Development of an Onboard and Wireless Data Telemetry Systems for Electric Vehicle

K Sundralingam¹, S.A Abu Bakar², M.F.M. Said³ and M. Muralitharan⁴
¹,²,³,⁴School of Mechanical Engineering, Faculty of Engineering, Universiti Teknologi Malaysia, 81300, Skudai, Johor Bahru, Malaysia

E-mail: saiful@mail.fkm.utm.my, mugilan110393@gmail.com

Abstract. This research aims to design and develop a data monitoring and acquisition system of an onboard and wireless data telemetry system for electric vehicle. The scopes of this research are sensor integrations (6DOF IMU sensor and voltage sensor), creating a Graphical User Interface (GUI) for onboard monitoring system, conducting tests on data acquired by systems and connection’s durability testing for the developed systems. The onboard system consists of Arduino Uno, sensors, a serial communication module, LCD display and a memory card which is fitted onto RC car for data recording. The data is transmitted to the wireless system via radio frequency through the serial communication module. The wireless system consisting of Arduino Uno and a serial communication module are connected to a laptop. The data collected from both systems are compared to ensure minimal data losses. It is found that there are no data losses between the data transmitted and received. As an outcome from this research, a telemetry system has been developed to be used on RC cars.

1. Introduction
An Electric vehicle (EV) is a battery powered vehicle that uses electric motor(s) to turn its wheels that does not produce tailpipe emissions whereby the batteries are charged by plugging into the power grid. A data telemetry system is a data monitoring system that records and transmit data from one location to another by means of wired, wireless or a combination of both. As described by Hay and Nebel [1], biotelemetry allows researchers to monitor animals that are migrating. Besides that, according to Önler et al [2], EVs used for agricultural purposes require constant monitoring for an effective usage and safe operation of the batteries. RC car has many applications with its usage growing into various purposes such as racing and remote expedition for wildlife & geographical studies. As such, it is important to know and monitor the health and status of the car as it goes through different terrain and conditions. However, RC cars having monitoring systems are rare, making it difficult to acquire data when needed. This research focuses on the development of an onboard and wireless telemetry system for an RC car that can record and transmit information for real time data monitoring and acquisition.
2. Methodology

As shown in Figure 1, the data telemetry consists of two subsystems; onboard and wireless system. The onboard system is fitted to the RC car and records the data from the RC car. The data recorded is shown on the LCD display, saved to SD card and is transmitted to the wireless system. The wireless system been placed at a fixed location receives the data from the onboard system. The wireless system is connected to a laptop for real-time monitoring.

Figure 2 shows the system layout of the onboard system as well as the hardware arrangement of the onboard system. The sensors are connected at analogue pin of Arduino Uno to send the recorded data. The HC-12 wireless module is connected at digital pin of the Arduino for data transmission by wireless system.
Table 1 above shows the components and number of units for each component used to develop onboard and wireless data telemetry system.

### Table 1. List of Hardware

| No. | Item                                                                 | Unit |
|-----|----------------------------------------------------------------------|------|
| 1   | Arduino Uno                                                          | 2    |
| 2   | MPU6050 IMU Sensor                                                  | 1    |
| 3   | Max471 Voltage Sensor                                              | 1    |
| 4   | HC-12 Serial Communication Module (RF 433Mhz)                      | 2    |
| 5   | Memory Card Shield                                                 | 1    |
| 6   | LCD Display Shield                                                 | 1    |

Table 2 shows the CRMS values of two systems which was calculated using MATLAB-Simulink. The percentage of error indicates the percentage of CRMS value difference between the two systems. Zero percent error indicates that there is no difference in the value proving that there is no data loss during data transmission.

