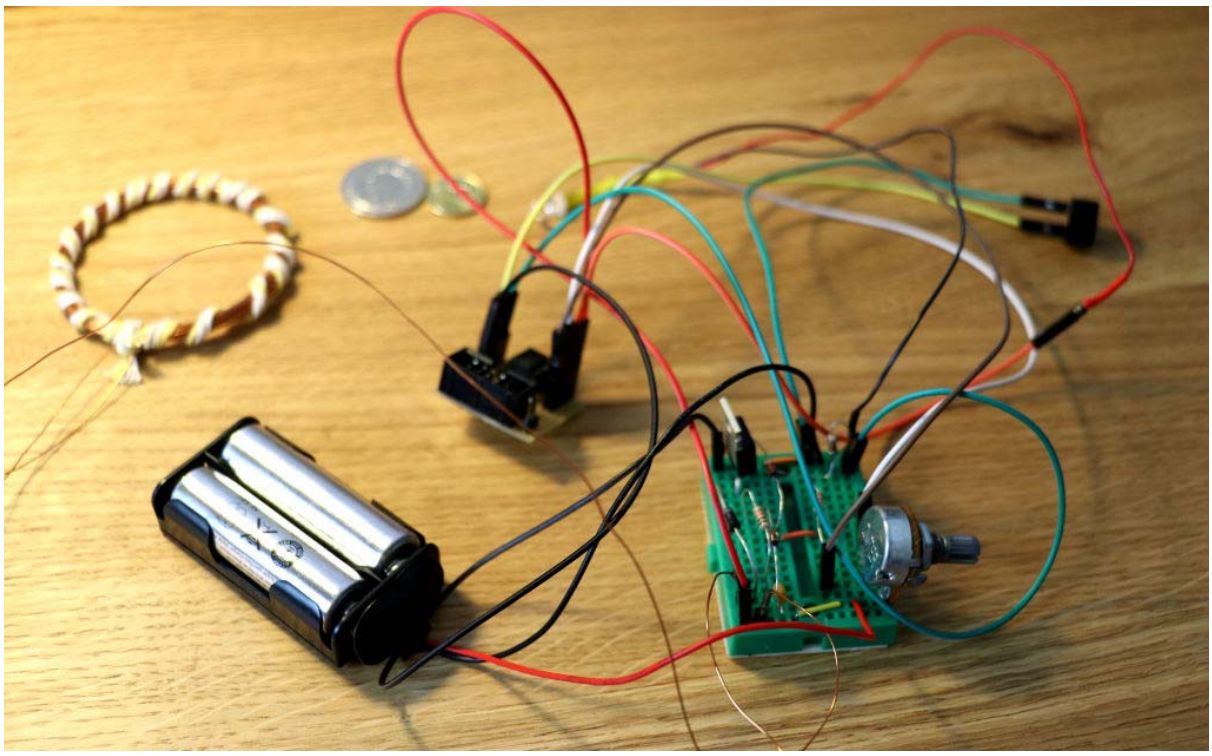
