iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 13 Issue: VI Month of publication: June 2025

DOI: https://doi.org/10.22214/ijraset.2025.71829

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 13 Issue VI June 2025- Available at www.ijraset.com

Electronic Measurement Techniques for Coating/Paint Thickness Using STM32 Microcontroller

Vinod Yadav[1], Arvind Kumar Mishra[2], Bharat Kathe[3]
Lecturer, Department of Electronics Premlila Vithaldas Polytechnic, SNDT Women's University, Mumbai

Abstract: Paint or coating thickness plays a critical role in product quality control, corrosion resistance, and cost optimization. This paper explores electronic methods for measuring coating thickness on various substrates using STM32 microcontrollers. The methods implemented include Magnetic Induction for ferrous materials, Eddy Current for non-ferrous substrates, and Ultrasonic Pulse-Echo for universal applications. Each sensor method is integrated with STM32 microcontroller-based data acquisition and control, with added support for Bluetooth transmission and Excel-compatible data logging. The goal is to provide a low-cost, modular, and portable alternative to conventional thickness gauges.

Keywords: STM32, Coating Thickness, Magnetic Induction, Eddy Current, Ultrasonic Testing, Non-Destructive Testing (NDT), Paint Gauge, Bluetooth Logging, Sensor Electronics, Excel Interface

I. INTRODUCTION

Thickness measurement of surface coatings and paints is a crucial aspect of industrial quality control. Improper application of coatings can lead to corrosion, wear, and failure of components, especially in critical applications such as aerospace, automotive, and marine industries. Traditional coating thickness gauges, although accurate, are often expensive and may lack customization or integration options for digital data logging. This study introduces a cost-effective system for measuring coating thickness using STM32 microcontroller platforms.

II. MEASUREMENT PRINCIPLES AND METHODS

A. Magnetic Induction Method

This technique is used for measuring non-conductive coatings (e.g., paint) on ferrous substrates. A Hall effect sensor (e.g., A1302) detects changes in magnetic flux density due to coating thickness variation.

B. Eddy Current Method

Suitable for conductive coatings on non-ferrous metal substrates, this method uses the principle of eddy currents. The change in impedance of a coil is related to the thickness of the conductive layer.

C. Ultrasonic Pulse-Echo Method

This technique employs a piezoelectric transducer to send ultrasonic pulses. The time delay of the reflected echo helps compute the thickness of the coating. This method is material-independent.

III. SYSTEM ARCHITECTURE

A. Hardware Components

- STM32F103C8T6 microcontroller (Blue Pill board)
- A1302 Hall Effect Sensor
- Custom Eddy Current Sensor (with driver circuitry)
- Piezoelectric Ultrasonic Transducer
- HC-05 Bluetooth Module
- 16x2 LCD or OLED display (optional)

B. Data Acquisition and Bluetooth Transmission

Sensor outputs are acquired using STM32's ADC or Timer Input Capture modules. Data is processed in real-time and transmitted via Bluetooth to a PC or smartphone. Python scripts and Excel macros support automated logging.

