Data Acquisition and Transmission System for Energy Boat

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Abstract- **This paper presents the design, development, and deployment of a reliable, real-time data acquisition and telemetry system for monitoring parameters aboard Team Sea Sakthi's electric catamaran. The Design is to monitor and log parameters like current, voltage, , efficiency of the propulsion system, and navigation metrics like speed and geolocation. These real-time measurements are instrumental in maintaining operation reliability, optimizing power efficiency, and enhancing fault diagnostics of the vessel. The system combines a variety of sensor modalities and employs hybrid data transmission methods involving Radio Frequency (RF) communication for near-shore relays and cloud- enabled IoT solutions for long-range operation insights.**

Keywords—data acquisition, telemetry, electric propulsion, real-time monitoring, CAN protocol, RF communication, IoT

I. INTRODUCTION

Electric boats are to be a sustainable alternative to conventional propulsions with internal combustion engines. Electric catamarans, in fact, have many advantages such as lower environmental impact, lower operating costs, and better hydrodynamic efficiency. For efficient operation, a onboard data acquisition and telemetry system is a requirement for real-time monitoring of energy consumption, system health, and performance. One of the challenge in electric catamaran operation is the efficient collection, processing, and wireless distribution of data such as battery state-of-charge (SoC), state-of-health (SoH), temperature measurements and navigation parameters. This paper introduces an system for real- time data acquisition that aggregates multi-domain sensor data, processes it onboard and distributes the data via radio frequency (RF) and cloud-based telemetry for remote diagnosis and analytical analysis.

II. SYSTEM ARCITECHTURE

II. A. BATTERY MANAGEMENT SYSTEM (BMS) AND DATA ACQUISITION

The BMS plays a crucial role in ensuring the safety, efficiency, and longevity of the battery pack. The system employs a DALLY 300A BMS, specifically designed for high-current applications, and provides protection features such as overcharge, over-discharge, short circuit protection, and temperature monitoring. By continuously tracking the state-of-charge (SoC) and state-of-health (SoH) of the battery, the BMS enables optimal performance while mitigating risks such as thermal runaway. The BMS communicates with the onboard computing system through the CAN protocol although not for the data transmission purpose. This integration ensures battery status updates and enables power distribution based on real- time. The selection of the DALLY 300A BMS is driven by its high current capacity, making it well-suited for the electric propulsion system of the catamaran. As does not appear to be sufficiently fast or accurate for the data transmission, and its data sampling rate seems too low for this specific application. Therefore, we primarily extract data of temperature from the CAN, relying predominantly on sensor outputs while using the BMS data for temperature monitoring.

II. B. CAN PROTOCOL AND MCP2515 TRANSCEIVER

The CAN protocol provides a secure and efficient communication channel between the BMS and the onboard computing unit.. The MCP2515 transceiver serves as a interface between the CAN bus and the ESP32 microcontroller, facilitating seamless data transmission and robust error handling. This integration ensures a stable and noise-resistant connection, preventing data corruption even in harsh maritime environments. Additionally, RF-based telemetry enables reliable data transmission from the vessel to shore, ensuring continuous monitoring and diagnostics over extended distances.

II. B. 1.CAN data format:

Baud rate: 250k

II. B. 2. Address assignment

Module	Address
BMS master	0x01
Bluetooth APP	0x80
GPRS	0x20
Upper computer	0x40

II. B. 3 CAN Communication Format

CAN ID (4 Bytes)	Data
Priority + Data ID + BMS Address +PC Address 0x18100140	8 Bytes

II. B. 4 The slave responds to the host command

CAN ID (4 Bytes)	Data
Priority + Data ID + BMS Address +PC Address 0x18104001	8 Bytes

II. B. 4 The slave responds to the host command

Data Message	Data ID
SOC of total voltage current	0x90
Maximum & Minimum voltage	0x91
Maximum & Minimum temperature	0x92
Charge & discharge MOS status	0x93

II. C. . SENSOR INTEGRATION

The data acquisition system employs a variety of sensors to measure key performance parameters:

II. C .1.Voltage sensor: A high-accuracy voltage divider circuit interfaced with an analog-to-digital converter (adc) to monitor battery pack voltage levels.

II. C .2. Current sensor: a hall-effect sensor-based measurement unit to capture real-time current consumption patterns of the propulsion system.

FIG 2.CURRENT SENSOR (HE300T04)

II. C . 3. GPS module: a high-sensitivity Neo 6M gnss module providing real-time geospatial data for vessel tracking and route optimization.

