# AVR Programming with the ATtiny45

Becky Stewart and Ingo Randolf

# Download

Download or clone the repository at:

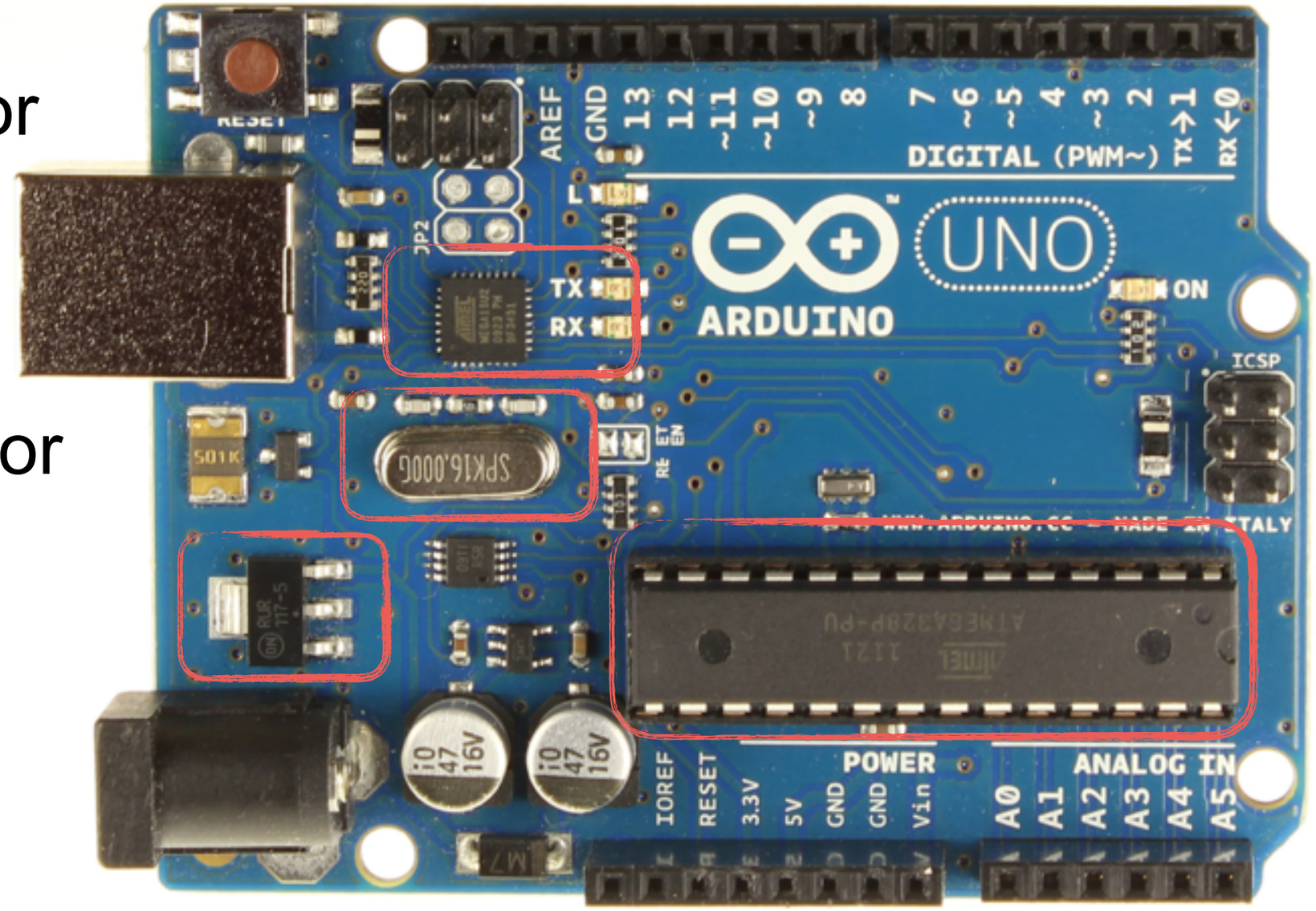
https://github.com/i-n-g-o/attiny_examples

# What is a microcontroller?

- Processor, memory, some other useful stuff.
- Arduino is a microcontroller platform in that it contains a microcontroller and a bunch of other things to make interacting with that microcontroller easier.