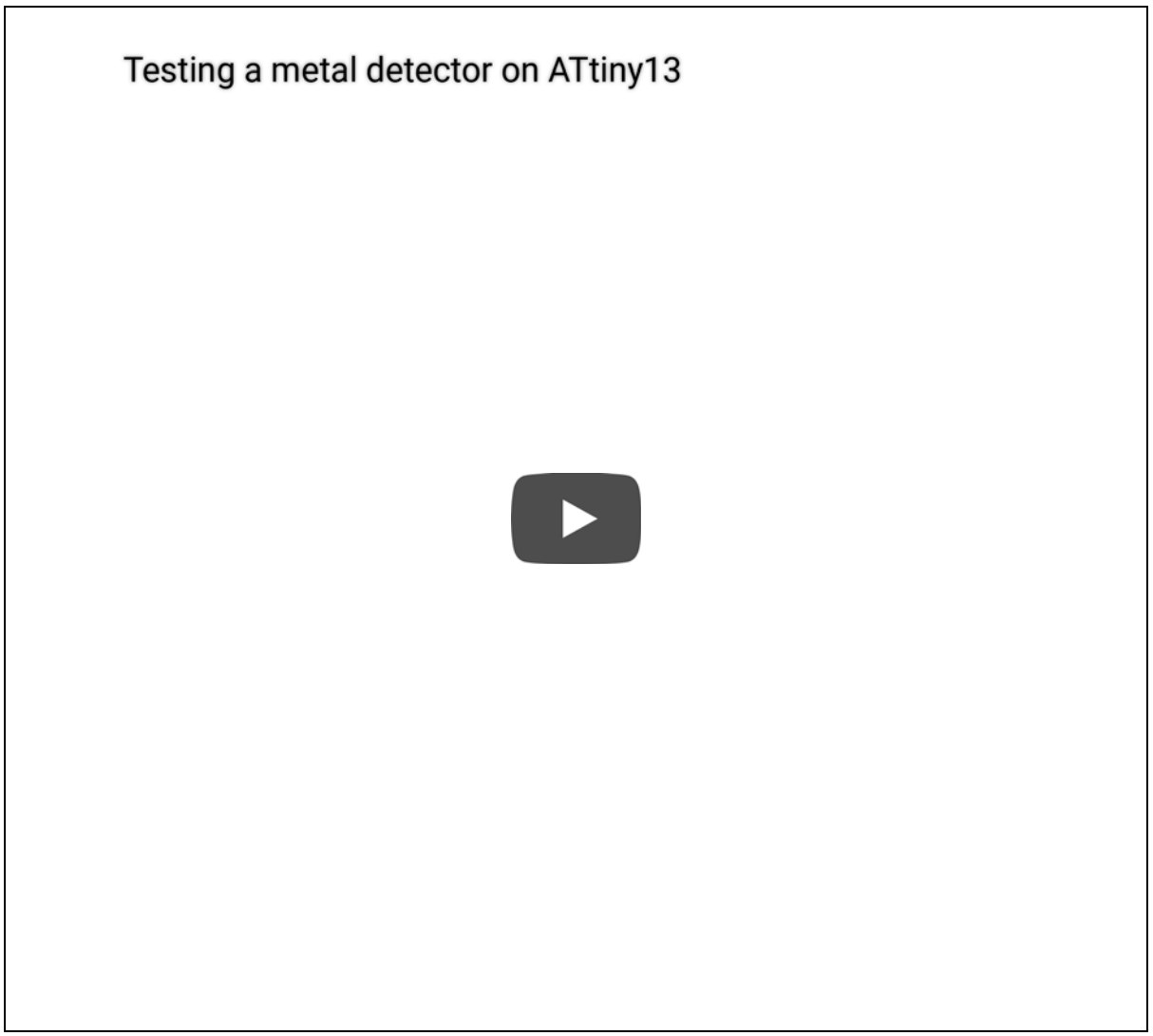