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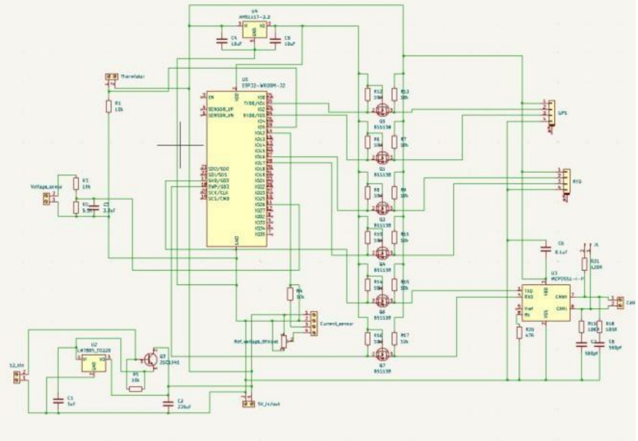

FIG 3 .SCHEMATIC OF THE BOARD

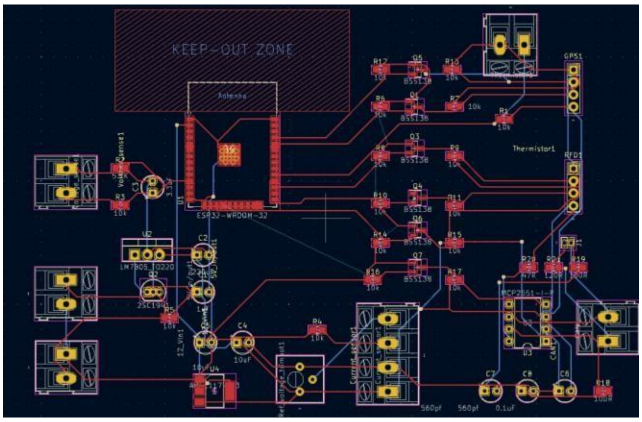

FIG 2 . PCB LAYOUTII. D. MODULAR WIFI

II. D. COMMUNICATION AND CLOUD INTEGRATION

The Wi-Fi communication module offers a solution for real-time data transmission. ESP32 sends processed data over Wi-Fi to Firebase, a cloud-based real-time database. Modular architecture lends itself to easy deployment flexibility and adaptation to varying vessel types and network configurations. Encrypted communication protocols for secure and error-free data transmission prevent data interception and loss risks. Modular design of the system also facilitates future expansion and integration with other cloud platforms. Firebase supports real-time data logging, predictive analysis, and remote monitoring and supports multiple users for real-time access to telemetry data for decision-making and diagnosis.This system is currently used to log the data from the system

III. IMPLEMENTATION AND TESTING

III.A. DATA STORAGE AND SECURE TRANSMISSION

The data acquisition system employs structured storage formats such as CSV and JSON to ensure compatibility with various analytics tools. A dual-layered storage approach is implemented, where real-time data is temporarily stored in the ESP32's internal memory before being transmitted and logged in Firebase for long-term analysis.

To maintain data integrity and security, end-to-end encryption is applied to the transmission process. Additionally, a buffering mechanism ensures that data is stored locally during connectivity disruptions, preventing information loss. The system is designed for modular expandability, allowing integration with alternative cloud platforms or local servers when necessary**.**

III. B. RF TRANSMISSION

Field testing was conducted to determine the reliability of RF and Wi-Fi communication methods under varying environmental conditions. RF telemetry was found to have consistent performance with little packet loss over a distance of upto 2 kilometers. Environmental conditions such as humidity and physical obstructions were tested in an attempt to optimize antenna placement and ensure signal integrity. Wi-Fi-based transmission speed was tested in terms of connectivity reliability, bandwidth usage, and latency when sending data to Firebase. Testing revealed that Wi-Fi communication is highly efficient in near-shore waters, with virtually zero delays. To further optimize system reliability, a hybrid transmission protocol that employs RF for long-range communication and Wi-Fi for cloud connectivity was employed. This method ensures uninterrupted data availability under varying maritime conditions.

