DISTRIBUTED EMBEDDED SYSTEM FOR ULTRALIGHT AIRPLANE MONITORING

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Abstract: This paper presents distributed embedded monitoring system that is developed for small aircrafts, sports and ultralights airplanes. System is made from modules connected by industrial bus CAN. This low cost system is trying to solve bad situation with many ultralights without any digital measurement unit due to their prices. The contribution shows basic architecture of the embedded monitoring system and presents some parts of hardware and software implementation. The interface between aviator and airplane is established using graphic user interface based on operating system uClinux.

1 INTRODUCTION

This paper is concentrated to avionic system especially to small sporting or ultralight airplanes. Here is basic information about small airplanes.

Figure 1: Ultralight airplane – illustrative photo.

Ultralight airplane is constructed for maximally 2 persons, with a stalling speed lower than 65km/h and a maximum flight weight of 450 kg. (Figure 1) Its price is much lower than professional airplanes but it is possible to fly for thousand kilometres. There are many standards describe ultralight league in many countries all over the world. The specification mentioned above is validated for Europe especially Czech Republic.

This project is focus on developing an alternative to high price products. The project has been developed together with the private company FALKON Electronics. We have developed the system architecture, which supports a flexible configuration. The configuration can grow from small, which measures basic values, to a wide range system. This is possible thanks to the module architecture.)

System is distributed into the independent modules that measure specific value on mechanical parts of the airplane. System is a configurable according type of airplane. The highest layer is graphic user module that represents received data on the LCD display. Sense of monitoring system is offer customers same facilities as have pilots in the professional aircrafts and make aviation more easier using low cost embedded electronic system.

2 AIRCRAFT MONITORING VALUES

There are two basic groups of values which can be measured. The first group includes flying values such as attitude and air speed, the second group is engine values as RPM and oil temperature. There is

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also a third group for other values such as battery voltage, etc.

Fly values are the following:

- Attitude
- Altitude
- Airspeed
- Vertical Speed
- Gravitation
- GPS position
- Start, Fly, Actual Time

Engine values are the following:

- RPM
- Percent Power
- Oil temperature
- Oil pressure
- Cylinders temperatures
- Cylinders exhaust temperatures

The values that are mentioned above are only basic group for our purposes. Using embedded distributing system architecture we are able to extended whole system within other values.

3 MONITORING SYSTEM ARCHITECTURE

The real-time embedded control system is designed with a modular structure (Li and Yao 2003). This structure supports a flexible configuration. In terms of user requirements, the control system can be configured in different sizes and options. (Kotzian and Srovnal 2004) Several modules with different options were designed. All modules are connected to an industrial bus – so each module is the bus node. Except the GPS module, this is connected directly to the main control module.

The block diagram of a desk control and monitoring system with today's full configuration of prototype is shown in the Figure 2.

Designed modules are the following:

- Main control module
- User interface (LCD display) module
- Motor measuring values module
- Advanced avionic data module
- Black-Box module

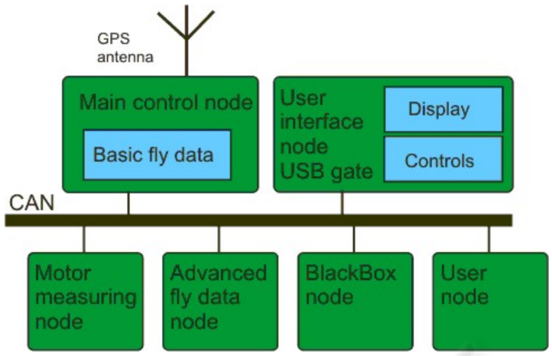

Figure 2: Block diagram of monitoring system

4 SYSTEM MODULES SPECIFICATION

The basic configuration contains only the User Interface Module and the Main Control Module. The Main Control Module has some basic inputs. Basic values are connected to these inputs, which have to be in the every airplane. The configuration can measure attitude, altitude, airspeed, gravitation, RPM, inside air temperature and battery voltage.