ATtiny13 – PI metal detector

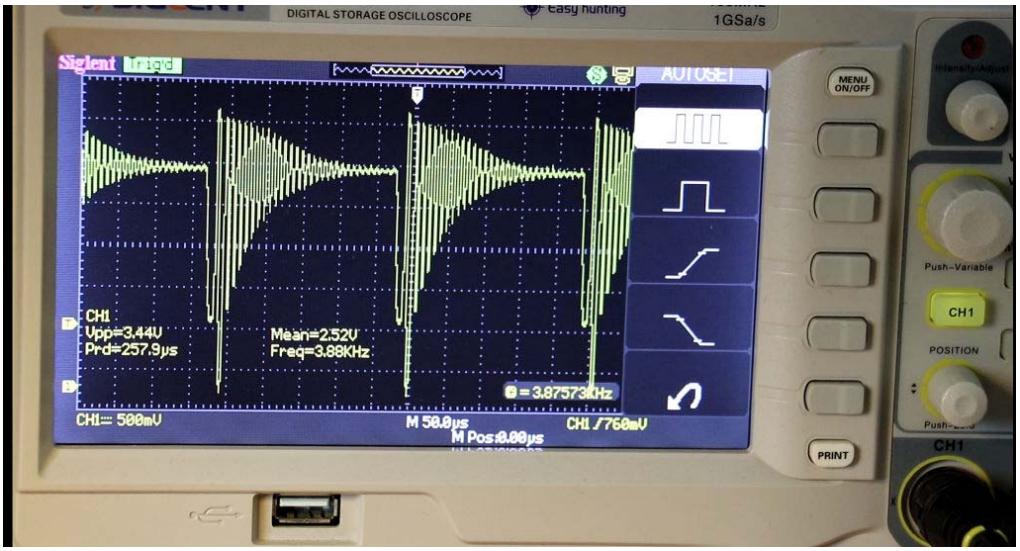
2019-02-17 by Łukasz Podkalicki

This experimental project shows how to build a simple PI (Pulse Induction) metal detector based on ATtiny13 / AVR microcontroller. My goals were to make a circuit as simple as possible and to use only popular / cheap electronic parts. The device has been tested with very small coil (55mm diameter, about 30 turns of 0.5 DNE) and only 3V power supply. It's my first design of PI metal detector and I'm really happy with the results! The prototype was able to detect little coins (6cm distance) and wires in the wall. The code is on Github, here.



How It Works?

Presented metal detector uses PI method to generate a voltage spike in a search coil connected in parallel with capacitor. Next, ATtiny13 uses an Analog Comparator to measure a decay time to zero of resonant circuit. When a metal object nears the loop it will decrease time it takes for the pulse to decay to zero. The change in the width of resonance time is measured to signal the presence of a metal target.



Note that the typical PI detector designs avoid resonant circuit and the measured factor is slightly different!

User Instructions

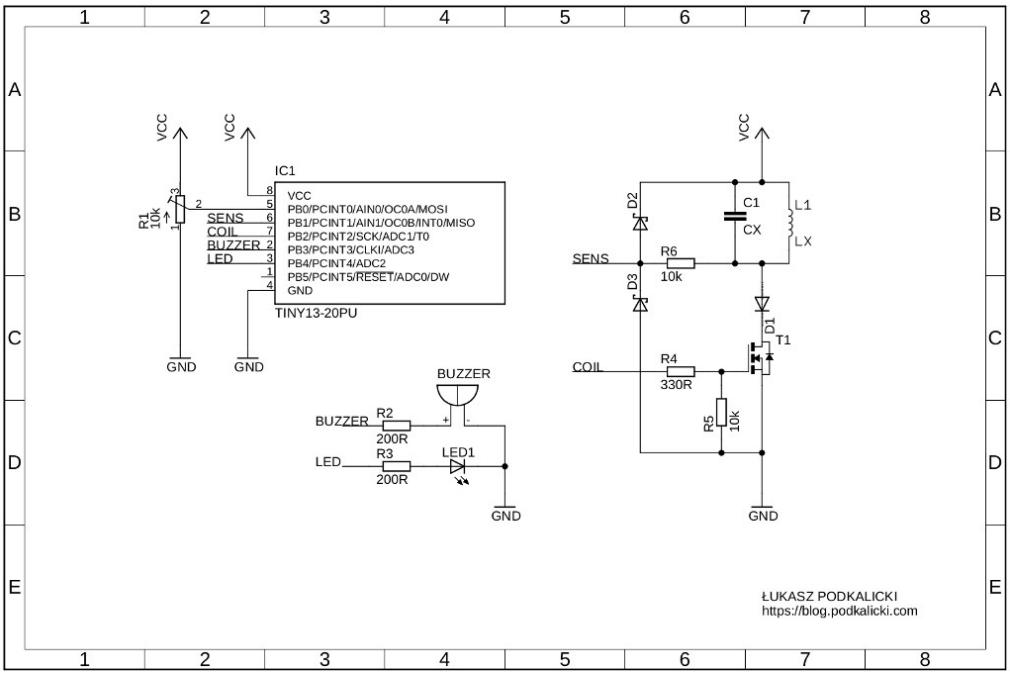
1. Turn on the device. The calibration process takes about second and ends with buzzer signal.
2. Use variable resistor to adjust detector sensitivity (you can find it somewhere between a continuous buzzer signal and complete silent).
3. The device is ready to work!

