Electronics
Pulse Width Modulation Sensors

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- This document gives a few examples.

Shaft encoders

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- *Absolute* position sensing

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- *Incremental rotary* encoding

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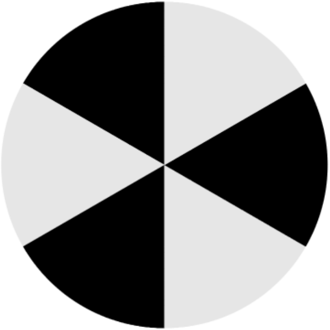
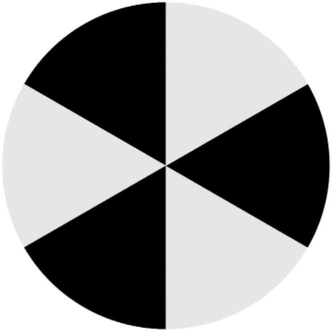
- *Absolute* position sensing

  doesn't use PWM
- *Incremental rotary* encoding

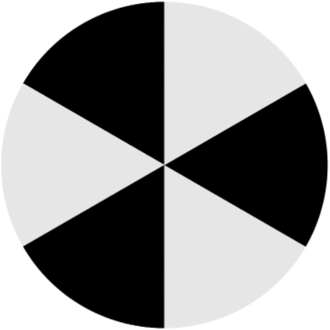
  uses PWM

As long as you know the initial position, you can update if you can sense changes.

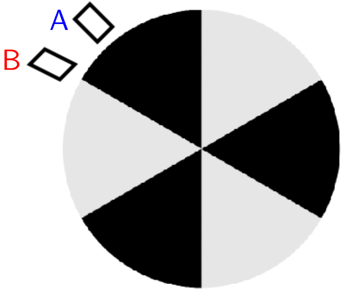




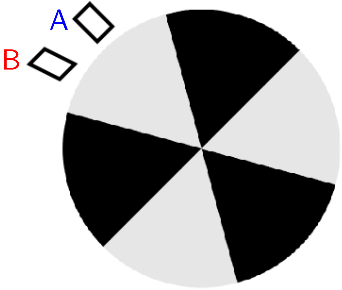
- Shaft encoder wheel



- Shaft encoder wheel
- Two sensors will allow determination of rotation *speed* and *angle*



- Clockwise



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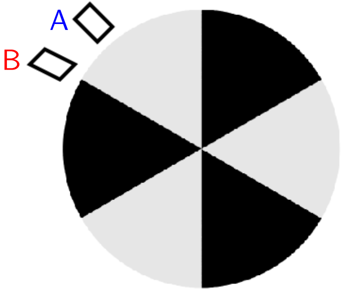

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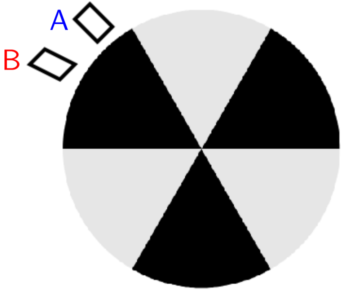
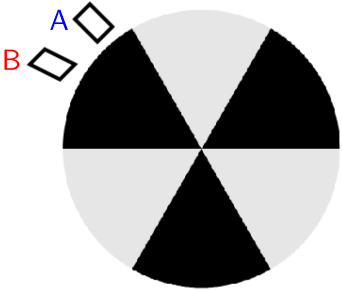
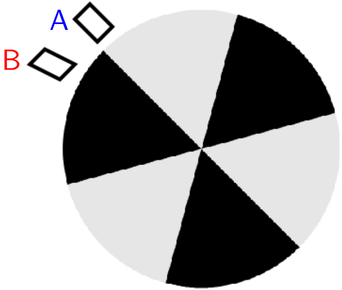


- Clockwise



- Counter-clockwise



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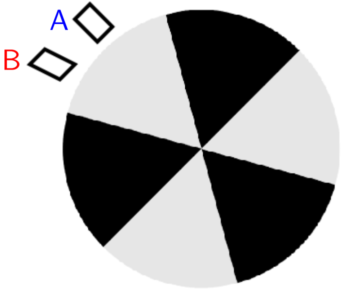

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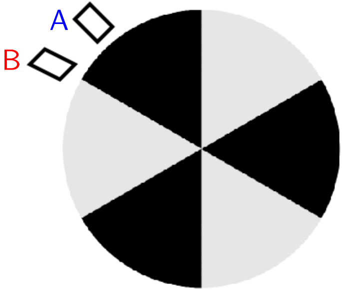