# What is on the Arduino Uno board?

- Microcontroller (ATmega328P) with bootloader
- Voltage regulator
- USB interface
- External oscillator

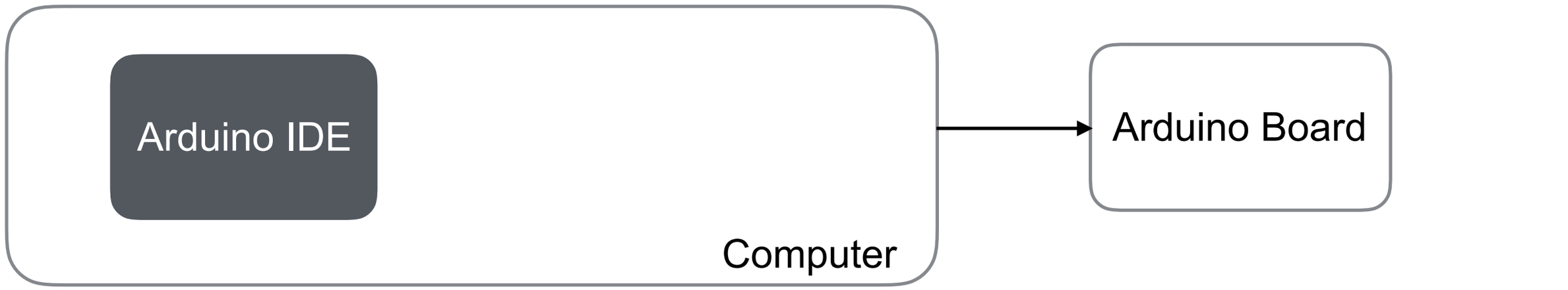


# Why Not Just Use an Arduino?

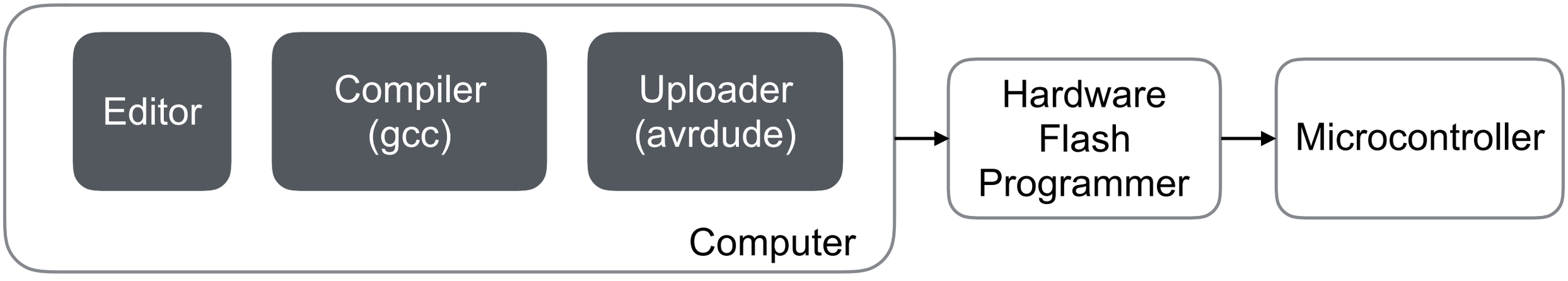
- Lots of extra stuff on there you might not need
- Cost
- It’s physically big and awkward
- Want more flexibility on pins and wiring
- Arduino IDE not great
- Arduino library can be slow
- To understand what is actually going on

# Toolchain

## With Arduino




## Without Arduino



# (A Portion of the) Atmel AVR Family

ATMega

- ATMEGA168
- ATMEGA328P
- ATMEGA32U4

ATtiny

- ATTINY45-20PU
- ATTINY85V-20SU

# (A Portion of the) Atmel AVR Family

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Name of product family

# (A Portion of the) Atmel AVR Family

ATMega

- ATMEGA168
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Size of Memory in KB

