

A NEW STUDENTS DEVELOPMENT BOARD FOR EMBEDDED SYSTEMS

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Abstract: This article describes a new development board for embedded system that was designed especially for Microcontroller and microprocessors student course. Not only hardware part was created, but also compiler, IDE and JTAG probe were selected. And of course, some examples were prepared.

Keywords: Microcontroller, design, development.

1. INTRODUCTION

Microcontrollers are in almost all electronic devices used nowadays. In the past typical camera was only mechanical device, some models had electronic exposure meters that did not need batteries to work. Photos were stored on photographic films. Now typical camera is sophisticated electronic device, where optical signal is digitalized and processed by processor unit. Photos are than stored to memory cards. Without batteries device could not be used. Similar situation is in household appliances. Washing machines, dishwashers, fridges and freezers, heating systems and many others are controlled by microcontrollers. Cars are another type of device that uses tens of microcontrollers. To talk about phones is just wasting a time.

Almost all of these devices use something called embedded device or embedded system. In general, embedded device or embedded system is a computer system which function is dedicated to the single application. This device may or may not be able to connect to the Internet.

Increasing number of used microcontrollers means that number of developers for these microcontrollers is increasing. They have to learn about microcontrollers and have to improve their skills in some courses, lectures and practical labs. For the practical classes the development kits for embedded devices are needed. In this article, we describe one of them, designed and developed especially for students signed in Microcontrollers and microprocessors class in bachelor study program.

At the beginning of the article is short introduction to the microcontroller vendors and basic kinds of microcontrollers. Next section contains description of Integrated Development Environment from Microchip Company, followed by section with a new development board description. At the end of the paper very short summary and future plans are described.

2. MICROCONTROLLERS, MICROCONTROLLER VENDORS AND DEVELOPMENT ENVIRONMENTS

There is wide range of microcontroller vendors available on the market place. In this article we won't focus on digital signal processors and other specialized processor units. We are not focusing on processors for PC, either. We will talk about 8-bit microcontrollers only.

8-bit microcontroller is small inexpensive microcontroller equipped with different peripherals. Available peripherals depend on microcontroller family and vendor. List of companies producing microcontrollers is quite long. From the top of them we should mention Microchip, Atmel, Silicon Labs and others.

Every microcontroller needs software. Without software it is only electronic device without functionality. 8-bit microcontrollers are the most often programmed in C language or in Assembler language. For both languages a compiler, some software that converts one language to another, is required. Program code is usually written in something called IDE (Integrated Development Environment). Some microcontroller vendors provide own compilers and IDEs, some of them just recommend third party compilers and IDEs with different features, advantages and disadvantages.

IDEs and compilers IAR Embedded Workbench from IAR Company support wide range of microcontrollers from different vendors [1]. IAR Embedded Workbench is a leader with code optimization technology, it generates very compact code with fast performance. IAR IDE contains the C-SPY Debugger that provides an instruction simulator and support for debugging probes. IAR Embedded Workbench main window is shown in figure 1.