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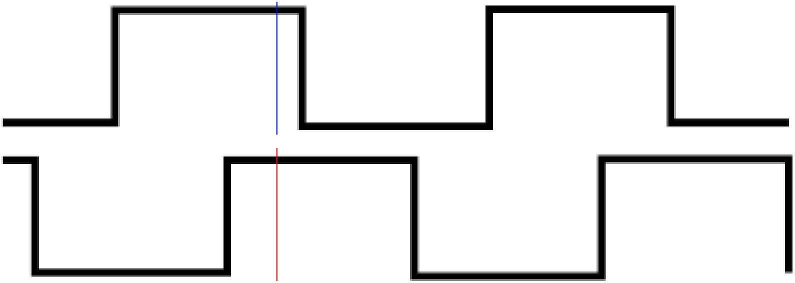
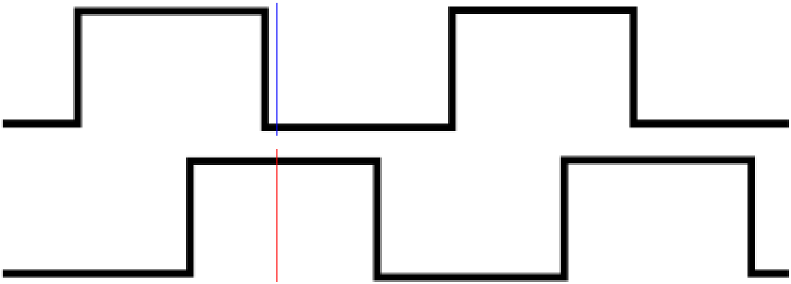
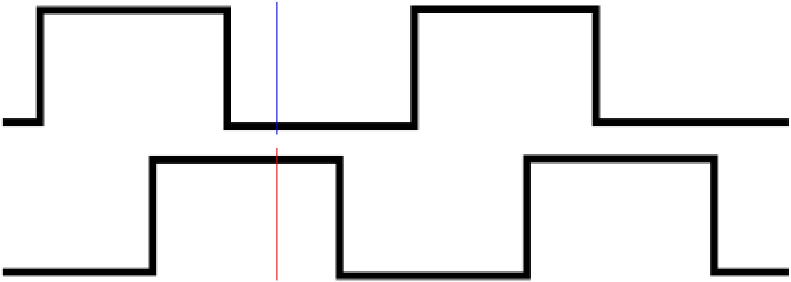


- Shaft encoder timing
- 1
- 1



- Shaft encoder timing
- 0
- 1



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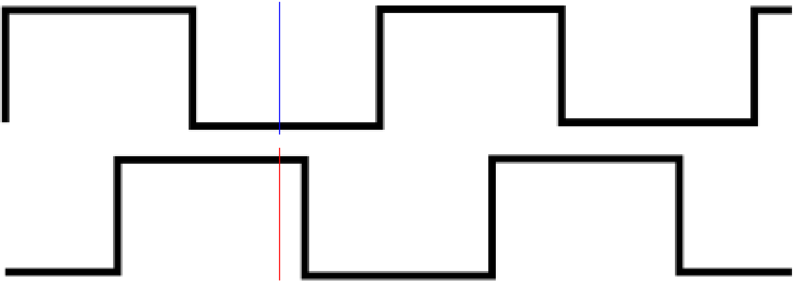

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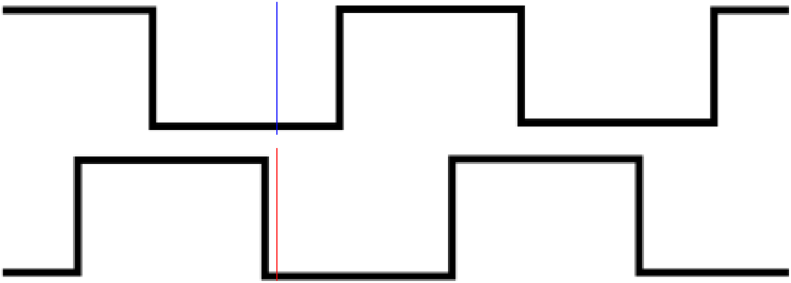