ATtiny

- ATTINY45-20PU
- ATTINY85V-20SU

# (A Portion of the) Atmel AVR Family

ATMega

- ATMEGA168
- ATMEGA328P
- ATMEGA32U4

Atmel picoPower (low power consumption)

USB controller

ATtiny

- ATTINY45-20PU
- ATTINY85V-20SU

Max clock speed

# (A Portion of the) Atmel AVR Family

ATMega

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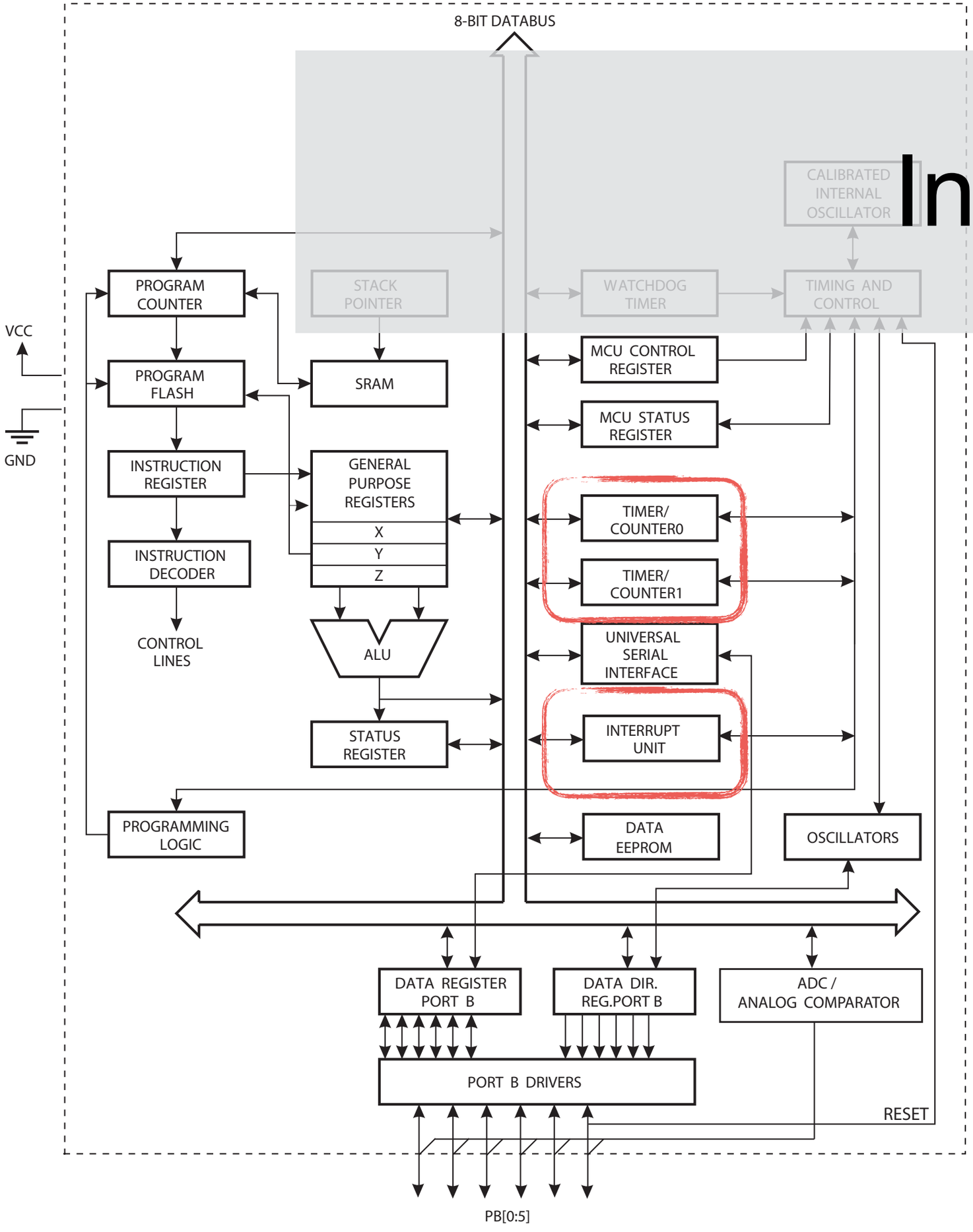
Package

