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# AMINIATURE ON-BOARD DATA RECORDER FOR UNMANNED PLATFORM

The article presents the miniature CAN recorder. Thanks to its small dimensions, being easy to use and able to cooperate with programs such as Matlab, the recorder proves to be an universal and indispensable tool when examining devices in which the essential communication between elements is based on the CAN bus. The example of such a device is UAV platform. The article also provides a short description of the CAN bus and CANaerospace protocol.

**Keywords:** data recorder, CAN, CANaerospace, UAV

## 1. Introduction

The process of controlling the current UAV platform requires installing several detectors on its board. These detectors are often built as ready, independently working measurement modules in different parts of a flying device due to the character of measuring tasks being performed. The central unit, acting as an autopilot, may collect data from measuring devices using different buses. From a practical point of view, the most comfortable situation takes place when all measurement modules communicate with a central computer using only one bus. The CAN bus makes it possible. The CAN (Controller Area Network) is a serial bus, produced by Robert Bosh GmbH in 1980s. Although the bus was firstly designed mostly for motor industry, its use was soon extended. The essential CAN bus properties include [1]:

- twisted pair wire,
- lack of a separate master unit,
- configurable bit rate (up to 1 Mbit/s),
- the bus length depending on bit rate,
- bus access controlled by hardware,
- error detection and signaling,
- guaranteed transmission times,
- short message-oriented transmission,
- high interference tolerance.

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The CAN bus message consists of an identifier (11 or 29 bit), data length code (DLC) and up to 8 bytes of data. The CAN bus enables easy adding of onboard devices which makes it relatively simple to extend the system with new, previously unpredicted elements. Adding another device to the bus does not involve any hardware changes but only software changes which seem to be relatively easiest to make. The use of the CAN bus for controlling UAV platform requires using a uniform protocol enabling data exchange between onboard units. CANaerospace standard has been developed for controlling airborne applications; the standard was defined in 1997. It is an open standard defining messages which are indispensable for the correct functioning of a flying bus. From a user's standpoint, CANaerospace is a thin software layer imposed on the CAN bus. The basic advantages of protocol include:

- multi – master protocol,
- code – assigned messages,
- self – identifying message format,
- ease of transmission continuity control,
- openness to extension and modification (also made by user),
- ease of implementation.

The CAN bus identifier decides about the message, whilst data bytes contain information on Node-Identifier (Node-ID), Service Code and four bytes of data together with the information about their interpretation. The more precise description of the standard one might see in [5].

## 2. Control system based on CAN bus

The figure 1. presents a scheme of sample distributed control system based on CAN bus in UAV platform. The main elements of the system are:

- central computer – functioning as an autopilot,
- Air Data Computer (ADC),
- IMU/AHRS system,
- GPS navigation system,
- implementation mechanisms control module (SM).

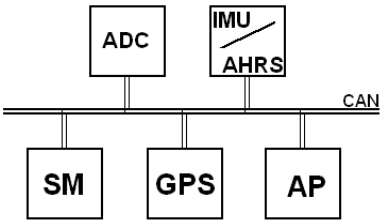


Fig. 1. A flow chart of sample distributed control system based on CAN bus in UAV platform

Each of devices connected to the bus sends it data within determined time intervals. Due to the fact that CAN is a serial bus, a single message characterized by strictly determined structure and destination appears in a given moment. The

messages take turns and get to all the devices attached to the bus. However, they can be received and interpreted only by the relevant destination devices. The solution based on CAN bus enables easier modifying a control system which is understood as either the exchange of complete modules connected to the bus or adding new modules. The only requirement here is maintaining software compatibility and that is accomplished by using the uniform CANaerospace protocol.

Eurotech LLC, a company from Mielec producing unmanned platforms (shown in fig. 2.) which use CAN bus, worked out a miniature onboard data recorder presented below in fig. 3. The following conditions were set at the stage of its designing:

- onboard supplying,
- recording data from onboard bus on SD card,
- ease of use – the right functioning of the recorder is possible just after inserting the card and connecting power supply,
- reading data from the card is carried out by means of an ordinary PC,
- data which have been read must be further easily converted to any chosen format (among others, for programs such as Excel, OO Calc, Matlab, Scilab).

Fig. 2. UAV MJ – 7 Szogun platform produced by Eurotech LLC from Mielec

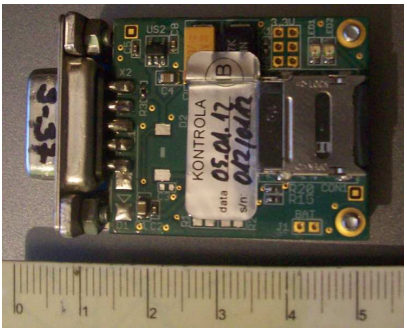


Fig. 3. Onboard recorder

In the case of using a single bus, flight process recording boils down to reading all messages which have appeared on the bus and subsequently saving them to the nonvolatile memory. It is the best when the format of written messages allows to read the collected data easily. Onboard recorder which meets all these expectations is invaluable tool not only for a researcher but also for a user or machine producer. The recorder provides data set which enables analysis of flights, both the ones which have turned out to be successful and those which have been a failure. Moreover, the recorder makes it easier to find the causes of the flight failure.