Parts Required

- ATtiny13 – i.e. MBAVR-1 development board
- T1 – IRF3205 (MOSFET; N-Channel)
- LED1 – basic LED
- D1 – i.e. 1N4007
- D2, D3 – 1N4148
- R1 – variable resistor 10kΩ
- R2, R3 – 220Ω (5%), see LED Resistor Calculator

- R4 – 330Ω (5%)
- R5, R6 – 10kΩ (5%)
- C1 – 470nF
- L1 – ø 50-55mm, about 30 turns of 0.5 DNE

Circuit Diagram



Software

This code is written in C and can be compiled using the avr-gcc. All information about how to compile this project is here.

```
/**
 * Copyright (c) 2019, Łukasz Marcin Podkalicki <lpodkalicki@gma
 * ATtiny13/037
 * Example of simple PI (Pulse Induction) metal detector.
 */
```

```
#include <avr/io.h>
#include <util/delay.h>
#include <avr/interrupt.h>

#define COIL_PIN                    PB2
#define BUZZER_PIN                  PB3
#define LED_PIN                     PB4

#define PULSE_WIDTH                 (32) // microseconds
#define CALIBRATION_ATTEMPTS_MAX    (128)
#define MEASUREMENT_ATTEMPTS_MAX    (2048)

#define SIGNAL_ON()                 (PORTB |= _BV(LED_PIN)|_BV(BUZ
#define SIGNAL_OFF()                (PORTB &= ~(_BV(LED_PIN)|_BV(B


static uint16_t
measure_decay(void)
{
    uint16_t i, counter = 0, decay = 0;

    PORTB |= _BV(COIL_PIN); // pulse on
    _delay_us(PULSE_WIDTH); // pulse delay
    PORTB &= ~_BV(COIL_PIN); // pulse off

    for (i = 0; i < MEASUREMENT_ATTEMPTS_MAX; ++i) {
        if (ACSR & _BV(ACO)) {
            decay = counter;
        }
        counter++;
    }

    return decay;
}

static uint16_t
calibration(void)
{
```

```
    uint8_t i;
    uint16_t tmp, decay = 0;

    /* calibration process */
    for (i = 0; i < CALIBRATION_ATTEMPTS_MAX; ++i) {
        tmp = measure_decay();
        if (tmp > decay) {
            decay = tmp;
        }
    }

    /* signalize end of calibration */
    for (i = 0; i < 3; ++i) {
        for (tmp = 0; tmp < 64; ++tmp) {
            SIGNAL_ON();
            _delay_ms(0.3);
            SIGNAL_OFF();
            _delay_ms(0.3);
        }
        _delay_ms(64);
    }

    return decay;
}

int
main(void)
{
    uint16_t decay_cur, decay_max;

    /* setup */
    DDRB = _BV(COIL_PIN)|_BV(LED_PIN)|_BV(BUZZER_PIN); // set CO
    ACSR = 0; // clear register

    decay_max = calibration() - 1;
    _delay_ms(500);

    /* loop */
    while (1) {
```

```
            decay_cur = measure_decay();
            if (decay_cur < decay_max) {
                SIGNAL_ON();
                _delay_us(100);
            }
            SIGNAL_OFF();
        }
    }
```

References

- http://www2.gi.alaska.edu/~jesse/treasure/misc/howdetector.html
- https://svet-el.si/download/Metal%20detector.pdf
- http://www.nuggetshooter.com/articles/UnderstandingPIdetector.html

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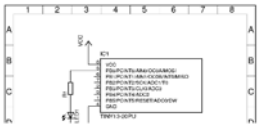
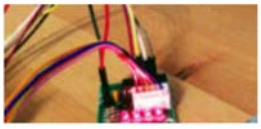


ATtiny13 – randomly flashing LED with PRNG based on BBS

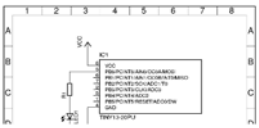
ATtiny13 – disco lights using DFT



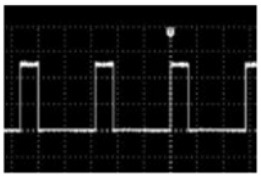
ATtiny13 – controlling stepper motor 28BYJ-48