Can run at 1.8V instead of 2.7V

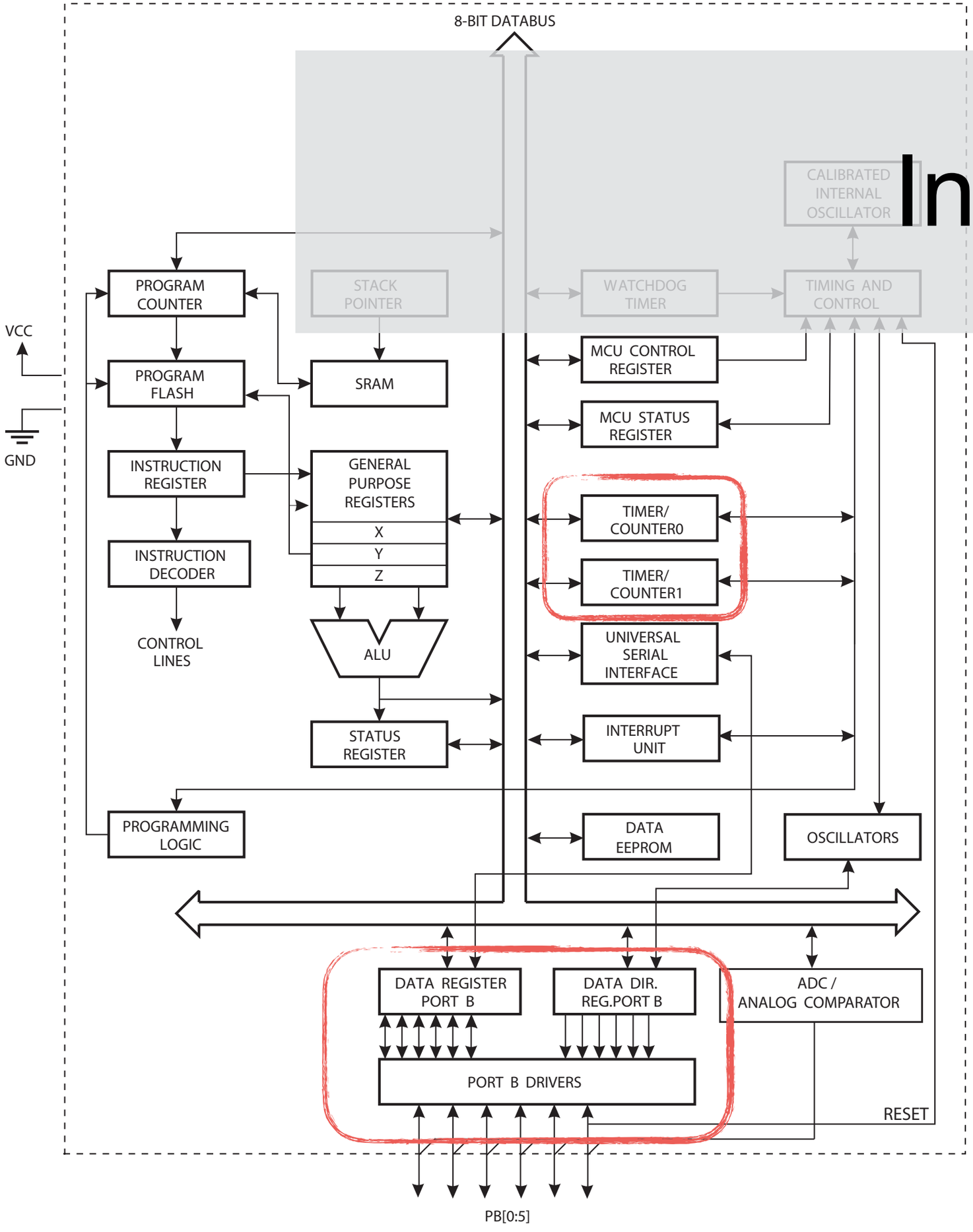
# Inside the ATtiny




2 Timers/Counters

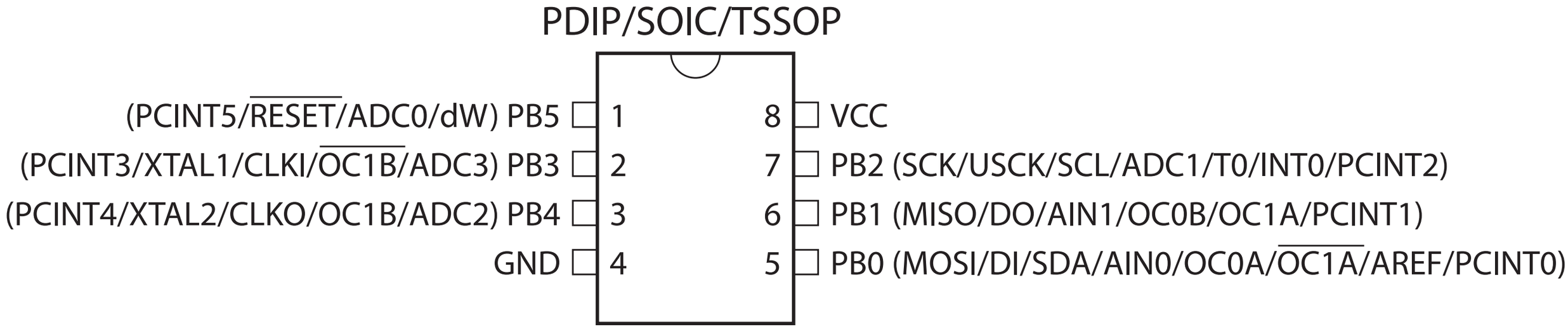
Interrupt functionality