4.1 Communication Protocol

Monitoring modules are connected together by using an industrial bus (Sridhar 2003). This bus has to be highly reliable and have enough speed. Depending on these two main requirements a CAN bus was selected. The main reason is that the CAN has an extremely low probability of non-detected error. The versatility of the CAN system has proven itself useful in other applications, including industrial automation as well. A CAN bus is given the international standard ISO11898 which uses the first two layers of ISO/OSI model (CAN-CIA 2005). (Kotzian and Srovnal 2003)

4.2 Main Control Module

The main control node serves as master for all other nodes. (Arnold 2001) (Figure 3,4) Requesting values from other nodes are compared with given limits and stored in the local memory. The main module decides what information will be display and send to the user interface module by the CAN bus.

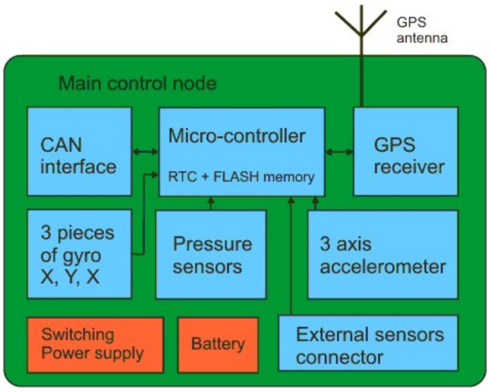

Figure 3: Main control node block diagram.

The main control module contains a real time clock and data flash memory for storing measured values and statistics. For measuring basic values the main module is equipped with the following measuring sensors:

- CSDX0811BARO for the altitude
- CSDX0025D4R for the air speed
- 3 x gyro sensor ADXRS401 for the attitude
- Accelerometer MMA7261Q

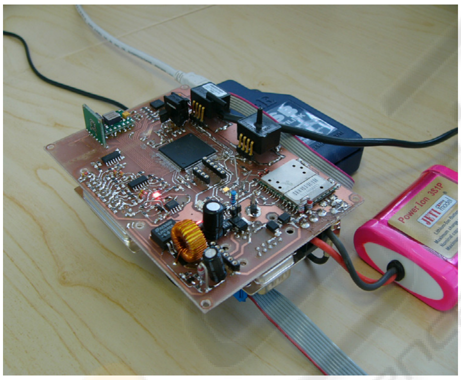

Figure 4: Main control module prototype (testing).

4.3 GPS Receiver

The GPS receiver is a small module with the passive antenna for receiving the position information from the global position system GPS. For its small size, good features and low price GPS Orcam 21SB was selected. The GPS module is integrated into the Main Control Module. External antenna is used due to the mounting possibility outside the plane (better GPS signal). The GPS module is connected by using a standard serial interface and standard GPS.

4.4 User Interface Module

The user graphic interface module serves as an interface between the user and all monitoring systems. There are two variants of the user interface module, an economical and comfort version.

The economical version includes the monochrome LCD Display GM62121 with the 320*248 pixels resolution. The economical version is equipped with a 16bit DSP controller without any operating system so it supports only necessary functions.

The comfort version includes a color TFT Display PD064 with a 640x480 pixels resolution. This version is equipped with a 32-bit processor (PPC or ColdFire) and operating system RT Linux (support MMU) (Hollabaugh 2002) or uClinux (MMU less). (Raghavan, Lad, Neelakandan 2006) There is also communication USB interface for storing the measured data in to the user USB devices (Service and diagnostic system). The operator panel of the comfort version is shown in the figure 5. The cheapest version uses a DSP controller as a display content computation and FPGA as a display driver.

Figure 5: Main operator panel in cockpit.

It is possible to select the avionic screen, engine screen or GPS map screen.

The firmware is based on embedded operating system Linux using 240 MHz processor core. There are implemented 4 interfaces in the operating system. Two communication interface – CAN, RS232 and USB and one display interface FB (framebuffer) with the driver. Graphic system is built on GUI – microwindows or miniGUI.

