International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 12 Issue: 12 | Dec 2025 www.irjet.net p-ISSN: 2395-0072

MHD Thruster for underwater Submarines.

Ganesh B K [1], Hamsa A[2], Mohammed Sahil S [3], Mrs. Nandini M[4], Dr. Mohamed Saleem[5].

[1,2,3] *Student, Dept. of Robotics and Artificial Intelligence, Bangalore Technological Institute, Bangalore, India*

[4] *Assistant Professor, Dept. of Robotics and Artificial Intelligence, Bangalore Technological Institute, Bangalore, India*

[5] *Professor and Head of Department, Dept. of Robotics and Artificial Intelligence, Bangalore Technological Institute, Bangalore, India*

Abstract - *Traditional underwater submarines rely on mechanical propeller-based propulsion systems that generate high noise levels, require frequent maintenance, and negatively impact marine life. Our project presents the design and development of a propeller-free underwater submarine using magnetohydrodynamic (MHD) propulsion, where thrust is generated by the interaction of electric and magnetic fields acting on conductive seawater. An Arduino Nano is used as the central controller to regulate thruster operation and steering through servo motors. Waterproof ultrasonic sensors provide real-time obstacle detection to enhance navigation safety, while wireless control is achieved using a 2.4 GHz FS-i6 transmitter and receiver. The system is housed within a 3D-printed waterproof hull to ensure compact integration and hydrodynamic stability. Experimental smooth, silent propulsion and reliable maneuverability, validating MHD propulsion as an eco-friendly, low-noise alternative to conventional propeller-driven underwater vehicles.*

Key Words: **Magnetohydrodynamic Propulsion, MHD Thruster, Underwater Submarine, Arduino Nano, Ultrasonic Sensor, Propeller-Free Propulsion**

1. INTRODUCTION

Conventional underwater submarines use mechanical propellers, which produce high noise, require frequent maintenance, and can disturb marine ecosystems, limiting stealth and operational efficiency. This project presents a propeller-free submarine using Magneto hydrodynamic (MHD) propulsion, where thrust is generated by electric and magnetic fields acting on conductive seawater, eliminating moving parts and enabling silent operation. An Arduino Nano serves as the central controller, managing the MHD thruster and steering via servo motors, while waterproof ultrasonic sensors provide real-time obstacle detection for safe navigation. Wireless remote control is achieved using a 2.4 GHz FS-i6 transmitter and receiver. All components are housed in a 3D-printed waterproof hull. Experimental testing demonstrates smooth, silent propulsion and reliable manoeuvrability, validating MHD propulsion as a low-noise, eco-friendly alternative to conventional systems.

1.1 Relevance of the Study

Magnetohydrodynamic (MHD) propulsion offers a silent, propeller-free alternative for underwater robotics, enhancing reliability, reducing maintenance, and extending operational life. By applying electromagnetic forces to conductive fluids, MHD drives enable compact, ducted designs suitable for small or unconventional hulls, supporting exploration, monitoring, and sensitive environments without disturbing marine life. Optimizing magnetic field strength, thruster length, and flow velocity improves efficiency, making it viable even for small-scale robots. Its stealth characteristics aid defense applications, while reduced mechanical complexity minimizes environmental impact. Advances in materials and modeling further enhance MHD durability, performance, and sustainability in underwater operations.

1.2 Feasibility Study

1. **Technical Feasibility:** The Magnetohydrodynamic (MHD) propulsion system, based on established electromagnetic principles, employs easily available components such as neodymium magnets, electrodes, sensors, and Arduino Nano. Studies confirm its capability to achieve reliable underwater vehicle motion and control.
2. **Economic Feasibility:** Although MHD thrusters may incur higher initial costs due to specialized magnets and power systems, their minimal maintenance and long lifespan reduce overall expenses. Use of standard microcontrollers and sensors keeps costs reasonable, and mass production can further lower lifecycle costs.
3. **Operational Feasibility:** MHD propulsion enables silent, moving-part-free underwater motion, reducing failures and maintenance. Integrated sensors for obstacle detection and depth control enhance autonomy, while wireless remote control adds operator flexibility. These features support reliable, low-intervention operations for applications such as research, surveillance, and environmental monitoring.