Figure 4. shows a block diagram of the designed recorder. One can distinguish 4 main blocks here: microcontroller block, SD card block, power supply

block and CAN driver block. In order to make the diagram clear, only the supply voltage line was shown whilst supplying lines for other modules were neglected. The main element of the recorder module is the ’81 family processor produced by Silabs, chosen mostly because of its inbuilt CAN controller and possibility of recording files on a SD card. CAN driver block ensures galvanic separation from CAN bus. The microcontroller connects with SD card through SPI serial interface. The power supply block provides the correct power supply. What is more, it also ensures reserves of energy, so in case of the power cut-off one may close safely an open file and consequently read it later. The miniaturization of the recorder was possible thanks to its uncomplicated construction including only indispensable elements.

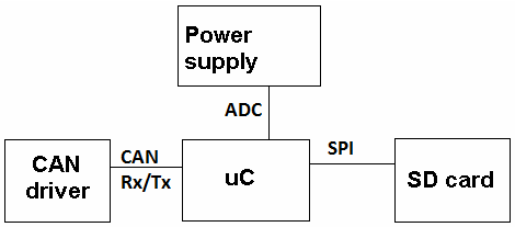


Fig. 4. Recorder block diagram

Inbuilt detectors were not included within the recorder module as it was assumed that its main task was recording board data and not realizing measuring functions. It results from accepting the general idea of distributed control system, where particular modules are responsible for specific actions, without unnecessary duplication of tasks. Connecting power supply results each time in creating a new file (by recorder). This file contains data taken from the bus. The system monitors a power supply and in the case of a power loss, it closes a file being just created so that the file can be read later. The size of a created file depends on the amount of data appearing in the bus and is limited by the maximum size of a file which is available for FAT files system. The system has been implemented to enhance transferring data from recorder to PC, where the data is read and processed. The speed of saving to SD card limits the number of recorded messages, up to 2000 per second, which is the value completely adequate for the amount of data appearing in the bus.

## 3. Use of recorder

One of the onboard recorder advantages is the ease of its use. After attaching power supply, if only a SD card has been inserted, the process of recording data from the bus is automatically launched. The card should be only formatted before to FAT system. Recorder saves data to the card, creating a new file each time after connecting power supply. All recorded data is saved to files with*.bin extension, which can be easily read on PC. The solution presented in this article is different from others [4] in that using the recorder does not require earlier pre-

paring a file on SD card. Any SD card formatted with the FAT system can be inserted in the recorder which immediately creates a file and starts recording data appearing on the CAN bus. It is worth noticing that a current version of the presented recorder does not allow recording frames to be filtered thus all the communication from the bus is recorded. It might be considered as both an advantage or a disadvantage of the recorder. Initially, the recorder was designed in order to record board data from CAN Aerospace protocol. This intention was abandoned and it was decided to save data on the SD card without any processing. Thanks to it, the recorder has been made more universal and not limited to the one type of a recorded protocol. For easier using of the recorder and viewing collected data, ET company worked out an application which is designed for PC and enables converting saved data to files with extension *.mat for Matlab and *.csv for spreadsheets (MS Excel, OO Calc). The files prepared with the means of this application can be easily analyzed and processed in abovementioned programs. Figure 5. shows a sample Matlab graph, obtained from author's research [2].

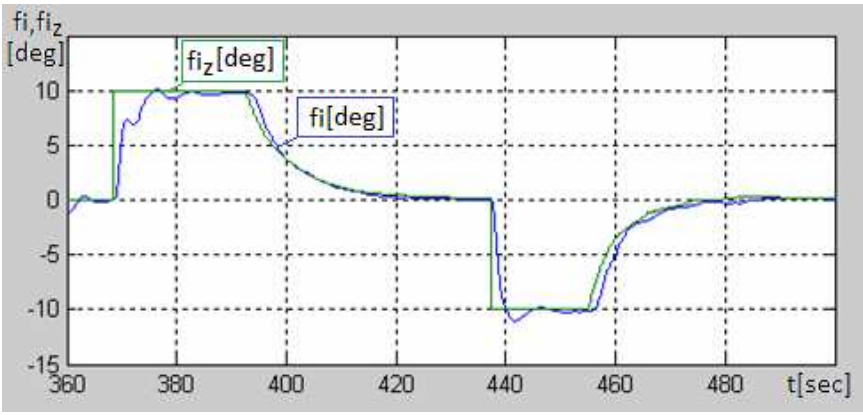


Fig. 5. Example excerpt of data recording converted to Matlab program

The recorder presented in this publication is applied in simulation research, but its main use is recording data during a flight. Among others, it has been used in author's work on fuzzy logic controlling algorytms for UAV platform [2]. It may also serve as UAV monitoring system completion [3] providing all board data which cannot be sent through data line to ground flight control station.

## 4. Conclusions

The recorder described here can be used as a miniature blackbox flight recorder for UAV platform. It is also an invaluable tool in research, not only on UAV platform but also other devices in which communication is conducted via

CAN bus. What is more important, the recorder together with PC application designed for it does not impose CANaerospace coding which makes the recorder even more universal tool.

## Acknowledgement

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## MINIATUROWY POKŁADOWY REJESTRATOR DANYCH DLA PLATFORM BEZZAŁOGOWYCH

**S t r e s z c z e n i e**

W artykule przedstawiono miniaturowy rejestrator CAN. Jego niewielkie wymiary, łatwość obsługi oraz przygotowanie do współpracy z programami, takimi jak Matlab czyni z niego uniwersalne i nieocenione narzędzie w pracy badawczej nad urządzeniami, w których podstawowa komunikacja pomiędzy elementami wyposażenia opiera się na magistrali CAN. Przykładem takiego urządzenia jest platforma UAV. Artykuł zawiera też krótki opis magistrali CAN oraz protokołu CANaerospace.

**Słowa kluczowe:** rejestrator danych, CAN, CANaerospace, UAV

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