic and human losses. This research presents the development of a microcontroller-based system designed to adjust ship steering angles in real-time, accounting for wind conditions and enhancing navigational safety. The system integrates various sensors, including wind speed and direction transducers, gyro modules, and GPS receivers, to continuously monitor both environmental conditions and navigational parameters. Data collected from these sensors are processed by a microcontroller, which utilizes a developed mathematical model to assess the impact of wind forces on the ship's motion. Based on this assessment, the model calculates the necessary steering angle adjustments to counteract the effects of wind forces, ensuring stable and safe maneuvering. Key factors considered in the model include wind force, centrifugal force, and heel angle, providing a comprehensive evaluation of ship stability under varying wind conditions. The system is designed to be compatible with existing steering mechanisms, ensuring cost-effectiveness and ease of implementation. Simulations demonstrate the system's ability to predict and correct steering angles accurately, significantly reducing the risk of over-steering and capsizing. Rigorous testing has validated the system's performance, showing substantial improvements in navigational safety under strong wind conditions. The proposed solution offers a robust method for enhancing maritime safety, protecting both crew and cargo.

Keywords: Microcontroller, Maritime, Steering angle, Mathematical models

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

Abbreviation	Description
ADC	Analog-to-Digital Converter
AIS	Automatic Identification Systems
AVR	Advanced Virtual RISC
AVS	angle of vanishing stability
CAN	Controller Area Network
CFD	Computational Fluid Dynamics
CMU	Central Microcontroller Unit
CPU	central processing unit
EEPROM	Electrically Erasable Programmable Read-Only Memory
GPS	Global Positioning System
HMI	Human-Machine Interface
HVAC	heating, ventilation, and air conditioning
LNG	liquefied natural gas
LPG	liquefied petroleum gas
MEMS	Micro-Electro-Mechanical Systems
MWV	Marine Wind Velocity
NMEA	National Marine Electronics Association
ROT	Rate of Turn
SMA	shape memory alloy
SOG	Speed Over Ground
SRAM	Static Random Access Memory
UI	User Interface