Those graphic user interfaces using two graphic libraries SDL (Simple DirectMedia Layer) and OpenGL ES. SDL is cross-platform multimedia library designed to provide low level access to audio, keyboard, mouse, joystick, 3D hardware via OpenGL, and 2D video framebuffer. OpenGL ES is a royalty-free, cross-platform API for full-function 2D and 3D graphics on embedded systems. Software implementation is base on Eclipse Workbench.

4.5 Black-Box Module

The black-box module controls all traffic on the CAN bus. It reads data from CAN messages and stores data in the local memory. The black-box module is equipped with its own RTC timer and stores time together with the CAN data. There is no other connection to this module with such high reliability.

5 DEVELOPING SYSTEM CONFIGURATION

The project is presently in last of developing state. We are beginning with the final versions of the modules. The Main Control Module is designed in its final version and is under testing.

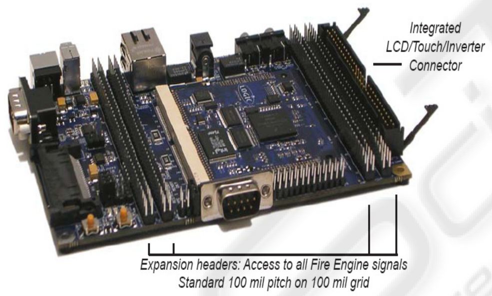

Figure 6: Evaluation kit for operator panel in cockpit.

Low cost version is based on EvbDSP module with a DSP56F805 controller, six 8-bits ports, CAN, SPI and serial interfaces and FPGA graphic driver interface (User Interface Module). The EvbHCS12 module is equipped with a MC9S12DP256 controller (Main Control Module). This module supports a wide range of interfaces: CAN, LIN, serial, SPI, I2C and six 8-bit ports. The smallest module is the EvbHCS08 with a MC9S08GT60 controller, LIN, SPI and serial interfaces, temperature and humidity sensors and four 8-bit ports (I/O devices). The comfort version has different User Interface Module that is based on 32-bit ColdFire controller (EvbMCF5329) with an integrated display controller – GUI (Figure 6). For EvbMCF5329 was used Linux BSP.(Yaghmour 2003)

6 CONCLUSION

The development and realization of the avionic control and monitoring system for ultra-light airplanes is very important for increasing the safety and security of pilots. The number of accidents of ultra-light planes is too high, especially during the starting and lending stages of flights. A low cost flight control and monitoring system is the best way to cut down on the number of accidents. The developed monitoring system can be configured from a minimal version to a wide system based on customer requirements.

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REFERENCES

Arnold K. (2001) Embedded Controller Hardware Design. *LLH Technology Publishing USA 2001, ISBN 1-878707-52-3*

Sridhar T. (2003) Design Embedded Communications Software. *CMP Books, San Francisco 2003, ISBN 1-57820-125-X*

Raghavan P., Lad A., Neelakandan S. (2006) Embedded Linux System Design and Development. *Auerbach Publication USA 2006, ISBN 0-8493-4058-6*

Li Q., Yao C. (2003). Real-Time Concepts for Embedded Systems, *CMP Books, San Francisco 2003, ISBN 1-57820-124-1*

Hollabaugh, Craig., (2002). Embedded Linux, *Pearson Education, Indianapolis 2002, ISBN 0-672-32226-9*

Yaghmour, Karim., (2003). Building embedded Linux systems, *O'Really & Assocites, Sebastopol 2003, ISBN 0-596-00222-X*

Kotzian J. and Srovnal V. (2004). Development of Embedded Control System for Mobile Objects Using UML. *In : Programmable Devices and Systems 2004-IFAC Workshop, Krakow, IFAC WS 2004 0008 PL, ISBN 83-908409-8-7, p.293-298*

Kotzian J. and Srovnal V. (2003). Can Based Distributed Control System Modelling Using UML. *In: Proceeding International Conference IEEE ICIT 2003, Maribor, Slovenia, ISBN 0-7803-7853-9, p.1012-1017*