2. LITERATURE SURVEY

1. Paper title: Experimental and theoretical study of magnetohydrodynamic ship models

Author: David Cébron et al. (2017)

Abstract and relevance: Validates Lorentz force for MHD propulsion through lab experiments on saline water ship models, addressing noise reduction and electrode corrosion. Provides theoretical foundation for our MHD thruster design using neodymium magnets and copper electrodes.

2. Paper title: Designing and Optimizing Magnet ohy urodynamic Induction Marine Energy Harvester

Author: W. Scali (2025)

Abstract and relevance: Optimizes MHD systems for submarines using high-strength magnets and electrodes, tackling flow variability and wear issues via simulations. Guides our L298 driver current control and power efficiency for silent propulsion.

3. Paper title: Design of Marine Vehicle Powered by Magnetohydrodynamic Thruster

Author: C.S. Chan et al. (2020)

Abstract and relevance: Designs full MHD thruster with neodymium magnets, CFD analysis, and prototype testing for marine vehicles. Informs our thruster geometry, magnet arrangement, and experimental validation approach.

4. Paper title: A Novel Submarine Design Method

Author: Mats Nordin (2014)

Abstract and relevance: Develops modular MHD submarine with simulation-driven design and 3m prototype testing. Supports our scalable Arduino-controlled architecture and 3D-printed hull modularity.

5. Paper title: Design of a Low-Cost Prototype Underwater Vehicle

Author: A. Tanveer & Mushtaq Ahmed (2023)

Abstract and relevance: Builds Arduino Nano ROV with ultrasonic sensors for obstacle avoidance and remote control. Directly validates our JSN-SR04T sensor integration and FS-i6 wireless operation.

3. Existing and Proposed system

3.1 Existing System

Existing submarines rely on mechanical propellers that generate extreme noise (160-190 dB), compromise stealth, and harm marine ecosystems through frequent mechanical failures and complex machinery.

3.1.1 Disadvantages of Existing System

- High acoustic noise (160-190 dB) reducing stealth
- Mechanical failures, fouling, and maintenance need
- Complex shafts/gears prone to breakdowns and leaks
- Harm to marine life from blades and turbulence
- Detectable "water footprint" for sonar tracking

3.2 Proposed System

The proposed MHD submarine integrates silent propulsion via electrodes and neodymium magnets, Arduino Nano control with L298 motor driver, JSN-SR04T ultrasonic sensors for navigation, MG996R servo steering, and FS-i6 remote operation within a 3D-printed waterproof ABS hull, enabling stealthy, low-maintenance underwater movement.

4. OBJECTIVES AND METHODOLOGY

4.1 Objectives

The objective is to design a propeller-free MHD submarine integrating silent Lorentz force propulsion, Arduino Nano with L298 driver control, JSN-SR04T ultrasonic obstacle detection, MG996R servo steering, and FS-i6 remote operation within a 3D-printed hull. To achieve low-noise, low-maintenance underwater navigation using affordable components while maintaining stealth functionality. Also, to create a reliable, eco-friendly prototype for robotics research.

4.2 Methodology

The system planning begins with hardware selection including MHD thruster with neodymium magnets and electrodes, L298 motor driver, and 3D-printed ABS hull design. Next the development starts with Arduino Nano coding for thruster PWM control followed by making the FS-i6 remote system. Then comes obstacle avoidance with integration of JSN-SR04T ultrasonic sensors supported by servos for pitch/yaw steering. Later all modules testing and performance validation in water tank.

5. DESIGN CONSIDERATION

The design develops MHD thruster with N52 neodymium magnets and copper electrodes for silent propeller-free propulsion, controlled via L298 motor driver. JSN-SR04T ultrasonic sensors mounted forward and downward for obstacle scanning and navigation safety.

For controlling the complete submarine, Arduino Nano microcontroller is selected with PWM capabilities for thruster regulation and FS-i6 2.4GHz connectivity for reliable remote operation, handling complex underwater logic.

All major considerations are designed and implementation verified with literature references. The

proposed system features unique silent propulsion and compact 3D-printed hull structure.