III. C. POWER MANAGEMENT

Power management is ensuring system operation aboard electric catamarans. The system helps dynamically adjusts power consumption based on real-time sensor activity and processing demands. Low-power sleep modes are utilized during idle periods, significantly reducing energy wastage. The BMS continuously monitors battery health and optimizes power distribution**.**

IV. RESULTS AND DISCUSSION

The implemented system successfully demonstrated real-time data acquisition and telemetry during field trials. The RF communication module provided reliable data transmission with negligible packet loss, even in adverse weather conditions. The integration of cloud-based analytics enabled predictive maintenance, allowing early fault detection in the battery system and propulsion module. Furthermore, real-time battery monitoring facilitated adaptive power management strategies, ensuring optimal energy utilization during the vessel's operation

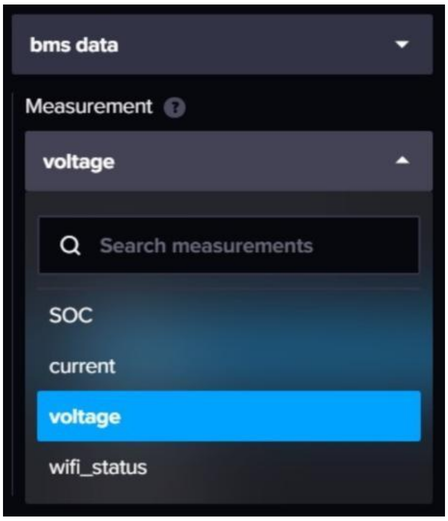

Fig 2 . Results from shore

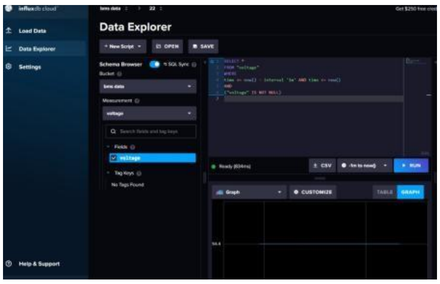

Fig 3 .Voltage Output

V. CONCLUSION

The developed data acquisition and telemetry system for Team Sea Sakthi's electric catamaran has proven to be a solution for real-time vessel monitoring. The combination of high-precision sensor integration, robust communication protocols, and advanced data storage mechanisms ensures the operational safety and efficiency of the electric propulsion system. Future improvements include the deployment of AI-driven predictive analytics, further RF range extension, and integration with advanced marine navigation systems for autonomous operation.

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VI. APPENDIX

Code to read CAN Data:

```
void setup() {
Serial.begin(9600);
```

```
if (CAN0.begin(MCP_ANY, CAN_250KBPS, MCP_8MHZ) == CAN_OK) {
    Serial.println("MCP2515 Initialized Successfully!");
  } else {
    Serial.println("MCP2515 Initialization Failed!");
    while (1)
      ;
  }
  CAN0.setMode(MCP_NORMAL);  // Set to normal mode
  pinMode(CAN0_INT, INPUT);

void loop() {
    float cumulativeVoltage = 0.0;
    float gatheredVoltage = 0.0;
    float currentval = 0.0;
    float socval = 0.0;
    float cellTemperature = 0.0;
    voltage.clearFields();
    current.clearFields();
    soc.clearFields();
    temperature.clearFields();
     Request Voltage, Current, SOC (0x90)
    unsigned char canData[8] = { 0 };
    CAN0.sendMsgBuf(0x18900140, 1, 8,
    canData); delay(100);
    if (!digitalRead(CAN0_INT)) {
      long unsigned int rxId;
      unsigned char len = 0;
      unsigned char rxBuf[8];
      CAN0.readMsgBuf(&rxId, &len, rxBuf);
      Serial.print("Received CAN ID: 0x");
      Serial.println(rxId, HEX);
      if (rxId == 0x98904001) {
        cumulativeVoltage = ((rxBuf[0] << 8) | rxBuf[1]) / 10.0;
        gatheredVoltage = ((rxBuf[2] << 8) | rxBuf[3]) / 10.0;
        currentval = (((rxBuf[4] << 8) | rxBuf[5]) - 30000) / 10.0;
        socval = ((rxBuf[6] << 8) | rxBuf[7]) / 10.0;
        voltage.addField("voltage", cumulativeVoltage);
        current.addField("current", currentval);
        soc.addField("soc", socval);
        Serial.println(cumulativeVoltage);
        Serial.println(currentval);
      } }
    CAN0.sendMsgBuf(0x18960140, 1, 8, canData);
    delay(100);

    if (!digitalRead(CAN0_INT)) {
      long unsigned int rxId;
      unsigned char len = 0;
      unsigned char rxBuf[8];
      CAN0.readMsgBuf(&rxId, &len, rxBuf);
      Serial.print("Received CAN ID: 0x");
      Serial.println(rxId, HEX);
      if (rxId == 0x98964001) {
        // Temperature response (Frame 0)
        cellTemperature = rxBuf[1] - 40;  // First cell's temperature
        Serial.print("Cell 1 Temperature: ");
```

```
        Serial.print(cellTemperature);

        Serial.println(" °C");

        // Add temperature data to InfluxDB point

        temperature.addField("temperature",
cellTemperature);

      }

    }
```