

## Exercise 5

# **Communication interfaces – measuring random and pseudo-random signals**

## Laboratory Instruction

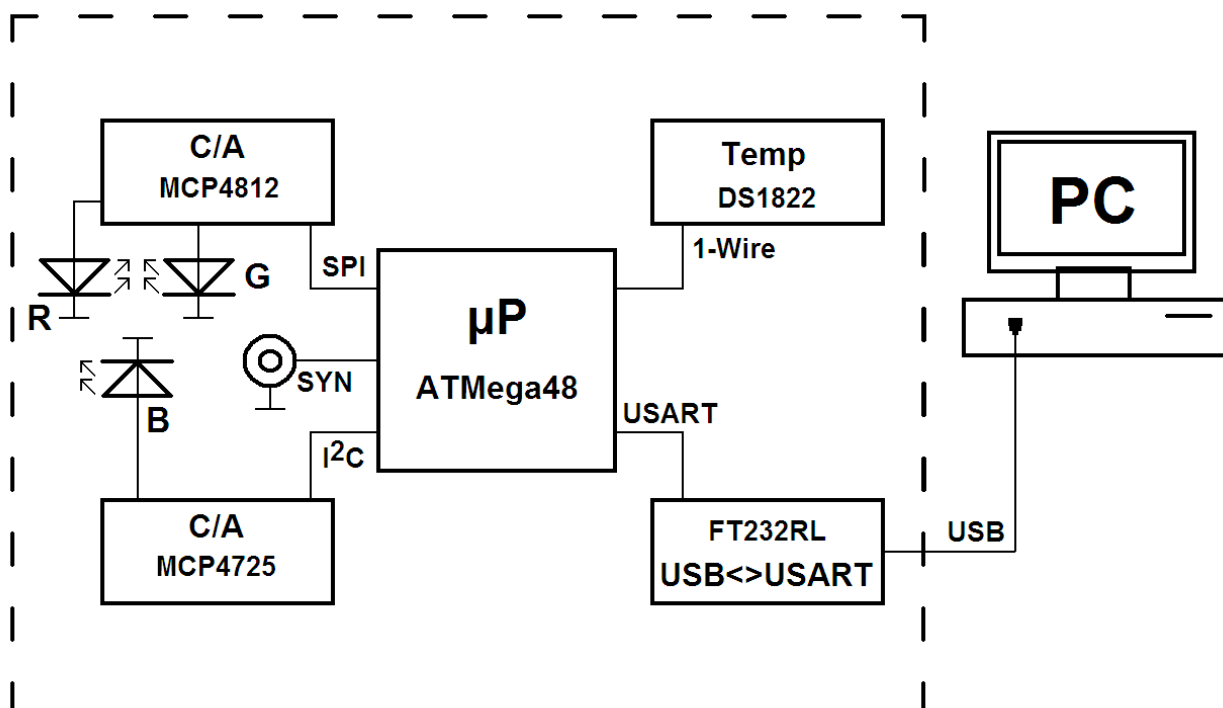
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## 1. Aim of the exercise

Developing skills in operating a digital oscilloscope, especially the triggering modes allowing registering and analyzing non-periodic signals and signals including short pulses.

## 2. Circuit description

The block diagram of the system used during the laboratory exercise is presented below.



The model is composed of a few blocks. The core of the system is formed by a microcontroller (ATmega 48), controlling the operation of various peripheral circuits: temperature sensor (DS1822) using the 1-Wire interface, the single-channel D-to-A converter (MCP4725) using the I<sup>2</sup>C interface, the two-channel D-to-A converter using the SPI interface and the UART-USB converter (FT232). The module is supplied from 5 V voltage regulator, connected to the wall plug-in transformer.

Signals from all interfaces are wired to the test points allowing probing them with the oscilloscope probes. Those signals are non-periodic and may be regarded as random ones (at least partially) because their form depends on the information transmitted by the interfaces (e.g. the actual temperature, the code of the key pressed on the keyboard of the computer etc.).

**All the signals appearing on the terminals of the model are within the range of 0-5 V and last only for a short period of time after sending the command using the terminal (the only exception is the run command, cyclically sending the data). During the measurements you should use DC coupling for all signals.**

The communication with the PC computer is performed via the USB interface, using a standard terminal-type software. The configuration of the transmission port is: 38400 bit/sec, 8 data bits, 1 stop bit, no parity. **Before starting the measurements you should turn the power supply of the model ON, next connect the USB cable connecting the model with the PC, and in the last step start the terminal software. In case of communication problems or software crash repeat all the steps in correct order.** The **SYN** output may be used optionally to mark the start of the transmission.