- Shaft encoder timing
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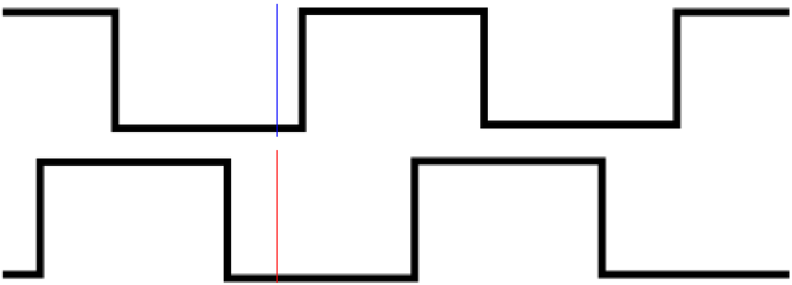

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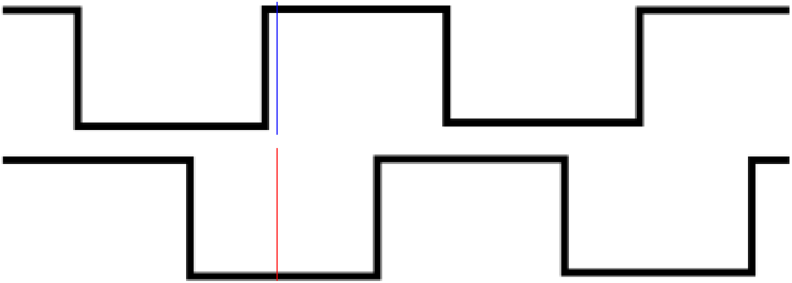

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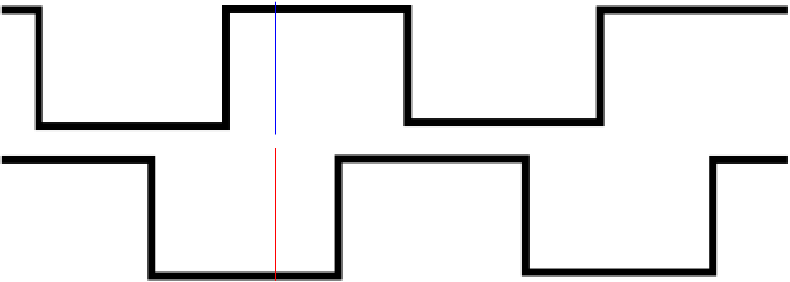

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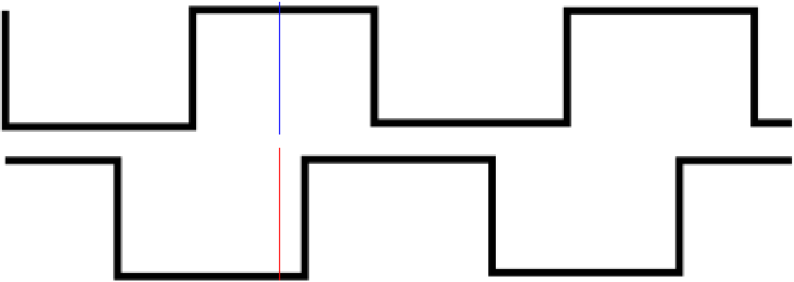

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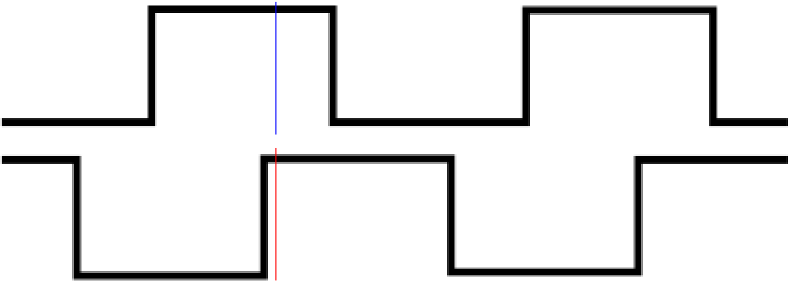

