Data acquisition unit for road vehicle or aircraft

Vojtech Šimák[1], Matúš Danko[2]

[1]Department of Control and Information Systems, Faculty of Electrical Engineering and Information Technologies, University of Žilina, Univerzitná 1, 01026, Žilina, Slovakia
[2]Department of Mechatronics and Electronics, Faculty of Electrical Engineering and Information Technologies, University of Žilina, Univerzitná 1, 01026, Žilina, Slovakia

Abstract Data acquisition is a critical aspect of modern vehicle and aircraft design, as it provides engineers and researchers with essential information on the performance and behaviour of these vehicles in various operating conditions. In this paper, we present a data acquisition unit (DAU) for road vehicle or aircraft that utilizes various sensors, including GNSS, INS, RPM measurement, barometric altimeter, and ESP32 microcontroller. The DAU consists of multiple sensors, including a GNSS receiver to determine the vehicle's position, speed, and heading. An inertial navigation system (INS) is used to measure the vehicle's acceleration and angular rate. RPM sensors are used to measure engine speed, and a barometric altimeter is used to measure the altitude of the vehicle. An ESP32 microcontroller is used to acquire, process, and store the data from these sensors. In the end the design and utilisation of DAU was success gaining data for research in field of road and air transport.

Keywords GNSS, INS, RPM

JEL L63, L93

1. Introduction

With the advancement in technology, the use of Internet of Things (IoT) devices has become prevalent in different domains, including aviation [1] and automotive industries. IoT devices have the potential to provide real-time data, which can improve the safety, efficiency, and performance of these industries. In this paper, we present an IoT-based Data Acquisition Unit (DAU) for aircraft and road vehicles. In aircraft sector the data could be provided to the OGN platform [2] and [3]. The proposed DAU is designed to collect data from different sensors, including Global Navigation Satellite System (GNSS), Inertial Navigation System (INS), barometric altimeter, and RPM measurement from voltage ripple. The collected data is transmitted to a remote server for further analysis and processing. The paper is structured as follows. Section 2 presents the architecture of the proposed DAU, followed by Section 3, which discusses the design of the DAU. Section 4 presents the experimental results, and finally, Section 5 concludes the paper.

2. Architecture of the Proposed DAU

The architecture of the proposed DAU is shown in Figure 1.

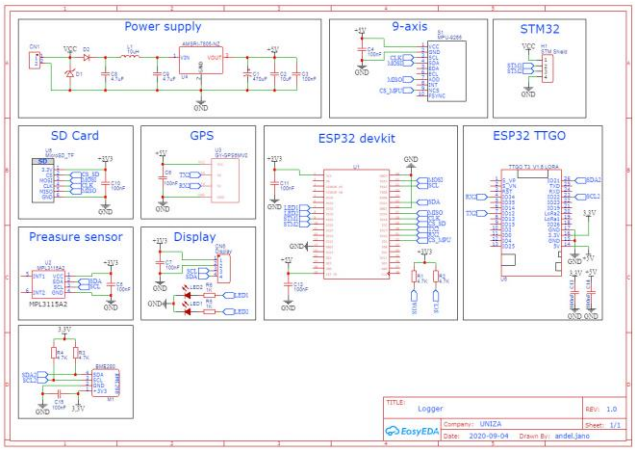

Figure 1. Schematic diagram of the DAU [5].

The design was based on [4] and [5]. The DAU consists of different modules, including a power supply module, a data acquisition module, a data processing module, a communication module, and a control module. The power supply module provides power to the DAU, which can be

DOI: 10.26552/tac.C.2023.1.7

either from the aircraft or vehicle's electrical system or a standalone battery.

The data acquisition module consists of different sensors, including GNSS, INS, barometric altimeter, and RPM measurement from voltage ripple, which collect data in real-time [6].