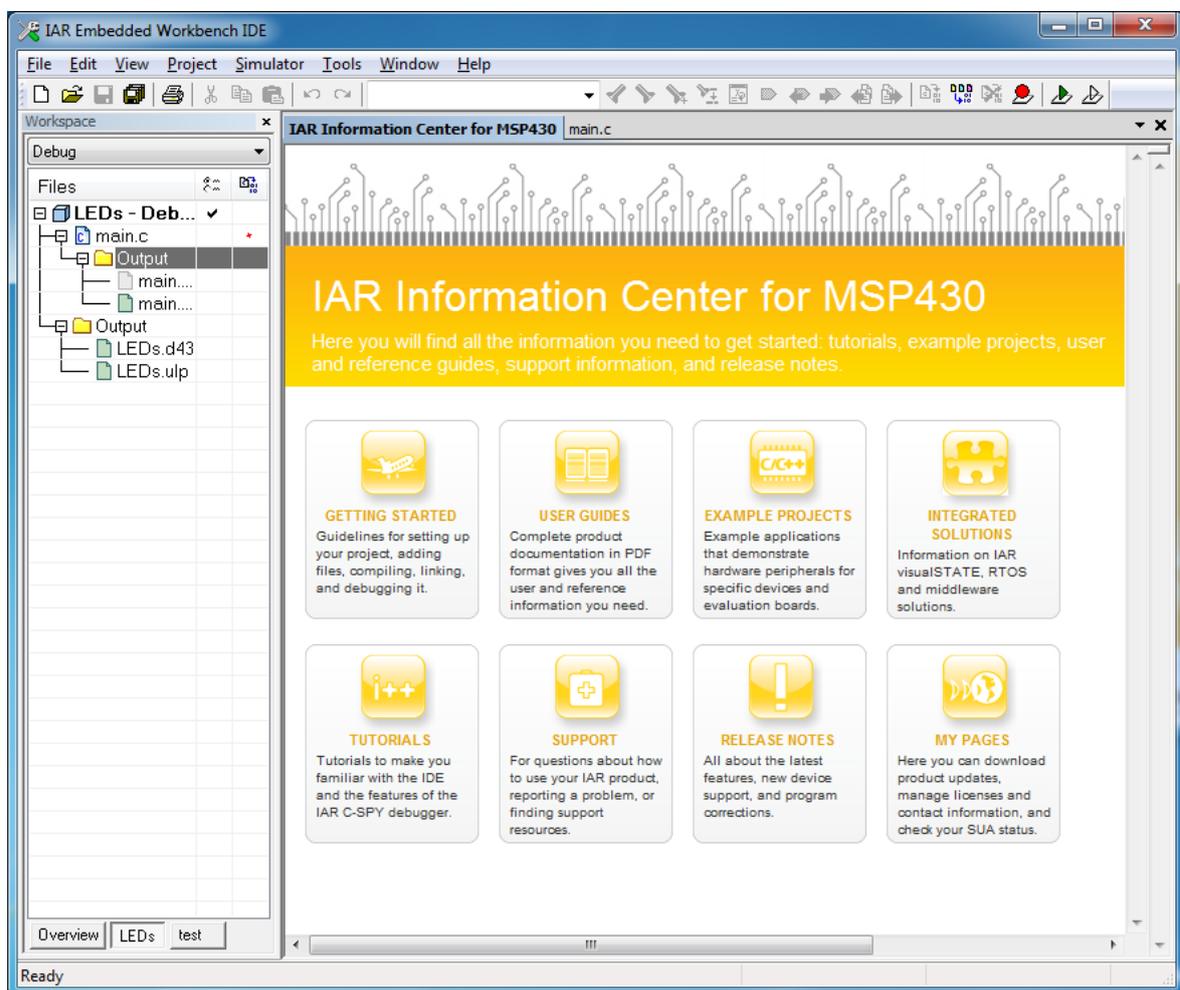


Figure 1: IAR Embedded Workbench.

3. THE DEVELOPMENT BOARD

For our development board microcontroller PIC18F66K80 from Microchip Company was chosen [5]. Some main microcontroller features are:

- Operating Voltage Range: 1.8V to 5.5V

- On-Chip 3.3V Regulator
- Operating Speed up to 64 MHz
- Up to 64 Kbytes On-Chip Flash Program Memory
- 1,024 Bytes of Data EEPROM
- 3.6 Kbytes of General Purpose Registers (SRAM)
- Three Internal Oscillators:
 - LF-INTOSC (31 KHz),
 - MF-INTOSC (500 kHz) and
 - HF-INTOSC (16 MHz)
- Self-Programmable under Software Control
- Priority Levels for Interrupts
- 8 x 8 Single-Cycle Hardware Multiplier
- Extended Watchdog Timer (WDT) programmable from 4 ms to 4,194 s
- Low power modes
- ECAN Bus Module

For practical lab we selected IDE called MPLAB X [2] and compiler XC8 from Microchip Company [3]. Compiler and IDE are available for free. There are some limits in optimizing process, but for teaching purposes a free version is sufficient. MPLAB IDE main window is shown in figure 2.