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- 1
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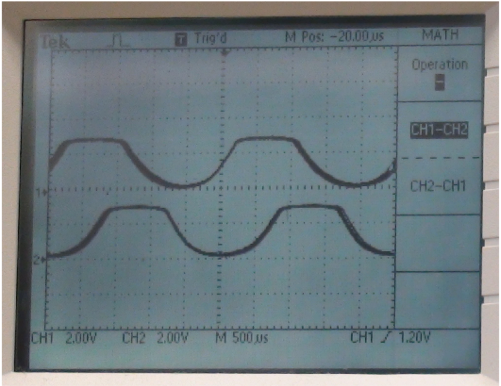
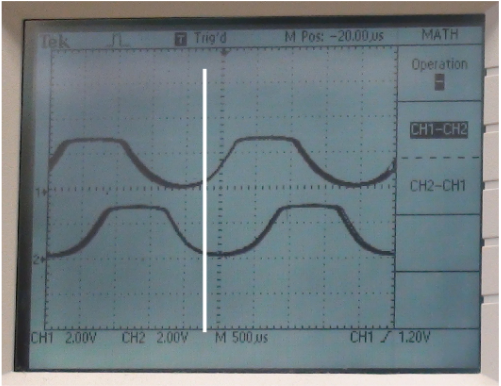
- *Speed* of rotation from frequency of either channel

- *Speed* of rotation from frequency of either channel
- *Angle* of rotation from combination

- *Speed* of rotation from frequency of either channel
- *Angle* of rotation from combination

Here's an example from an actual motor.


Tek
Trig'd
M Pos: -20.00us
MATH
Operation
CH1-CH2
CH2-CH1
CH1 2.00V
CH2 2.00V
M 500us
CH1 1.20V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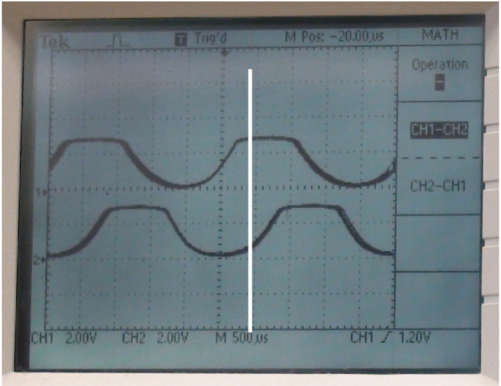
Tek
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M Pos: -20.00us
MATH
Operation
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CH2-CH1
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CH2 2.00V
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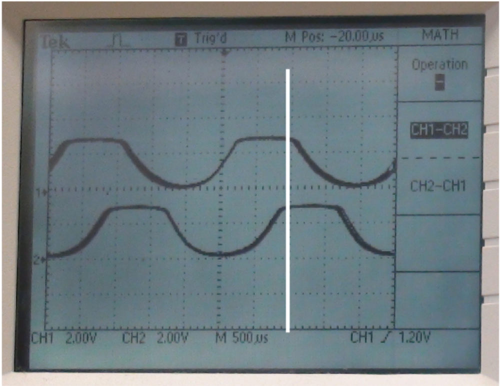
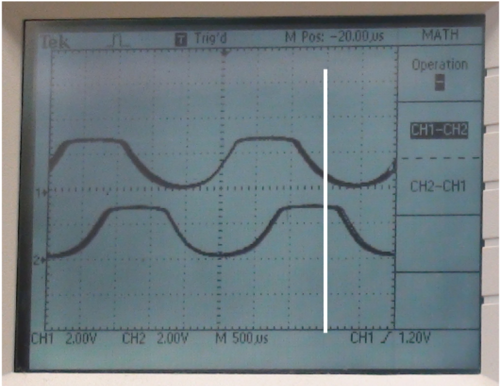
CH1 1.20V

10


Tek
Trig'd
M Pos: -20.00µs
MATH
Operation
CH1-CH2
CH2-CH1
CH1 2.00V
CH2 2.00V
M 500µs
CH1 ∕ 1.20V

11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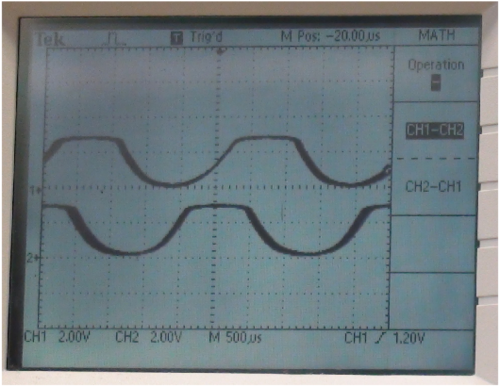
01


