Information system with light display for visualization of temperature, pressure and time

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Abstract: *A specific solution for the creation of an information system for visualization of temperature, pressure and time, built over the module principle is being given in the current report. The technical solution is based over the use of microcontroller PIC16F873, sensors for temperature and pressure, real-time clock, light display with control unit and RS232 communication. The light display is built with light-emitting diodes arranged as a matrix. For the communication with the real-time clock and the sensors the I^2C interface is used.*

Key words: *Microcontroller, PIC16F873 Application, LED matrix, I^2C, Sensor, Algorithm.*

INTRODUCTION

Latterly more often there is need the information from different kind to be collected, processed and visualized. This is the reason for designing and building of information systems in the fields like the industry, the popular customs, the agricultural, the transport, the sanitation and etc. Such information systems are for example the security systems, video control of train- and bus-stations, for the needs of civil defense, intelligent information systems for the car drivers and etc. One part of them is based on the personal computers and other - on microcontrollers connected with sensors and peripheral devices. Topical information connected with reading of temperature, pressure and time is need that is happen very often. This is why there is need to being made such information systems with light displays for visualization of above listed physical values. In the current report is propound a specific solution for building of one similar information system made over the module principle.

HARDWARE REALIZATION

The hardware part is synthesized on the base of the block diagram from Fig. 1. The base modules of the propounded specific solution are:

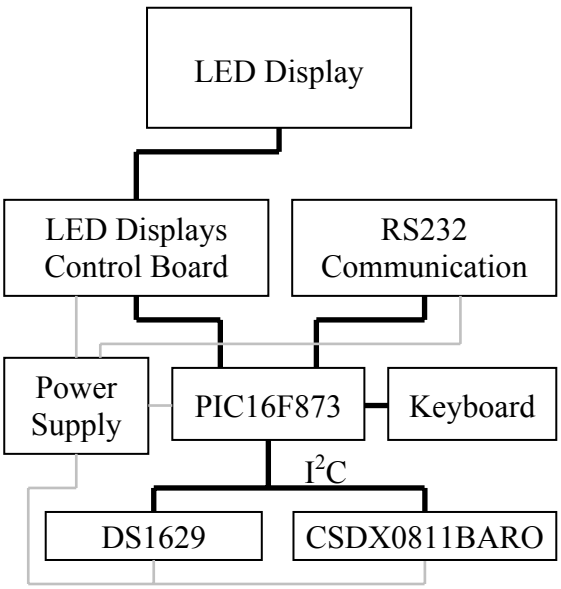

Fig. 1. Block diagram of the propound scheme solution

1. Microcontroller PIC16F873

The function of module microcontroller PIC16F873 made by Microchip is to control the work of the all other modules. The main features of this microcontroller are:

- Working frequency – 20MHz;
- Flash Program Memory (14-bit words) – 4K;
- RAM Data Memory – 192 bytes;
- EEPROM Data Memory – 128 bytes;
- Programmable digital inputs/outputs;
- Serial communications – MSSP (I^2C), USART (RS232);
- Timers – 3;
- Watchdog timer;
- 28-pin body.

The choice of this microcontroller is made in accordance with the technical features and it capabilities for current specific application [5].

2. LED Display Control Board

According with passed information from Microcontroller PIC16F873 to the control of the LED Display is made. There are six serial connected 8-bit shift registers, type 74HC595, for the control of the 48 columns of the LED Display. There is another one such shift register for management of the 8 rows from the matrix. These shift registers has build output buffer with 3 states, which is used for temporarily store of the visualized information [6]. The all outputs of 74HC595 are joined by means of transistors type TIP122 (by columns) and TIP127 (by rows) with the LEDs from the corresponding row and column [9]. At a given time only the LEDs from one of the matrix columns are lighting for the purpose reducing of the power consumption. The fast switching of the active columns gives the feeling for constantly written out symbols. The management of the LED Display Control Board from module microcontroller PIC16F873 is made by means of the next signals:

- data line for the shift registers by columns;
- clock line for the shift registers by columns;
- a line for transfer the data from the shift registers to the output buffers by columns;
- data line for the shift registers by rows;
- clock line for the shift registers by rows;
- a line for transfer the data from the shift registers to the output buffers by rows;
- a line for switching the outputs from the all shift registers in the third state (switch off the LED Display).