# Inside the ATtiny



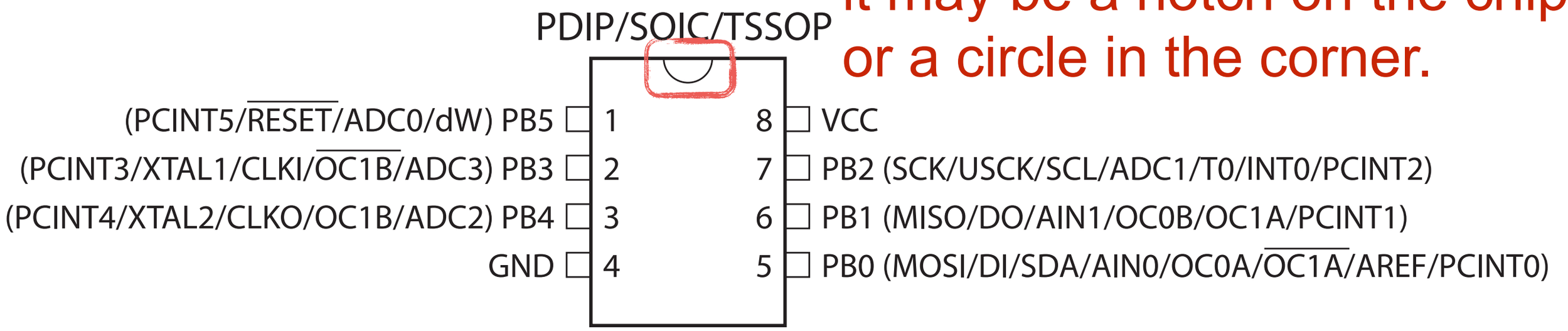

1 Hardware Register

# Outside the ATtiny



# Outside the ATtiny

This marks which end is ‘up’, it may be a notch on the chip or a circle in the corner.