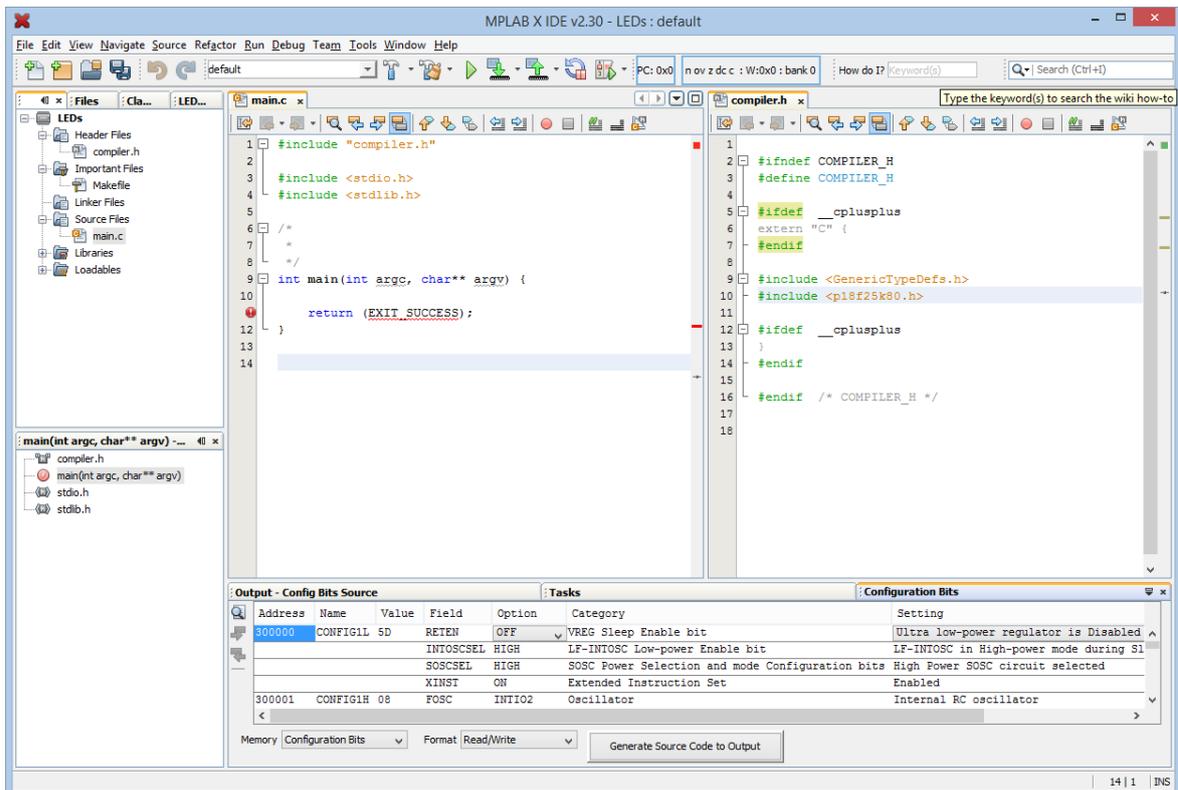


Figure 2: Microchip MPLAB X.

The most comfortable way how to test prepared program is using JTAG interface. This interface allows download program into program memory, check variables used in program, read program and data memory, use break points and other features oriented mainly to developer comfort and speed of software development. We selected all parts from Microchip Company, the same it is with JTAG interface. We will use ICD 3 JTAG interface [4].

Block diagram of whole board is shown in figure 3. Whole system is possible to split into three main parts. The core, external communication interfaces and on board peripherals.

The core contains microcontroller PIC18F66K80, clock source, which is composed from two crystal oscillators, one with frequency 16 MHz and one with frequency 32,768 kHz. Board is powered from batteries, or via plugged power adapter. In case of battery power, three AAA batteries are requested, for power adapter voltage from 5 to 15 V and current 250 mA is sufficient.

The second part contains external communication interfaces. Three of them are available. From software design point of view the most important is JTAG connection. This allows to debug software directly in microcontroller. The second interface is RS-232. RS-232 is communication bus that allows transfer data between devices and PC, with simple communication protocol. The last one is Controlled Area Network (CAN bus) a vehicle bus standard.

