System outline

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Project identity

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Document history

Version	Date	Changes	Sign	Reviewed
0.1	060222	First draw	ALL	AJ,MJ
0.2	060227	Second draw	CL	AJ,MJ
0.3	060228	Figure 1 updated, grammatical improvement, item list in ch. 6, 7 and 8	ALL	VG, CL, MJ
1.0	060315	Approved as version 1.0	J. Hol	

1 Introduction

The *General Avation* (GA) aircraft fleet has become very old (40+ year old aircrafts are now very common) thanks to reliable air frames and rapidly increasing prices of new light aircraft. A vast majority of these aircrafts are equipped with old-fashioned mechanical flight instruments, now reaching the end of their lifetime as the air frames become older. Instead of performing a complete upgrade of the entire instrument panel, which can result in costs often exceeding the value of the entire aircraft, one can complete the system with a much more affordable Micro EFIS. A Micro EFIS is, as the name implies, a small EFIS (*Electronic Flight Information System*), targeted for the GA market. It is intended as a backup system for the mechanical flight instruments.

1.1 Parties

Customer: Jan-Erik Strömberg, DST Control, Linköping

Supervisor: Jeroen Hol, Department of Electrical Engineering, Linköping Institute of Technology

Producent: A group of six students at Linköping Institute of Technology

1.2 Goal

The goal of this project is to design a stripped down version of a Micro EFIS and to evaluate the implementation based on state-of-the art *organic graphical display*; a so called OLED display. This to ensure high endurance at extreme temperatures (down to $-30°$ C). The system shall be implemented on one single FPGA to meet the need to be *small in size* and have a *low cost*. Since it is intented as a backup system it must have a *high reliability*, be *independent of external systems* and *simple to use*. To increase the ease of upgrading the system and to *incrementally add functions*, it shall be built in modules.

1.3 Use

The system is intented as a backup for the mechanical flight instruments and the primary use is in the case of instrument failure.

1.4 Notation and abbreviations

The following abbreviations and notations will be used:

ADI Attitude and Direction Indicator

A/C Aircraft

DST DST Control AB: the project owner

EFIS Electronic Flight Information System: a standardised terminology used for a system of sensors, computers and displays designed to present critical flight data to the pilot

ESI Engine Status Indicator

GA General Aviation: non-commercial air traffic (including aircraft operated by companies for internal use only)

GND Ground Level

GUI Graphical User Interface

HSI Horizontal Situation Indicator

MSL Mean Sea Level

SPI Serial Peripheral Interface

2 System overview

2.1 Product components

The Micro EFIS consists of an instrument casing with specific measures ($60 \times 60 \times 50\,\mathrm{mm}$), with a user interface on a single monochrome display (128×64 pixels) and one single rotary mode selector switch. Inside the box there will be an FPGA (field programmable gate array), an RTC (real-time clock), and a FLASH memory. Externally the box will be connected to a power supply and sensor units. A user manual and technical documentation will be included at delivery.