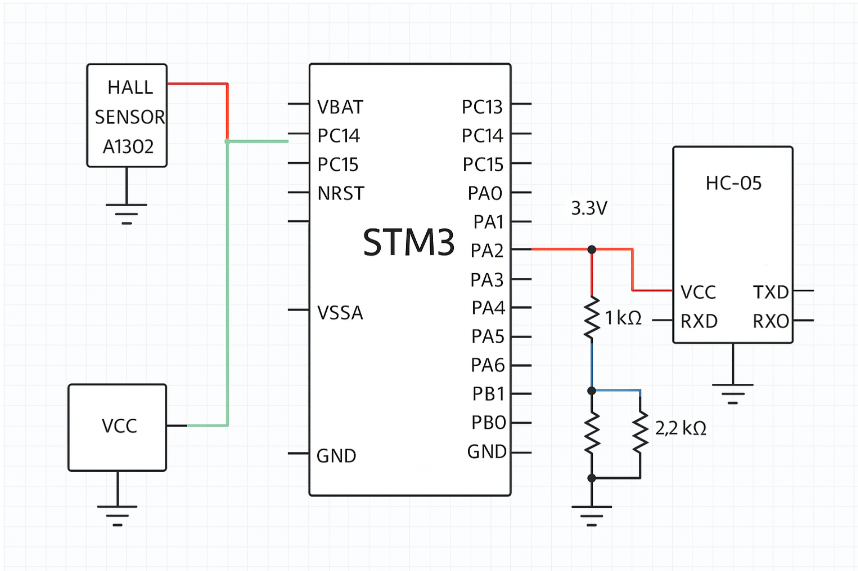


Figure 1:Schematic Diagram of Paint Thickness Measurement System

IV. IMPLEMENTATION AND CODING

The STM32 code was developed using STM32CubeIDE with HAL libraries. The system includes interrupt-based timers for ultrasonic sensing and ADC polling for magnetic and eddy current methods. Results are transmitted over UART to the HC-05 module.

- Sample UART transmission code for STM32:
- HAL_UART_Transmit(&huart1, (uint8_t*)message, strlen(message), HAL_MAX_DELAY);
- Sample ADC read:
- HAL_ADC_Start(&hadc1);
- HAL_ADC_PollForConversion(&hadc1, HAL_MAX_DELAY);
- uint32_t adc_value = HAL_ADC_GetValue(&hadc1);

V. EXPERIMENTAL RESULTS

Prototypes were tested on painted steel, aluminum, and plastic samples. Observed results:

- Magnetic method: Accuracy ±3% for 0–1.5 mm on steel
- Eddy current: Accuracy ±2% for 0–2 mm on aluminum
- Ultrasonic: Resolution of 0.01 mm, applicable to all substrates

VI. PRACTICAL CHALLENGES

- Magnetic method fails on non-ferrous materials
- Eddy current is sensitive to lift-off and curvature
- Ultrasonic requires couplant and smooth surface for accurate echo reception

VII. CONCLUSION

The proposed microcontroller-based system effectively measures coating thickness using three distinct techniques. Its low cost, modularity, and Bluetooth logging make it ideal for educational and industrial field applications. Future work includes Wi-Fi logging, Android app integration, and machine learning-based calibration.