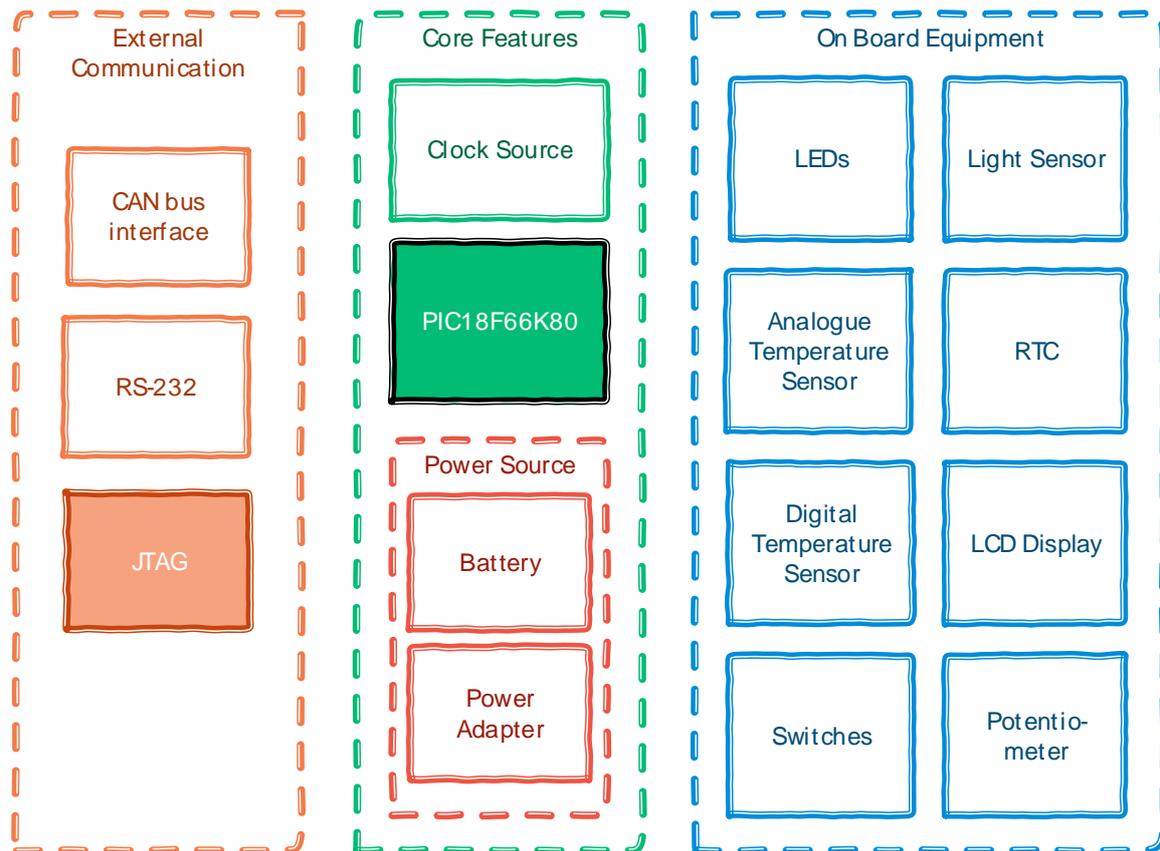


Figure 3: Block diagram of a new development board.

Last part of board is collection of on board peripherals. When students start with first “Hello World” program, they use LEDs connected directly to the microcontroller IO ports. When their knowledge and experience is growing up LEDs are used to indicate different program states. If LEDs are not enough, three lines alphanumeric LCD display is available. These two peripherals simulate actors in real applications. Sensor part is composed from switches, some of them are able to invoke interrupt, potentiometer, analogue temperature sensor and light sensor. They are connected to AD converter.

For digital communication tests digital temperature sensor is available. This sensor use 1-wire communication interface [6]. The same communication interface is used for battery powered Real Time Clock (RTC).

Because the main usage of the described board is for students, we prepared set of examples in C language that explain, how to control and use all available peripherals and interfaces. In some cases we wrote the program without any libraries, in some other we used free Microchip libraries available for selected microcontroller.

4. SUMMARY AND FUTURE WORK

In this article we described some basic information about microcontroller vendors and their products in field of 8-bit microcontrollers, available development environment, compilers. At the end is description of designed and developed development board for students of Microcontrollers and microprocessors course in bachelor study programme of FEEC BUT. Our plans for future are simple and realistic, we will use achieved results from the next semester in regular class laboratories.

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