Digital Electronics 2 (Brno University of Technology)

Assignment of lab #5

2019
October

Synchronize Git and create a new project

- In VS Code open your Digital-electronics-2 working directory and synchronize the contents of a repository with a single git command (`git pull`) or a sequence of two commands (`git fetch` and `git merge`).

- Create a new folder `project/05-segment` and copy three files from the last project: `main.c`, `Makefile`, `README.md`.

Multi-Function Shield
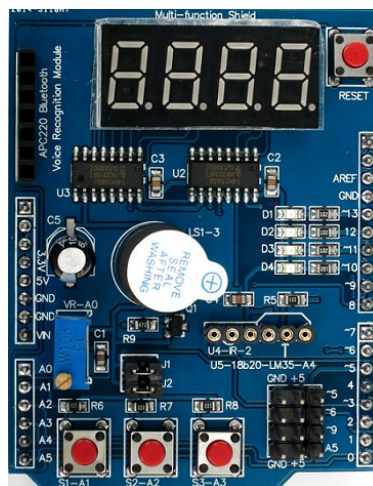
- In `docs/hw/` folder, see schematic of Multi-Function Shield and find out the connection of D1, D2, D3, D4 LEDs and S1-A1, S2-A2, S3-A3 push buttons.

- Use three push buttons and Pin Change Interrupts 11:9 to toggle a single LED. According to ATmega328P data sheet [1] configure the Pin Change Interrupts in PCICR (Pin Change Interrupt Control Register) and PCMSK1 (Pin Change Mask Register 1) registers. What vector name has the PCINT interrupt service routine [2]?

Seven-segment display

Seven-segment is an electronic display device and consists of eight LEDs connected in parallel that can be lit in different combinations to display the numbers and letters [3].

- In `docs/hw/` folder, see schematic of Multi-Function Shield and find out the connection of seven-segment display. What is the purpose of two shift registers 74HC595?

- Analyze timing of serial communication between ATmega328P and both shift registers.
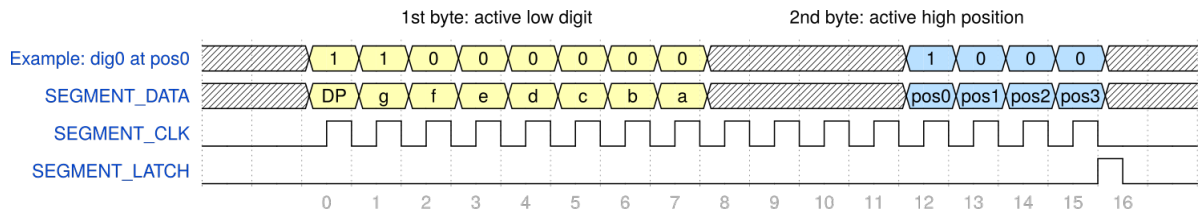
Note: The figure above was created in WaveDrom digital timing diagram online tool [4]. The source of the figure is as follows:

```
{signal: [
  {name: 'Example: dig0 at pos0',
   wave: 'xx33333333xxxx5555xx',
   data: ['1','1','0','0','0','0','0','0','1','0','0','0']},
  {name: 'SEGMENT_DATA',
   wave: 'xx33333333xxxx5555xx',
   data: ['DP','g','f','e','d','c','b','a','pos0','pos1','pos2','pos3']},
  {name: 'SEGMENT_CLK',
   wave: 'l.nn..............l.'},
  {name: 'SEGMENT_LATCH',
   wave: '0................pl'},
],
  head:{
  text: '      1st byte: active low digit
    2nd byte: active high position',
  },
  foot:{
    text: '',
    tock: -2
  },
}
```

- Create a new library header file `library/inc/segment.h` and define function prototypes for communication with shift registers [5].

- Create `library/inc/segment.c` source file according to [5]. Complete look-up tables and body of functions SEG_putc(), SEG_toggle_clk(). Verify the reliability of functions you have created and the correct settings of all digits.

- Add the source file of seven-segment library between the compiled files in `05-segment/Makefile`.

Decimal counter

- Use Pin Change Interrupt 11:9 to increment value at seven-segment display from 0 to 9.

- Use Pin Change Interrupt 11:9 to increment value at seven-segment display from 0 to 99. Use 8-bit internal Timer0 to multiplex the display position.

- At what frequency it is necessary to switch between the display positions in order to avoid blinking?

Clean folder and synchronize git

- Remove all binaries and object files from the working directory. Then use git commands [6], commit all modified/created files to your local repository and push them to remote repository. Use VS code editor options to perform these operations.

Ideas for other tasks

- Extend the look-up-table and define letters according to ASCII table. Program a scrolling text application at seven-segment display.
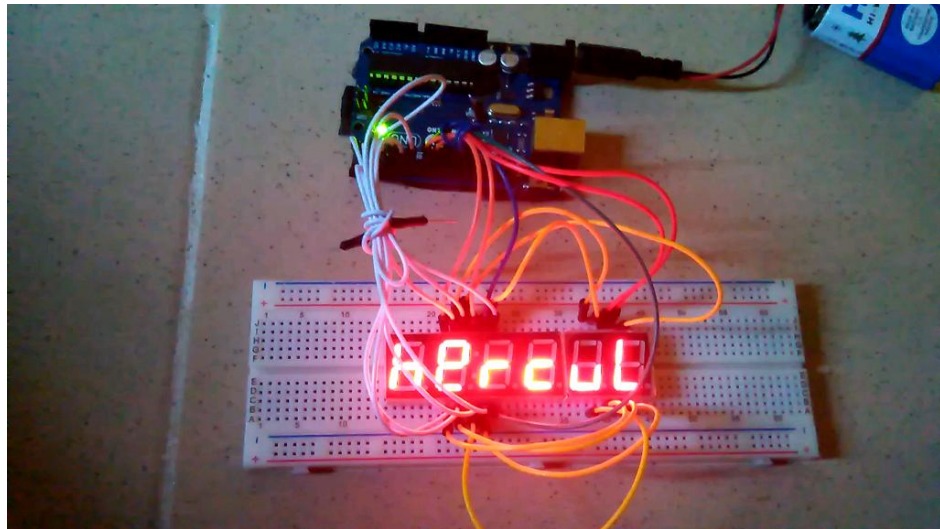
- Use basic Goxygen commands inside C-code comments [7] and prepare your `segment.h` library header file for easy PDF manual generation.

- Complete `README.md` file.

References

[1] ATmega328P - 8-bit AVR Microcontrollers,
https://www.microchip.com/wwwproducts/en/ATmega328p

[2] avr-libc, Standard C library for AVR-GCC, Interrupts,
https://www.nongnu.org/avr-libc/user-manual/group__avr__interrupts.html

[3] 7-segment Display and Driving a 7-segment Display,
https://www.electronics-tutorials.ws/blog/7-segment-display-tutorial.html

[4] WaveDrom, Digital Timing Diagram everywhere,
https://wavedrom.com/

[5] AVR repository for DE2 course at Brno University of Technology,
https://github.com/tomas-fryza/Digital-electronics-2

[6] Git Commands,
https://github.com/joshnh/Git-Commands

[7] Doxygen, Documenting the code,
http://www.doxygen.nl/manual/docblocks.html#specialblock