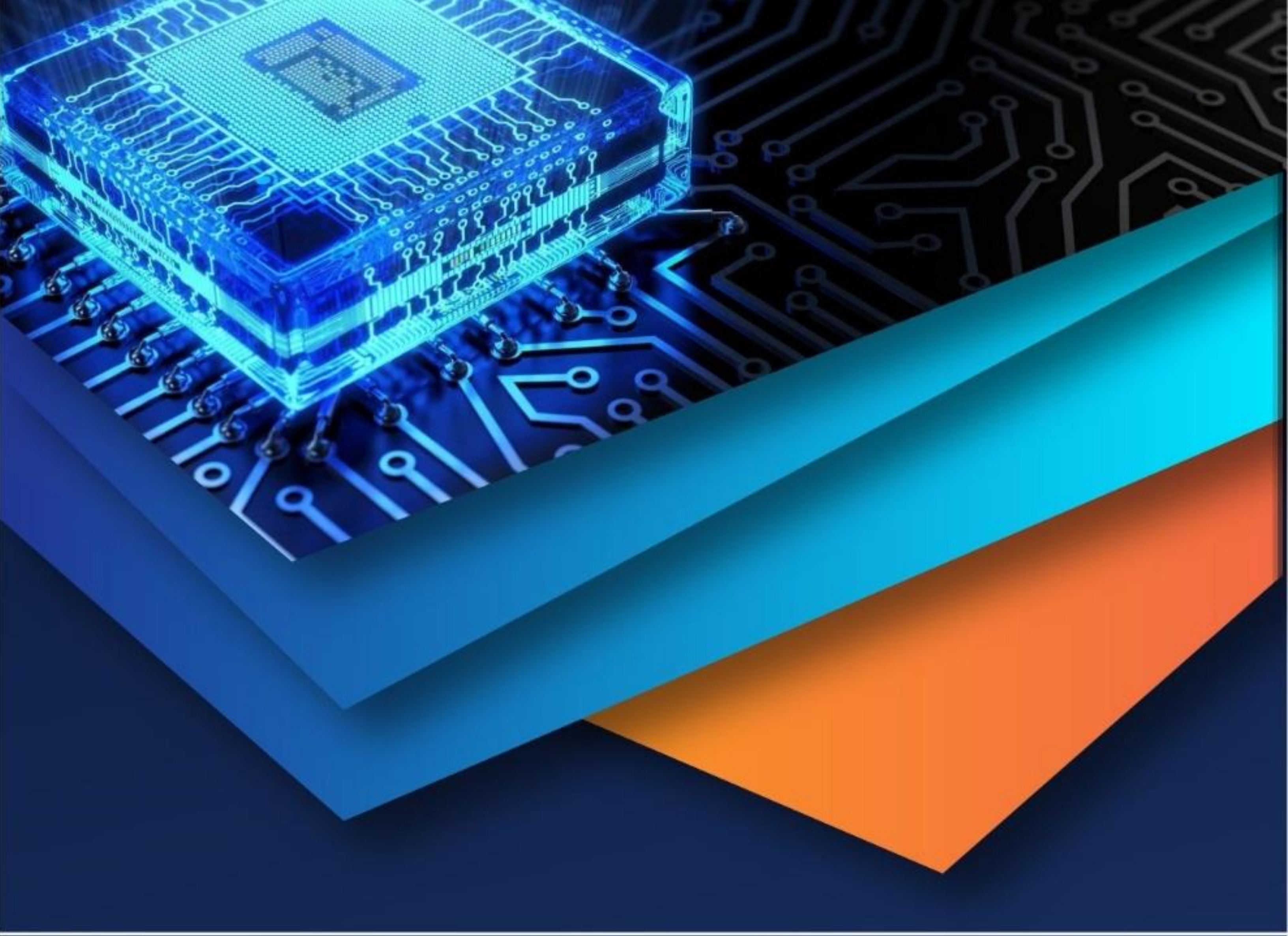
REFERENCES

[1] ISO 2178:2016 – Non-magnetic coatings on magnetic substrates – Magnetic method
[2] ISO 2360:2017 – Non-conductive coatings on non-magnetic metal substrates – Eddy-current method
[3] ASTM E797 – Standard Practice for Measuring Thickness by Ultrasonic Pulse-Echo Contact Method
[4] M. Y. Demirci et al., 'Low-Cost Non-Destructive Thickness Measurement System Using Microcontroller,' Sensors, 2021.
[5] STM32CubeIDE and HAL Libraries – STMicroelectronics Documentation
[6] A1302 Hall Effect Sensor Datasheet – Allegro Microsystems
[7] HC-05 Bluetooth Module Datasheet – Wavesen Technology
[8] Z. Tang et al., 'Development of Eddy Current Sensor for Coating Thickness Measurement,' IEEE Transactions on Instrumentation and Measurement, 2019.
[9] I. A. Ismail, 'Ultrasonic Thickness Measurement System Using Arduino and Piezoelectric Transducer,' IJSE Research, 2020.
[10] G. Srivastava, Electronic Measurements and Instrumentation, New Age International Publishers, 2009.

Vinod Yadav
Lecturer (Selection Grade), Department of Electronics
PremlilaVithaldas Polytechnic, SNDT Women's University, Mumbai
Email: vinod.yadav@pvp.sndt.ac.in

Arvindkumar Mishra
Lecturer, Department of Electronics
PremlilaVithaldas Polytechnic, SNDT Women's University, Mumbai
Email: arvindkumar.mishra@pvp.sndt.ac.in

Bharat Kathe
Lecturer, Department of Electronics
PremlilaVithaldas Polytechnic, SNDT Women's University, Mumbai
Email: bharat.kathe@pvp.sndt.ac.in



10.22214/IJRASET

INDEX COPERNICUS

45.98

IMPACT FACTOR: 7.129

TOGETHER WE REACH THE GOAL

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Call : 08813907089 (24*7 Support on Whatsapp)