### Table 2. Comparison of CRMS Values for Onboard and Wireless Data

| Parameters Recorded | Onboard  | Wireless | Error (%) |
|---------------------|----------|----------|-----------|
| Longitudinal Acceleration, Ax | 0.7802   | 0.7802   | 0         |
| Lateral Acceleration, Ay      | 0.8333   | 0.8333   | 0         |
| Voltage, V              | 7.831    | 7.831    | 0         |

3. Results

For this test, the car is driven on the road with slight roughness and the throttle of the RC car is not pressed continuously for a long time. It is constantly been engaged and released resulting in a changing forward acceleration and deceleration. Based on figure 4, the graph rises and falls which shows that RC car is speeding up and slowing down. The highest peak of the graph shows that the car is under high forward acceleration whereas the lowest peak indicates that the car is at the least of forward acceleration.

On the other hand, figure 5 shows an ununiform shape of the graph indicating that the car is travelling on a surface with changing elevation. The sharp dip in the graph shows that the car is going down a drop, whereas the sharp peak of the graph shows that the car is going through a jump.

Based on the figure 6, the voltage level recorded is dropping and rising probably due to noise or the rough terrain condition affecting the connection between the battery and the sensor. However, even with these changes in the data, it is still clear that the battery voltage level remains just below 8 volts.
Comparison of Longitudinal Acceleration between Onboard and Wireless System

Comparison of Lateral Acceleration between Onboard and Wireless System

Comparison of Battery Voltage Level between Onboard and Wireless System

Figure 4. Comparison of Longitudinal Acceleration Between Onboard and Wireless System

Figure 5. Comparison of Lateral Acceleration Between Onboard and Wireless System

Figure 6. Comparison of Battery Voltage Level Between Onboard and Wireless System
The data read by the sensors are raw data which needs to be converted in order to get the acquired reading.

Equation 1 is used in order to convert the raw data from the MPU6050 IMU sensor to acceleration,

\[ \text{Acceleration} = \frac{x}{16384} \times g \]  

where, \( x \) = raw value from sensor and \( g = 9.81 \text{ m/s}^2 \)

Equation 2 is used to convert the raw data from the MAX471 Voltage sensor to voltage value,

\[ \text{Voltage} = y \times \left( \frac{5.0}{1024} \right) \times 5.0 \]  

Where, \( y \) = raw value from sensor

4. Conclusion
From this research, an onboard and wireless data telemetry system has been developed which has been tested on an RC car. The test data also shows that there is no loss of data between the onboard and wireless system. As for the recommendation for the future works, the developed system has potential to be installed in an electric vehicle as an effort in monitoring the conditions of the EV, using a low-cost development solution.

Acknowledgement
This research is supported by Universiti Teknologi Malaysia using a research grant with vote no. Q.J130000.3551.06G62

References
[1] Hay, M. & Nebel, S. (2012). The Use of Biotelemetry in the Study of Animal Migration. Nature Education Knowledge. 3(12):5.
[2] Onler, Eray & Çelen, Soner & Moralar, Aytaç & Celen, Ilker. (2016). Development Of Telemetry System For Electric Powered Vehicle. International Journal of Current Research. 8(9): 38715-38719.
[3] Grecu, C and Iordache, C. (2015). Portable I2C monitor and debugger. IEEE 21st International Symposium for Design and Technology in Electronic Packaging (SIITME), Brasov. pp: 131-134.
[4] Chen, H and Tian, J. (2009). Research on the Controller Area Network. International Conference on Networking and Digital Society. Guiyang, Guizhou, pp:251-254.
[5] Fathirad, I and Whittington, J. (2011). A Flexible FPGA and SBC Based Electric Vehicle Telemetry System. 7th International Conference on Broadband Communications and Biomedical Applications, Melbourne, VIC, pp:219-226.
[6] Tang, K.Z., Tang, S., Kusumadi, N.P and Chuan, S.H. Development Of A Remote Telemetry And Diagnostic System For Electric Vehicles And Electric Vehicle Supply Equipment. 10th IEEE International Conference on Control and Automation (ICCA). Hangzhou. pp:609-613.
[7] Calderón, G., Ruiz, G.G., and Bohórquez, A.C.G. (2013). GPRS telemetry system for high-efficiency electric competition vehicles. World Electric Vehicle Symposium and Exhibition (EVS27), Barcelona. pp: 1-7.