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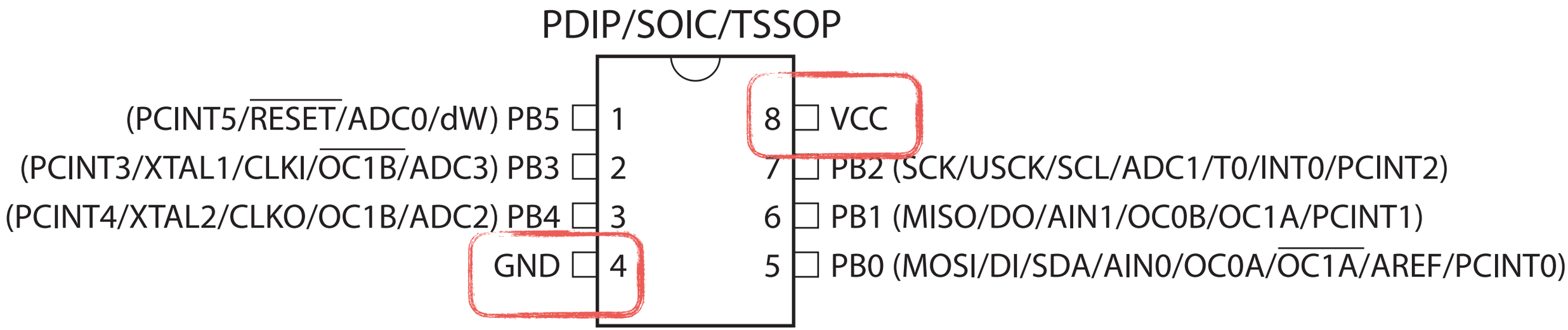
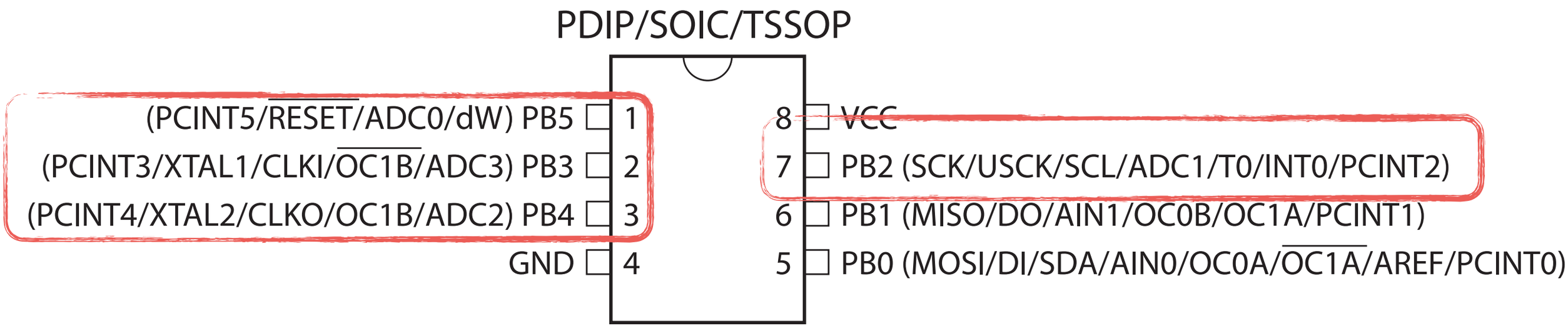