ATtiny13 – reading temperature and humidity from DHT11

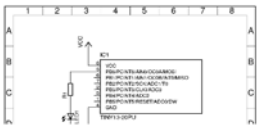
ATtiny13 – simple timer on TM1637



ATtiny13 – blinky with timer COMPA (assembler version)



ATtiny13 – hardware PWM



ATtiny13 – blinky with timer OVF (assembler version)

ATtiny13 – controlling LEDs WS2811/WS2812

AVR, Lab, Project
ATtiny13, AVR, Metal Detector, microcontroller, PI, Pulse Induction
◂ Arduino – blinky with Timer1 COMPA
▸ Arduino – example of 28BYj-48 stepper motor controller

16 thoughts on “ATtiny13 – PI metal detector”

Ladislav
2020-10-02 at 6:14 AM | Reply

Ahoj prosím ťa mohol by si mi poslať hex súbor.
Ďakujem
S pozdravom
Laco

Piotr
2020-06-08 at 10:25 AM | Reply

Witam
Spodobał mi się ten detektor metali.
Robię taki dla siebie i syna.
Mam wszystkie części.
Problem to zaprogramowany układ.
Można taki z softem gdzieś kupić.

Proszę o info.
Pozdrawiam

OneHalf
2020-04-15 at 4:04 PM | Reply

Zrobiłem to urządzenie, ale z jakiegoś powodu działa bardzo cicho. I bez względu na obecność tranzystora 😕 Metal wykrywa (szczypce – 5 cm.). Powiedz mi, gdzie mam szukać problemu? 🙂

Łukasz Podkalicki
2020-06-02 at 8:15 PM | Reply

Zgaduje, że kiepski buzzer użyłeś (albo z generatorem, w tym projekcie powinien być bez generatora). Ten piezzo co ja używałem, po wielu próbach, mimo iż minęło wiele miesiący od tego czasu, nadal mi dzwoni w uszach 😉

Dude
2019-11-20 at 2:45 PM | Reply

WinAVR is a severe pain in the ass!
Why can't you just post a compiled .hex file here? I would be happy to have it! Thanks!

pw
2019-11-06 at 2:41 PM | Reply

Hi Łukasz

Very nice! I was wondering : wouldn't it be more sensitive measuring the shift in frequency instead of shift in decay time (i.e. resonance position instead of resonance width) ?

Rlo
2019-10-08 at 5:19 AM | Reply

Hi lukasz … can u upload the hex code here ?
I made the metal detector but it dosnt sens any metal object

Alex
2019-07-05 at 5:02 AM | Reply

This looks like a funny and interesting experiment. Why did u choose to program in C language?

Chris
2019-06-14 at 12:47 PM | Reply

I tried to compile this code in the AVR sketch but it gives me an error code.
uint16_t measure_decay() ' was declared 'extern' and later 'static' [-fpermissive]
Where did I go wrong?

Łukasz Podkalicki
2019-06-15 at 4:42 PM | Reply

Hi, I dont know what require AVR sketch to build this project but you can be sure that avr-gcc compiles it well.

Chris
2019-05-23 at 9:21 AM | Reply

You say to use coil wire 0.5DNE
What does DNE mean?
I only know AWG or SWG wire.
Thanks

Łukasz Podkalicki
2019-06-15 at 4:48 PM | Reply

Chris, its simply Cu wire like that one used it DC/AC motors with 0.5mm diameter.

Frazer
2019-02-28 at 4:38 AM | Reply

Have you tried any of those experiments with higher supply voltage/larger coil? I'm interested in using this to detect nails and similar in wood that I'm salvaging, to spare the cutting blades from damage.

Łukasz Podkalicki
2019-02-28 at 8:10 AM | Reply

I have tested it with 5V supply and longer pulse (~100us). The device consumes more current but gives better results with the same coil. I think, it should detect the nails in wooden plank.

Alexander Pruss
2019-02-27 at 2:38 PM | Reply

How small a metal item can this detect at 5cm? I often lose a small screw on the floor and this could help.

Łukasz Podkalicki
2019-02-27 at 3:20 PM | Reply

The coil I presented here doesn't detect a smaller screws then M4. There is a space for experiments with bigger coil and higher power supply (5V) to get better range/params.

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