ELEC 291/292 201 (2019W2)

Project 2 README

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1 Introduction

This project is a metal detector circuit that uses a Colpitts Oscillator to detect metal.

2 Hardware Construction

2.1 Microcontroller

This system uses the ATMega328P by Atmel, and communicates with a PC using the BO230XS Serial Adapter provided in this course. Clock is provided by a 16MHz crystal. The schematic is as follows:

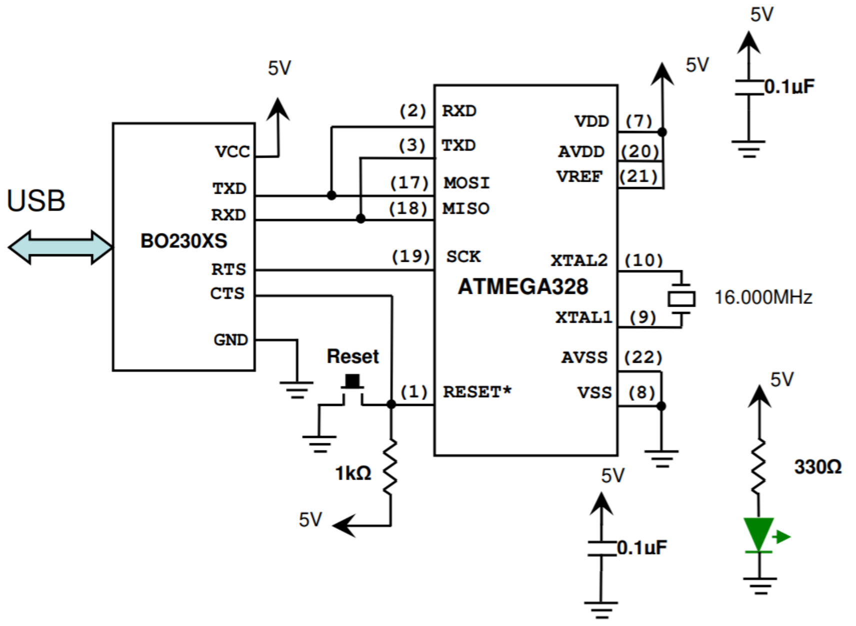

Figure 1: Microcontroller system circuit schematic

2.2 Colpitts Oscillator

The Colpitts Oscillator was built using two MOSFETs (one N-channel and one P-channel) as the oscillator's active stage. The table below outlines the parts used to build the oscillator:

Component Type	Name	Datasheet
MOSFET - Power, N-Channel, Logic Level, DPAK/IPAK	NTD3055L104, NTDV3055L104	ON Semiconductor
MOSFET - Power, P-Channel, DPAK	NTD2955, NVD2955	ON Semiconductor
$2 \times 0.1\mu F$ Capacitors	C1, C2	N/A
$0.1H$ Inductor	L	N/A
100Ω Resistor	R	N/A

This is the circuit diagram for the oscillator taken from the (old) Project 2 Slide Set written by the course instructor:

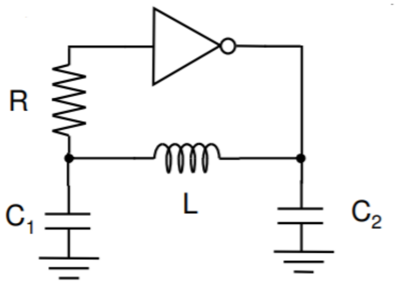

Figure 2: Colpitts Oscillator circuit diagram

The CMOS inverter was built using the above MOSFETs. This is the circuit schematic:

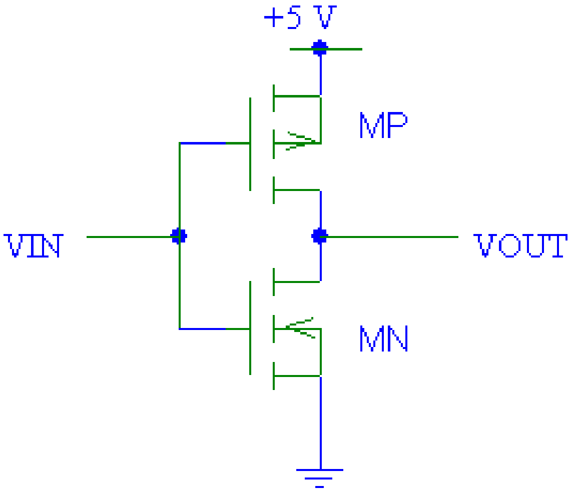

Figure 3: CMOS inverter using MOSFETs

2.3 Other hardware

- 3 small yellow LEDs to indicate proximity to metal
- 1 red LED to replace a speaker (mine was faulty and I could not acquire a replacement in time for the project)
- 2 push-buttons to mute and/or turn off small LEDs

3 Compilation/Building of Software

3.1 List of files used

3.1.1 C/Makefiles

1. `project2.c`
2. `project2.mk`
3. `usart.c`

3.1.2 Header files

1. avr/io.h
2. avr/interrupt.h
3. stdio.h
4. stdbool.h
5. util/delay.h
6. avr/sfr_defs.h
7. usart.h

3.2 Building and compilation

CrossIDE was used to build the Makefile and load it onto the microprocessor using spi_atmega provided by the course instructor. wait.zip, provided by the course instructor, was also extracted to the same directory as CrossIDE, as the Makefile uses the function. The CrossIDE Makefile page is as follows:

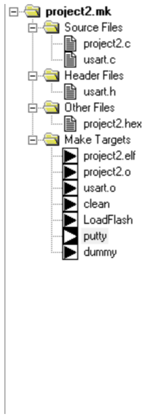

Figure 4: CrossIDE Makefile pane

4 Operation of Metal Detector

4.1 Initialization

Upon asserting RESET, `PuTTY` will print a welcome message and prompt the user to calibrate the detector.

The Input Capture Unit is used to measure `base_period` (no metal) and `metal_period` (metal right on top of inductor). The microcontroller's Input Capture Unit (ICU) will trigger at every rising edge of the input signal. Two timestamps are taken and their difference (taking into account Timer 1 overflows, which is handled by a separate ISR) will be the period.

`metal_period` and `base_period` are used to calculate `threshold`, which divides the frequency into 3 stages which indicate different proximity levels.

4.2 Operation

The PuTTY will display the following messages depending on the proximity of metal to the system. The LEDs will also light up as follows:

- no metal nearby:
  ```
  No metal detected...
  ```
  ○ ○ ○
- some metal nearby:
  ```
  Some metal detected...
  ```
  ○ ○ ●
- almost near metal:
  ```
  Getting closer to metal...
  ```
  ○ ● ●
- metal detected:

```
Metal detected!
● ● ●
```

4.3 Video of operation

A video of operation is available on Youtube.

5 Extra features

- AVR's Input Capture Unit used to measure period of signal using interrupts
- 3 LEDs provide an indication of proximity to metal
- PuTTY will inform the user of proximity to metal

6 References

- Course instructor's notes on course Canvas page
- ATMega328P datasheet by Atmel
- https://www.elecrom.com/avr-tutorial-2-avr-input-output/
- https://www.electronicwings.com/avr-atmega/atmega1632-timer-input-capture-mode
- http://class.ece.iastate.edu/cpre288/lectures/lect14$_1$5*IC.pdf*
- https://embedds.com/programming-16-bit-timer-on-atmega328/
- https://efundies.com/avr-advanced-timer-interrupts/
- https://efundies.com/avr-usart-serial/