1.8 - 5.5V

or

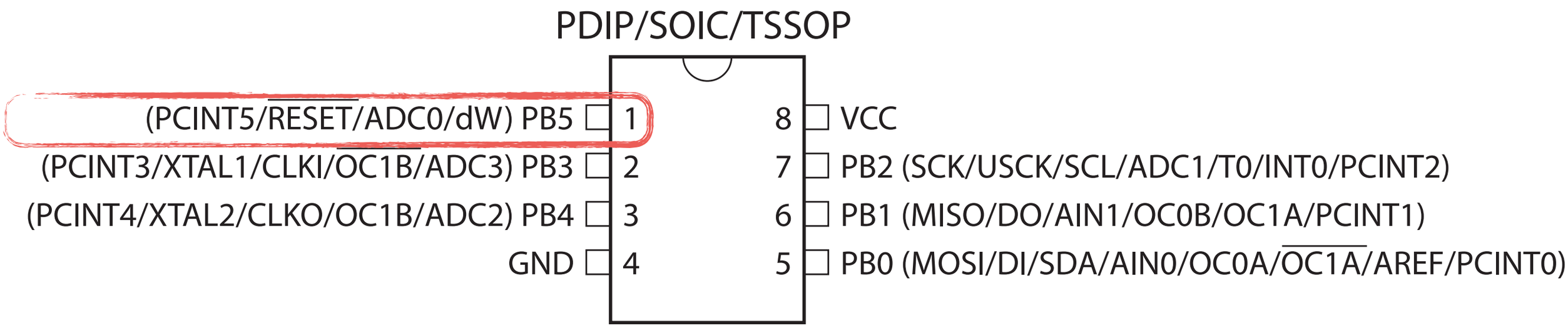
2.7 - 5.5V

# Outside the ATtiny




Analog Inputs

# Outside the ATtiny




If RESET is held low for long enough, will reset the chip

# Using `avrdude`

- Pro-tip: gently bend legs of ATtiny so fits cleanly into holder/breadboard

- In a terminal type:

```
> avrdude -p t45 -c usbtiny
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ATtiny45 Using a USBTiny programmer

# Blinking

- Download code if you haven’t already
- In a terminal window, use `cd` to go to the directory

  `/etextile-summercamp/00-blink_with_delay`
- In the terminal type

  ```
  > make
  ```
- Then type

  ```
  > make install
  ```

# Looking at the Source

```
#include <avr/io.h>                          /* Defines pins, ports, etc */
#include <util/delay.h>                       /* Functions to waste time */


int main(void) {

  // -------- Inits --------- //
  DDRB = 0b0000001;                  // Data Direction Register B: writing a one to the bit
                                     //enables output.

  // ------ Event loop ------ //
  while (1) {

    PORTB = 0b00000001;            /* Turn on first LED bit/pin in PORTB */
    _delay_ms(1000);                                              /* wait */

    PORTB = 0b00000000;            /* Turn off all B pins, including LED */
    _delay_ms(1000);                                              /* wait */

  }                                                    /* End event loop */
  return 0;                                 /* This line is never reached */
}
```

# Looking at the Source

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

same as Arduino

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  }                                                  /* End event loop */
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same as Arduino

like `setup()` and `pinMode()`

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    _delay_ms(1000);

    PORTB = 0b00000000;
    _delay_ms(1000);

  }
  return 0;
}
```

same as Arduino

like `setup()` and `pinMode()`

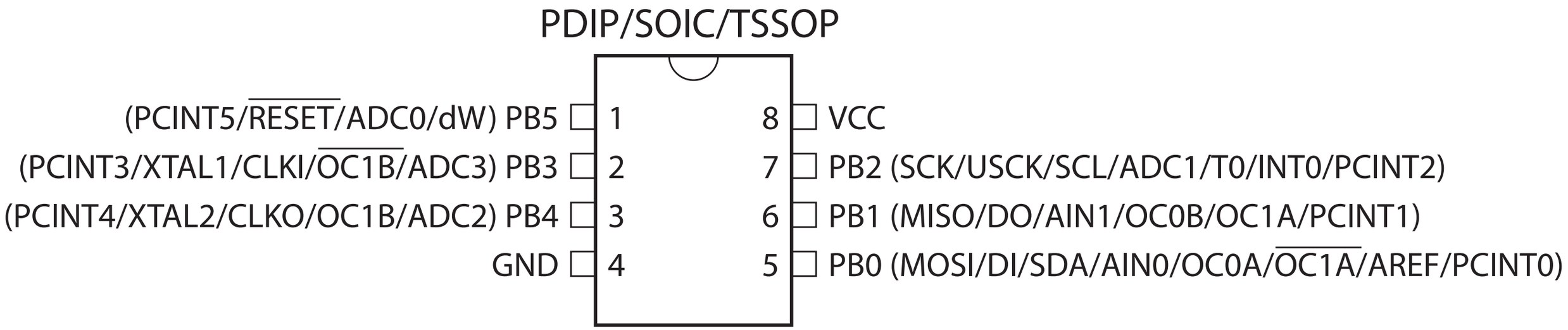
like `loop()`, `digitalWrite()` and `delay()`