The list of terminal commands that are accepted by the model:

**temp[Enter]** – the start of the temperature measurement; the answer is sent back to the terminal. The data are transmitted using the USB, UART and 1-Wire interfaces. The signals may be observed on the oscilloscope using the probes connected to the appropriate test points.

**r[*digit 0 ... 9*]g[*digit 0 ... 9*]b[*digit 0 ... 9*][Enter]** (e.g. **r3g5b1[Enter]**) – the command sends the information to the D-to-A converters, controlling the brightness of the three sections of the RGB LED. The values of the voltages are unimportant and the change of the LED color is used just to show the operation of the converters. The information is transmitted using the USB, UART, I2C and SPI interfaces. The signals may be observed on the oscilloscope using the probes connected to the appropriate test points.

**run[Enter]** – starts the continuous transmission of the data (numbers changing from 1 to 255) via the interfaces UART, USB, 1-Wire, I2C and SPI. In this mode it is possible to observe the signals without sending any additional commands from the terminal. Pressing any key stops the **run** command.

### **3. Preparation to the exercise**

**PLEASE NOTE: students unprepared to the laboratory (in the range mentioned below) will not be allowed to do the exercise.**

1. Learn the operation of a digital oscilloscope using the material presented during the lecture. Understand the operation and purpose of different triggering modes. Learn how to check proper compensation of the oscilloscope probe and compensate it if necessary. Understand when using of the oscilloscope probe is necessary or recommended.
2. Determine the reasonable settings of oscilloscope timebase speed for observing signals transmitted with the rate of 38400 bits/sec. What input sensitivity would be adequate for observing signals varying in the range of 0-5 V?
3. Familiarize with the ASCII codes, write the code of some letter or digit in your notebooks (it will be used further).
4. Learn the structure of simplest data frame used by UART interface (start bit represented always as a low level, 8 bits of data, stop bit represented always by a high level). Write the frame with the chosen ASCII data code.

5. Familiarize with the electrical specification of the USB interface. Consider the problem of measuring the differential voltage signals using an oscilloscope.

#### **4. Plan of the exercise**

##### **1. UART interface**

- a. Connect the oscilloscope probes to the UART test points. Observe the single data frame. Use the NORMAL and ONE SHOT triggering modes. Observe the differences and compare with using AUTO triggering mode.
- b. Compare the frame acquired using the oscilloscope with the frame formed “manually” in the preparation to the exercise.
- c. Determine the bit duration and the transmission speed in units of [bits/sec].

##### **2. USB interface**

- a. Connect the oscilloscope probes to the points marked DP and DM and observe the waveforms. Measure the signals at two different settings of the probes: x1 and x10. Draw some conclusions and report them to the laboratory supervisor.
- b. Set the oscilloscope and the probes in a way allowing observing the difference between the points DP and DM (the USB interface uses the differential signaling).
- c. Set the triggering mode and triggering parameters in a way allowing seeing stable and clear waveform on the oscilloscope.
- d. Determine the transmission speed that results from the duration of the shortest event that might be observed using the oscilloscope (i.e. the shortest distance between two slopes – the rising and falling - of the signal).

##### **3. SPI interface**

- a. Connect the oscilloscope probes to the three test points allowing observation of the signals of the SPI interface. Observe the SPI data frame.
- b. Determine the duration of the data bit and the transmission speed in units of [bits/sec].
- c. Determine the duty cycle of the clock signal using oscilloscope markers.

##### **4. I2C interface**

- a. Connect the oscilloscope probes to the relevant points and set the oscilloscope to be triggered by the start of the frame.
- b. Change the settings of the oscilloscope to trigger it by the third slope of the SDA signal counting from the start of the frame.

**5. 1-Wire interface**

- a. Connect the probe to the 1-Wire test point and observe the signal.
- b. Set the oscilloscope to be triggered by the shortest observed pulse.
- c. Measure the time duration of this pulse, the rise time and the fall time using oscilloscope markers.
- d. Compare the results of manual measurements with the results of the automatic oscilloscope measurements.

**5. Elaboration of the results**

There is no “Elaboration of the results” part in this exercise. The mark you may get will depend on your progress in the realization of the tasks and your skills when operating the oscilloscope. You will get your mark at the end of the exercise.