3. LED Display

LED Display is a matrix build with LEDs of type L813SRC/F arranged in 16 rows and 48 columns. To be achieved the purpose of the visualized symbols bigger size, every pixel from the display is build by 2 serially joined LEDs. This type LEDs was chosen for the purpose of the rising of the lighting power and the viewing distance [2].

4. DS1629

The DS1629 2-Wire Digital Thermometer and Real Time Clock integrates the critical functions of a real time clock and a temperature monitor in a small outline 8-pin SOIC package. Communication to the DS1629 is accomplished via a 2-wire interface. The wide power supply range and minimal power requirement of the DS1629 allow for accurate time/temperature measurements in battery-powered applications.

The digital thermometer provides 9-bit temperature readings which indicate the temperature of the device. No additional components are required; the device is truly a "temperature-to-digital" converter.

The clock/calendar provides seconds, minutes, hours, day, date of the month, day of the week, month, and year. The end of the month date is automatically adjusted for months with less than 31 days, including corrections for leap years. It operates in either a 12- or 24-hour format with AM/PM indicator in 12-hour mode [1].

5. CSDX0811BARO

Module CSDX0811BARO is represent by a integral circuit, which consists from a sensor for absolute pressure with build-in temperature compensation and a 12-bit ADC for a conversion to digital value of the analogue value from the sensor. In the module a cyclic program is executed, which every 10 ms reads a new 12-bit value from the pressure sensor and stores it in the output buffer of the scheme. The range of the measurement of the barometric pressure is from 800 mbar to 1100 mbar (80000 Pa to 110000 Pa). The value in the output buffer is available for readings by means of the communication over the I^2C interface [8].

6. Keyboard

Module Keyboard consists from four buttons which are used for the management of the work of the device. The functions of the buttons are:

- for Reset of the device;
- for switching of the work mode – mode 'adjusting' and mode 'normal work';
- for adjustments of the clock's hours;
- for adjustments of the clock's minutes;

The zeroing of the clock's seconds is done when there is switching between the mode 'adjusting' and the mode 'normal work'.

7. RS232 Communication

Module RS232 Communication is based on the build-in USART module into the PIC16F877. There is a voltage converter for TTL/RS232 levels type MAX232 made by Maxim Integrated Products. The recommended scheme is used with some additional electrical parts, according the documentation [4].

With the help of this module it is possible to be made a serial communication with personal computer by means of build-in into it RS232 interface. A previously defined higher level protocol is used to transfer the information from the device to the personal computer.

8. Power Supply

The module Power Supply creates the voltages for the normal work of the all modules in the device. These voltages are created with the help of integral voltage regulators type 7805 and 7812, respectively:

- +5 V (200 mA) – for the power supply of the modules: PIC16F873, LED Display Control Board, RS232 Communication, I^2C Bus, DS1629 и CSDX0811BARO;
- +12 V (1 A) – for the power supply of the high power part from the LED Display Control Board.

To guarantee the local autonomous of the device toward temporal drops of the electrical network power an accumulator battery is used in the scheme to supply the uninterrupted work of the clock module into DS1629.

9. I^2C интерфейс

The I^2C interface is used to make the communication between the modules DS1629 and CSDX0811BARO and the microcontroller PIC16F873. When the configuration of the interface is made it is accepted that the microcontroller will work as master device and the other devices will work in slave mode. The all devices in the I^2C bus have their own addresses and thus the communication with them is possible. In the manufacturing process there is assigned slave address (1111000xb) to CSDX0811BARO, thus it is not possible to connect more than one such integrated circuit scheme to the I^2C bus.

It is possible to be connected up to 7 slave devices toward the microcontroller. The built-in interface in PIC16F873 is used for the synchronous serial communication (MSSP), which can be configured to work like I^2C interface according the specification [7].