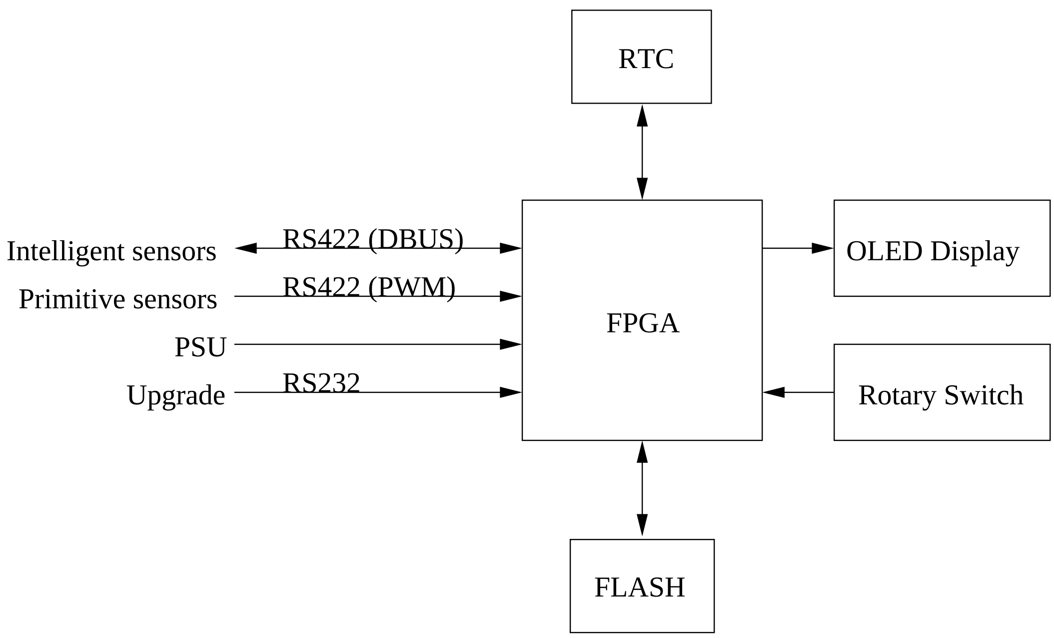

Figure 1: System overview

2.2 Subsystems

The system will be divided into the following subsystems: OLED unit, HSI/ADI/ESI display modes, setup mode, sensor unit, main unit, and a rotary switch unit.

2.3 Design method

The system shall be built in modules with well defined interfaces to enable upgrade of a single subsystem independent of the others. The system shall

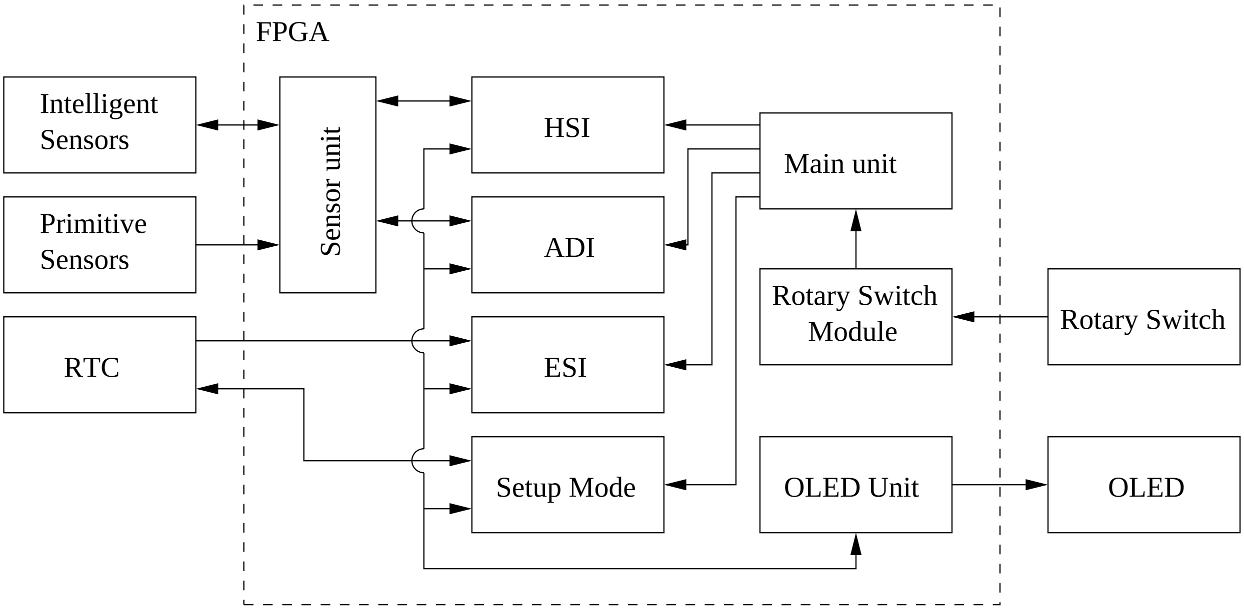

Figure 2: Inside FPGA

be developed with use of VHDL, if needed a softcore will be included. One single FPGA shall be used and one single FLASH memory.