# Hardware Registers

- Registers are (tiny) physical switches on the chip and you turn them on and off by setting them to `1` or `0`

- The ATtiny45 has one set of registers name B

- Bigger microcontrollers like the ATmega have more like C and D



# Hardware Registers

- Data direction registers are like `pinMode()`
  - `1` sets that pin to output, `0` to input

DDRB =

| 0 | 0 | 0 | 0 | 1 |
|---|---|---|---|---|
| PB5 | PB3 | PB2 | PB1 | PB0 |

- PORT is the register for setting outputs 0 for LOW and 1 for HIGH for each pin

PORTB =

| 0 | 0 | 0 | 0 | 1 |
|---|---|---|---|---|
| PB5 | PB3 | PB2 | PB1 | PB0 |

- PIN is the register for reading in inputs (not using this yet)

# Binary and Hex Numbers

- Decimal (Base 10) - 0 1 2 3 4 5 6 7 8 9

```
x = 49;
```

- Binary (Base 2) - 0 1

```
x = 0b0101; // 5 in base 10
```

- Hexadecimal (Base 16) - 0 1 2 3 4 5 6 7 8 9 A B C D E F

```
x = 0xFF; // 255 in base 10, 11111111 in base 2
```

Task

# Change the delay time

# Task

Change the LED pin

Build the LED circuit using a breadboard

# Reading Input

- In a terminal window, use `cd` to go to the directory

  `/etextile-summercamp/01-button_read`

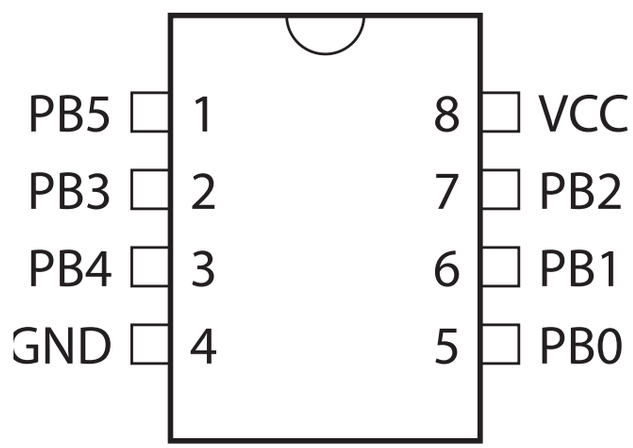
- On a breadboard connect a switch to PB1 and ground.

- In the terminal type

  ```
  > make
  ```

- Then type

  ```
  > make install
  ```



# Reading Input

- The PINB holds the values of the input on each pin, whether HIGH or LOW

- Setting the PORTB HIGH for an input pin turns on the pull-up resistor

# Bitmasks

OR

| A | B | out |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 1 |

AND

| A | B | out |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 0 |
| 1 | 0 | 0 |
| 1 | 1 | 1 |

XOR

| A | B | Out |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 0 |

# Bitmasks

OR

| A | B | out |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 1 |

AND

| A | B | out |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 0 |
| 1 | 0 | 0 |
| 1 | 1 | 1 |

XOR

| A | B | Out |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 0 |

```
1 << 2 = 00000100

00000100 & 00010100 = 00000100
00000100 | 00010100 = 00010100
00000100 ^ 00010100 = 00010000
```

want to clear all bits and set the mask

want to leave all other bits alone and set the mask

want to leave all other bits alone and toggle the mask

# Resources

- Make: AVR Programming by Elliot Williams
  - Example code: https://github.com/hexagon5un/AVR-Programming
- http://www.atmel.com/images/atmel-2586-avr-8-bit-microcontroller-attiny25-attiny45-attiny85_datasheet.pdf
- http://www.avrfreaks.net/
- http://www.ladyada.net/learn/avr/index.html