ALGORITHM REALIZATION

The purpose of the information system is to visualize the information for the current barometric pressure, temperature and time by means of LED Display. This is done as the information for the barometric pressure is cyclically exchanged by the information for the temperature and current time.

There is need of cyclical reading (lower than 1 minute periods) of the actual values from the real-time clock and the sensors for pressure and temperature, and to store the read values into the microcontroller's memory. The communication with the real-time clock and the sensors is possible with the use of I^2C interface and the previously defined in the specifications protocols for reading and writing.

There is need too the read values to be converted in the appropriate format before their actual visualization. For that purpose the filling with zeroes and ones is done of the three previously defined pixel tables. Every cell from these tables corresponds to one pixel

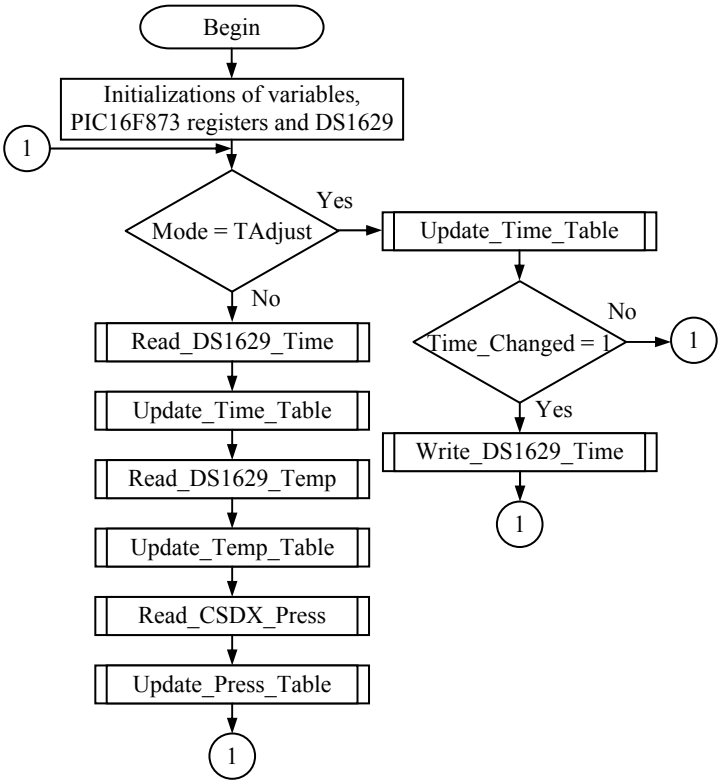

Fig. 2. Algorithm of the main program

from the LED matrix for the visualization of the three kinds of information, and the value into the cells determines the state of the pixels – turn off or turn on.

The refresh frequency of the information over the LED Display is chosen to be 100 Hz to achieving the more stable display image without flickering and blinking. In this situation the refreshing of the visualized information is reduced to cyclically selecting of one of the 48 columns every 200 μs (5 kHz) and it's reloading with the values from the corresponding pixel table which is chosen.

To expand the features of the device there is in the design a support of the RS232 interface for the purpose to make a communication with personal computer. There is need to be recognized the sent commands from the computer toward the device and to be returned the corresponding data in response, i.e. to be supplied the communication with the help of previously defined higher level protocol for the exchanging of commands and data.

For the solving of the defined tasks the feature of the microcontroller PIC16F873 is used for rising of software interrupts when there are some events into its internal modules. The algorithms for the execution of the main program and for subprogram for processing of the interrupts are showed in Fig. 2 and Fig. 3. For the purpose of synchronization and the events control in the time, the next sources of interrupts are used:

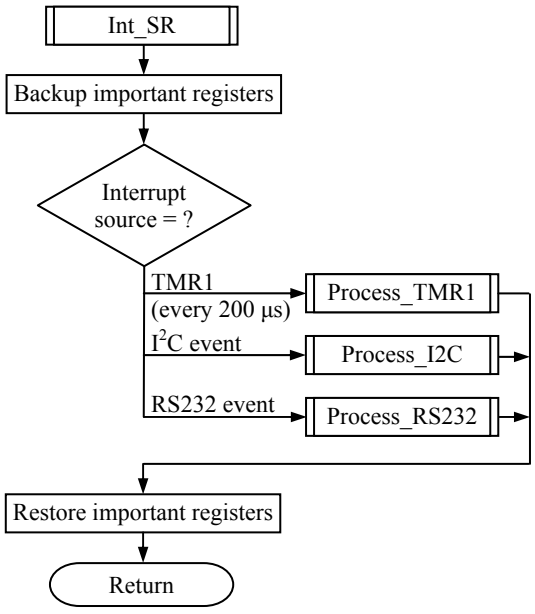

Fig. 3. Algorithm of subprogram for interrupts processing

- Timer 1 (TMR1) every 200 μs – for the activation of the refreshing procedure for the next column of the LED Display, for clearing of the Watchdog Timer and for generating of time delays with 100 ms and 1 s periods:
  - Every 100 ms – the scan of the buttons for changes in their state and for switching the working mode and/or for changing of the value of the current time;
  - Every 1 s – to set the request for refreshing the contents of the pixel tables, generating of time delays with 10 s and 2 minutes periods;
  - Every 10 s – choice of another pixel table for visualization;
  - Every 2 minutes – check for long periods with equal image for minutes (to prevail the eventual errors over the communication with DS1629); in the

mode 'adjusting' this is the time period for timeout – for returning back to mode 'normal work'.

- SSP module – to manage the communication over I^2C interface;
- USART module – to manage the communication over RS232 interface;
- Watchdog Timer – to guarantee the correct work of the software – executes Reset procedure on the microcontroller when there are bigger time delays than 6.5 ms between the periods of execution of the instruction for Watchdog Timer clearing.

SOFTWARE DESCRIPTION

The software for PIC16F873 is created with the help of Microchip MPLAB IDE v6.12 with the use of Microchip MPASM Toolsuite, and the programming of the chip is made by means of ICProg v1.05c.

After the switching on of the power (or after a Reset procedure) the loaded software in the PIC16F873 starts to work. A single time are executed the procedures for the beginning initializations and configurations for the microcontroller, DS1629 and CSDX0811BARO. After this the execution of the infinitive cycle with the above described algorithm is started (Fig. 2).

The main tasks, performed by the microcontroller PIC16F873 are:

- Refreshing of the visualized information over the LED Display according to currently chosen pixel table;
- Changing of the active pixel table according to the previously defined time periods for visualization;
- Tracking of the changes in the buttons state from the keyboard and switching of the working mode and/or change in the contents of the pixel table for visualizing of time in response to pushed button;
- Converting of the received information from the DS1629 for hours and minutes into symbols and updating of the pixel table for visualizing of time;
- Converting of the received information from the DS1629 for temperature into symbols and updating of the pixel table for visualizing of temperature;
- Converting of the received information from the CSDX0811BARO for barometric pressure into symbols and updating of the pixel table for visualizing of barometric pressure;
- Reading of the actual information for hours and minutes from DS1629 according to the protocol for time reading over I^2C interface;
- Reading of the actual information for temperature from DS1629 according to the protocol for temperature reading over I^2C interface;
- Reading of the actual information for barometric pressure from CSDX0811BARO according to the protocol for barometric pressure reading over I^2C interface;
- Sending of data toward personal computer according the defined higher level protocol for sending over the RS232 interface;
- Receiving/recognizing of data/commands from personal computer according the defined higher level protocol for receiving over the RS232 interface;
- When works in 'adjusting' mode – writing the information for hours and minutes into DS1629 according the protocol for time writing over I^2C interface;
- When the device is switched on and when there is such need – initializing/configuring of the DS1629 and CSDX0811BARO according to their protocols for this;

CONCLUSIONS AND FUTURE WORK

The propound solution for information system for visualizing of the current time, temperature and barometric pressure can find practical applications in many fields.

The designed information system in combination with the sensor for humidity can be used also for giving of a weather forecast. The prognosis can be based of the statistical information and processing with linear algorithms for prediction. There are another methods for making of prognosis based over the different kind of analysis of statistical information which can be used for the synthesis of algorithms and their applying in the software of the device [3].

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