3 Sensors

The back of the MEFIS casing has eight possible external connectors. One of these is intended for power supply, one for upgrades/maintenance of the software in the FPGA, and the other six for sensor units.

We will use two different kind of sensors; simple and intelligent. The simple sensors are pulse width modulated (PWM) and the intelligent work through a standard (DBUS) developed by the customer (DST Control AB). We will use the following sensor units:

- Magnetic sensor unit (DBUS)
- Outside air temperature (PWM)
- Pneumatic sensor unit (optional)
- Engine sensor unit (optional)
- Electric sensor unit (optional)

Notice that all sensor units include several actual sensors.

3.1 Magnetic sensor unit

The magnetic sensor unit is an ”intelligent” unit, which means that we can both read from and write to it. From this unit we get the aircraft magnetic heading, with which we can measure the:

- Yaw angle and angular velocity
- Roll angle and angular velocity
- Pitch angle and angular velocity
- The magnetic heading (compass)

3.2 Outside air temperature

This unit simply supplies the outside air temperature as measured by a sensor

- Outside air temperature

3.3 Pneumatic sensor unit (optional)

The pneumatic sensor unit gives us the static and dynamic pressure from the aircraft pitot tube, which we can use to measure approximate values of the actual aircraft speed and altitude.

- Altitude
- Airspeed

3.4 Engine sensor unit (optional)

The engine sensor unit measures various engine parameters such as:

- Oil pressure
- Fuel flow
- Manifold pressure
- Engine speed (RPM)
- Oil temperature

3.5 Electric sensor unit (optional)

The electric sensor unit measures the status of the airplane battery:

- Battery voltage
- Alternator current
- Load current

4 Flash

The FLASH memory contains the configuration of the FPGA. The configuration will be downloaded to the FPGA every time the MEFIS is started. If needed by the Setup module, some of the remaining memory can be used for configuration parameters for the MEFIS.

5 RTC (real-time clock)

The RTC is programmable from the setup mode and is displayed in the ESI mode. It has four external pins for communication. The RTC is a calendar clock and can be updated and read through the external interface. The RTC communicates through an SPI interface.

6 Sensor module

6.1 Description

The sensor module handles the connected sensors and collects its data. The primitive sensors are continuously sending data to the sensor module, which must hold the data stable, and keep the sensor data from being overwritten while the subsystems are collecting the data. The intelligent sensors must be asked to send data, which will be done when needed.

6.2 Interface

The primitive sensors communicate via PWM and the intelligent via DBUS, which is developed by DST Control AB. Both PWM and DBUS use the RS422 protocol.

7 HSI display mode

7.1 Description

The function of a HSI display mode is to display data such as:

- roll angle
- pitch angle
- slip (lateral g force)
- outside air temperature
- vertical speed
- air speed (optional)
- pressure altitude (optional)
- true elevation (optional)

If the aircraft is equipped with a GPS system (optional), the ground speed and true altitude can be displayed as well.

```
PA: 40     OAT: -10
RA:  2     SLIP:  1
VS: 40
```

Figure 3: HSI display layout

7.2 Interface

The subsystem communicates with the sensor and OLED units. The communication with the OLED unit is specified in section 13.1.

8 ADI display mode

8.1 Description

The function of an ADI display mode is to display data such as:

- magnetic heading
- outside air temperature
- true heading (optional, GPS)
- true track (optional, GPS)
- direction/track to radio beacon (optional)

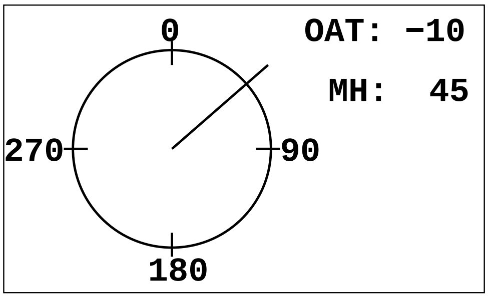

Figure 4: ADI display layout

8.2 Interface

The subsystem communicates with the sensor and OLED units. The communication with the OLED unit is specified in section 13.1.