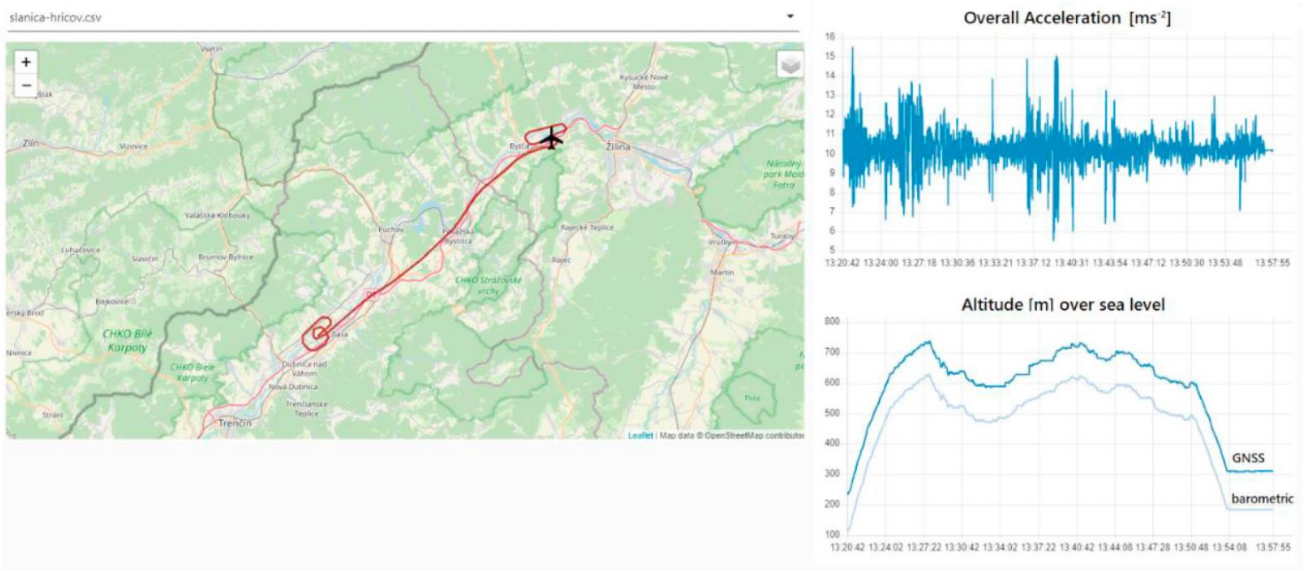

Figure 2. Data recorded by the unit during flight from airport Slávnica (Dubnica nad Váhom) to Žilina airport in Dolný Hričov (airplane L13SE Vivat reg. OM9112) [5].

The data processing module processes the collected data and prepares it for transmission to the remote server. The communication module establishes a connection with the remote server and transmits the data. Finally, the control module manages the operation of the DAU.

3. Design of the DAU

The design of the DAU is based on an Arduino micro controller board. The microcontroller board is connected to different sensors through a sensor shield. The sensor shield provides a plug-and-play interface for the sensors, which simplifies the integration of the sensors with the microcontroller board. The microcontroller board is also connected to a Wi-Fi module, which is used for communication with the remote server transmission (see Figure 3).

The GNSS sensor provides the location, velocity, and time data, which are essential for navigation. The INS sensor provides the attitude, velocity, and acceleration data, which are essential for navigation and control. The barometric altimeter provides the altitude data, which is essential for navigation and control.

The collected data is processed by the microcontroller board and prepared for transmission to the remote server. The data is transmitted using the HTTP protocol, which is widely used for web communication. The remote server receives the data and stores it in a database for further analysis and processing.

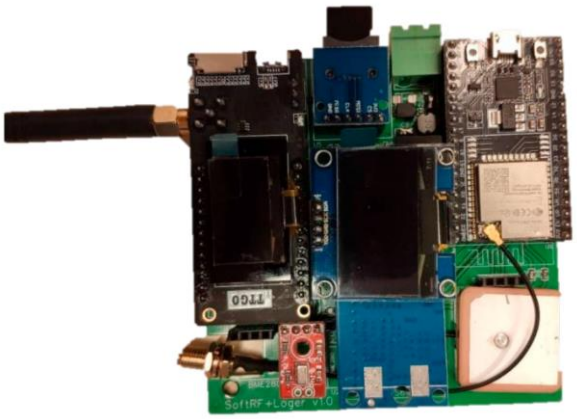

Figure 3. Complete DAU [5]

4. Experimental results

The proposed DAU was tested on a small aircraft and a car. The DAU successfully collected data from the different sensors and transmitted it to the remote server. The collected data was analysed, and the results showed that the DAU can provide real-time data, which can be used for navigation, monitoring, and control.

An measurement of voltage ripple was also performed on 8th of July 2020 airplane Zlin 226 reg. OM-LWA. Figure 4 shows the ripple of 27V mains in airplane by 2000 RPM. The resulting ripple of voltage was cca 300 mV pp.