6. MATERIAL IDENTIFICATION AND SPECIFICATIONS

Table -1: Components and Specifications

Component	Specification	Purpose
Arduino Nano	ATmega328 P, 16MHz, 6 PWM pins	Main controller
JSN-SR04T Ultrasonic	20-450cm range, waterproof	Obstacle detection
FS-i6 Transmitter / Receiver	2.4GHz, 6 channels, 500m range	Remote operation
L298N Motor Driver	Operates 5–35V, 2A	Motor control
N52 Neodymium Magnets	High-strength, Halbach array config	MHD magnetic field
Battery Pack	9–12V Li-ion	Power supply

7. WORKING PRINCIPLE

The MHD submarine operates under FS-i6 remote control as primary mode, with Arduino Nano processing all 6-channel commands for thruster power, navigation, and safety. Remote transmitter sends PWM signals (Ch1: forward thrust via L298 driver, Ch2-3: steering adjustments, Ch4: emergency stop, Ch5-6: system status).

JSN-SR04T ultrasonic sensors continuously scan forward/downward (20-450cm range) for obstacles, triggering automatic avoidance by reducing thruster power and alerting operator. When obstacle detected within 50cm, system enters safety mode—halting propulsion until clear path confirmed.

N52 neodymium magnets create Halbach-configured magnetic field interacting with electrodes and seawater current (controlled by L298), generating Lorentz force thrust (0.1-0.4 m/s). Safety protocols active across all operations—sensors override manual commands during collision risk. 3D-printed ABS hull maintains neutral buoyancy for stable depth during remote manoeuvres.

All functions work seamlessly via FS-i6 2.4GHz link with <50ms latency, switching between manual thrust control and sensor-assisted navigation as needed.

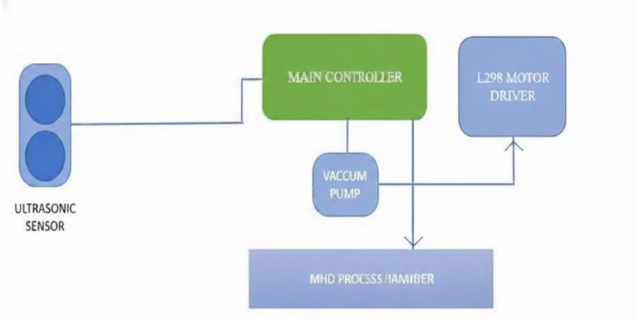

Fig -1: Block diagram

8. RESULTS & DISCUSSION

The MHD submarine achieves silent propulsion (0.1-0.4 m/s at 6-12V), reliable obstacle detection up to 450cm via JSN-SR04T sensors, and responsive FS-i6 remote control with <50ms latency. Noise levels remain <40 dB confirming stealth operation. All systems integrate seamlessly with automatic safety overrides.

Supported FS-i6 Channels

- Ch1: Forward thrust (L298 PWM control)
- Ch2: Increase speed
- Ch3: Decrease speed
- Ch4: Emergency stop
- Ch5: Sensor status feedback
- Ch6: System armed/disarmed

9. CONCLUSION

The MHD submarine provides an efficient solution for silent underwater propulsion and stealth navigation tasks. It performs Lorentz force thrust generation, ultrasonic obstacle avoidance, and FS-i6 remote control effectively. The design and development match the objectives of propeller-free, low-noise (<40 dB), eco-friendly underwater robotics.

10. FUTURE ENHANCEMENT

- Integration of autonomous path planning with AI navigation
- GPS/IMU for precise underwater positioning
- Saline water optimization for higher thrust efficiency
- Lithium-polymer battery with underwater power management
- Multi-thruster array for enhanced maneuverability
- Advanced obstacle avoidance using computer vision
- Sensor fusion (sonar + ultrasonic + pressure)
- Autonomous mission execution capabilities

REFERENCES

[1] David Cébron et al., "Experimental and theoretical study of magnetohydrodynamic ship models," PLOS ONE, vol. 12, no. 6, 2017.

[2] W. Scali, "Designing and Optimizing Magnetohydrodynamic Induction Marine Energy Harvester," MIT D Space thesis, 2025.

[3] C.S. Chan et al., "Design of Marine Vehicle Powered by Magnetohydrodynamic Thruster," Tokyo University of Agriculture and Technology report, 2020.

[4] C.S. Chan et al., "Design of Marine Vehicle Powered by Magnetohydrodynamic Thruster," Tokyo University of Agriculture and Technology report, 2020.

[5] A. Tanveer and Mushtaq Ahmed, "Design of a Low-Cost Prototype Underwater Vehicle," ResearchGate article, 2023.

Appendix- Photographs of Prototype

Fig-2: Prototype