9 ESI display mode

9.1 Description

The ESI display mode will initially only display date and time.
The following simple PWM sensors are **optional** but should not be hard to implement with an upgrade:

- battery voltage

- alternator current
- load current
- engine RPM
- engine oil pressure
- engine oil temperature

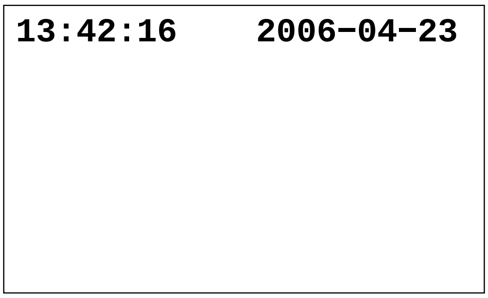

Figure 5: ESI and Setup display layout

9.2 Interface

The subsystem communicates with the RTC, OLED and Sensor (optionally) units. The communication with the OLED unit is specified in section 13.1.

10 Setup mode

10.1 Description

In this mode the pilot will be able to set time and date of the RTC, which will be displayed in ESI mode. Therefore the display of the Setup mode will be similar to the ESI display.
The following settings will be **optional**:

- Set the barometric pressure (provided by air traffic control)
- Turn off some functions in HSI and ADI mode
- A possibility to select between two light intensity modes: normal and dimmed, and to adjust the intensity in these modes

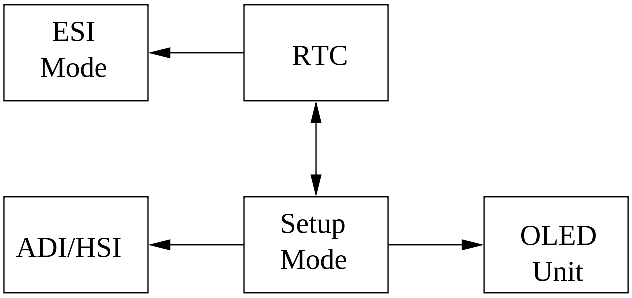

Figure 6: Setup mode overview

10.2 Interface

The subsystem communicates with the OLED and RTC. The communication with the OLED unit is specified in section 13.1.

11 Rotary switch unit

11.1 Description

This unit utilizes a button integrated with a rotary switch and decoding hardware.
The following functions shall be detectable by the rotary switch unit and will be outputs to the Main unit:

- Single tap
- Rotary switching to the left and right
- Double tap (optional)
- Holding down the button (optional)

12 Main unit

12.1 Description

This unit will handle which mode that is active. Input signal is the interrupt from the rotary switch unit. The unit will work through a flow diagram, that will be specified in the design specification. This will handle all the different commands given by the rotary switch unit, and depending on which mode is currently active, decide what to do from there.

13 OLED

This module is supposed to act as a graphic generator and present the data sent by HSI, ADI, ESI and the Setup modules on the display. The display hardware has none of the features such as character, line or circle generators. All these will, if time allows, be implemented in the FPGA in the module OLED. For the ease of upgrade and module block thinking the data received from the other blocks will be sent in a particular order. More about the packet organisation can be found under the subsection *Data receiver*.