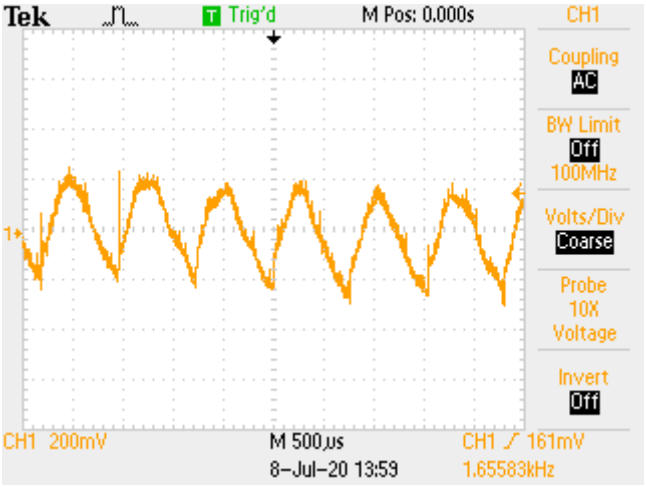

Figure 4. Voltage ripple caused by aircraft engine electrical generator

5. Conclusions

In this paper, we presented an IoT-based Data Acquisition Unit (DAU) for aircraft and road vehicles.

The proposed DAU is designed to collect data from different sensors, including GNSS, INS, barometric altimeter, and RPM measurement from voltage ripple.

The collected data is transmitted to a remote server for further analysis and processing. The experimental results showed that the proposed DAU can provide real-time data, which can improve the safety, efficiency, and performance of aircraft and road vehicles. The proposed DAU can be further improved by adding more sensors and improving the communication protocol for more efficient data transmission. In conclusion, a data acquisition unit that incorporates GNSS, INS, RPM measurement, and a barometric altimeter can provide valuable data on the position, speed, altitude, and orientation of a road vehicle or aircraft. The ESP32 is one example of a low-cost microcontroller that can be used to implement a DAU with these sensors..

ACKNOWLEDGEMENTS

"This publication was realized with support of Operational Program Integrated Infrastructure 2014 - 2020 of the project: Innovative Solutions for Propulsion, Power and Safety Components of Transport Vehicles, code ITMS 313011V334, co-financed by the European Regional Development Fund".

EUROPEAN UNION
European Regional Development Fund
OP Integrated Infrastructure 2014 – 2020

MINISTRY OF TRANSPORT AND CONSTRUCTION OF THE SLOVAK REPUBLIC

REFERENCES

[1] Bugaj, M., Urminsky, T., Jurák, P., Pecho, P., 2018. Analysis and implementation of airworthiness directives In. Transport Means - Proceedings of the International Conference, 2018-October, pp. 1174-1178..

[2] Open Glider Network Project [WWW Document]. Open Glider Network - Open Glider Network Project. URL http://wiki.glidernet.org/ (accessed 12.15.20)

[3] Santel, Ch., Gerber, P., Mehringskötter, S., Schochlow, V., Vogt, J., Klingauf, U., 2014. How Glider Pilots misread the FLARM Collision Alerting Display: a Laboratory Study. In: Aviation Psychology and Applied Human Factors. 4. 86-97. 10.1027/2192-0923/a000060

[4] Yufei, L., Noboru, N., Kazunobu, I., 2014. Development of a Low-cost IMU by Using Sensor Fusion for Attitude Angle Estimation. In: IFAC Proceedings Volumes, Volume 47, Issue 3, Pages 4435-4440, ISSN 1474-6670, ISBN 9783902823625, https://doi.org/10.3182/20140824-6-ZA-1003.00610. (http://www.sciencedirect.com/science/article/pii/S1474667016422974)

[5] Andel, J. Šimák, V. Škultéty, F. Nemec, D. IoT-based Data Acquisition Unit for aircraft and road vehicle In: 14th International scientific conference on sustainable, modern and safe transport: sborník příspěvků 23. ročníku konference : Praha, November 8, 2017. - ISSN 2336-1662. - Prague: University of chemistry and technology, 2017. - ISBN 978-80-7592-002-7.

[6] Aftatah, M. Lahrech, A. Abounada, A. Soulhi, A. GPS/INS/Odometer Data Fusion for Land Vehicle Localization in GPS Denied Environment In: Modern Applied Science; Vol. 11, No. 1; 2017 ISSN 1913-1844 E-ISSN 1913-1852 Published by Canadian Center of Science and Education, 2017 [cit. 2019-10-08] URL: <https://pdfs.semanticscholar.org/4778/a2e85effdb4e0cf875b40e377efec0d94332.pdf>