The OLED module is divided into the following six blocks:

- Data receiver
- Character generator
- Line generator (optional)
- Circle generator (optional)
- Initiator
- Data transmitter

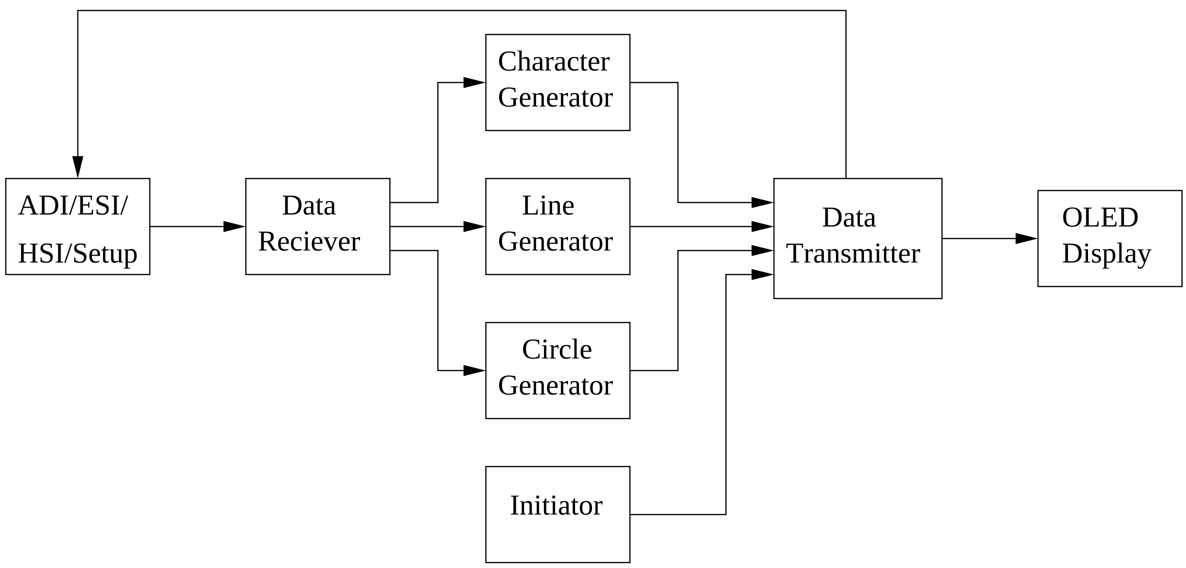

Figure 7: Overview of the OLED unit

13.1 Data receiver

This block will recieve data from the ESI, HSI, ADI, and Setup modules. The data is received in a particular order in a packet. The data packet contains information on type of data (character, line, circle or command) and position on the display. The MSBs of the packet contains the data type identifier. The next part of the packet contains start coordinates for the data to be displayed. The character position will be given with its upper left corner as reference. The line position will be given by a start and end point. Circles will be positioned on the display with reference to its centerpoint and radius. If the data is of type character the last data in the packet contains which character to display. If the data is of type line it is the end point and if it is a circle the data is the radius of the circle.

Figure 8: Data receiver communication protocol

13.2 Character generator

If the data received is of character type this block will get the corresponding character from a character memory and send it to the *Data transmission* block. The characters are predefined and stored in the FPGA. All characters are of the same height and width (monospace).

13.3 Line generator (optional)

If the data received is of line type this block will compute the pixels that are to be lit and send it to the *Data transmitter* block.

13.4 Circle generator (optional)

If the data received is of circle type this block will compute the pixels that are to be lit and send it to the *Data transmitter* block.

13.5 Initiator

This block is active when the circuit is reset and initiates the display for correct operation.

13.6 Data transmitter

This block receives data from the blocks *character generator, line generator, circle generator* and *initiator* and forwards it to the display. When it is finished it will confirm this to the active unit with a handshake.

References

[1] Tomas Svensson & Christian Krysander, *Projektmodellen Lips*, kompendium, Linköpings Tekniska Högskola, Version 1.2.

[2] George Grätzer, *Math into LATEX*, Birkhäuser, 1996.

[3] Jan-Erik Strömberg, *Requirement specification – Micro EFIS*, DST Control, MEFIS/Doc/Spec/R0543S01.fm, version 1.0.0.