Tek
Trig'd
M Pos: -20.00 us
MATH
Operation
CH1-CH2
CH2-CH1
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CH2 2.00V
M 500 us
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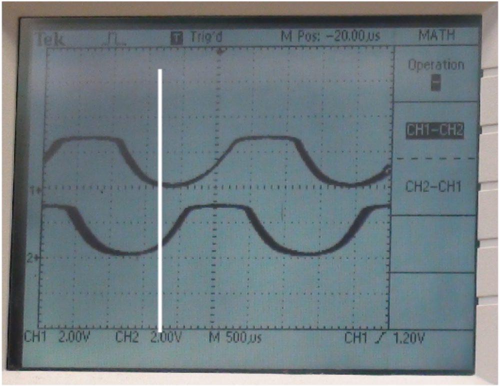
Tek
Trig'd
M Pos: -20.00µs
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CH1-CH2
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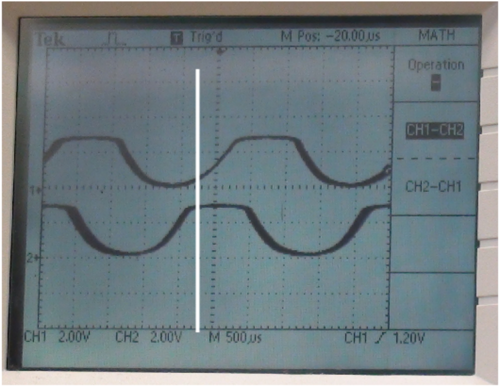
CH1 ∕ 1.20V

00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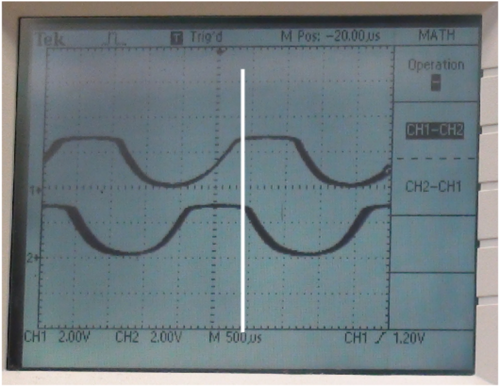
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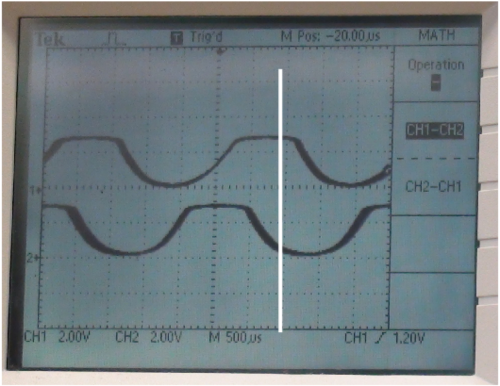
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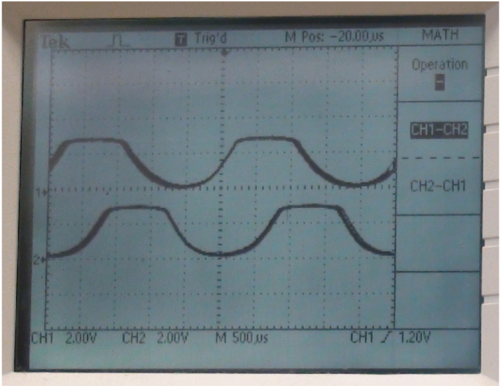
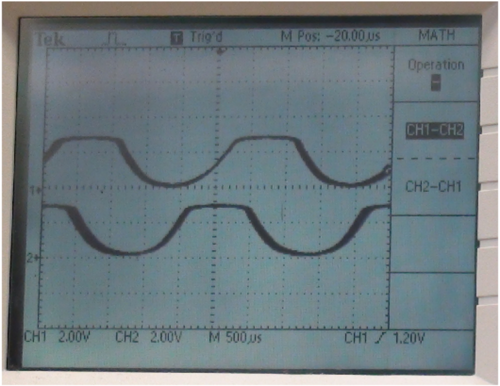
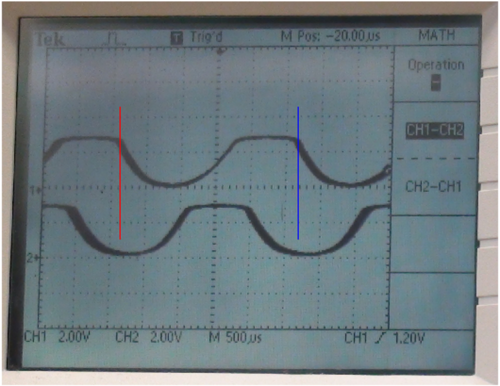


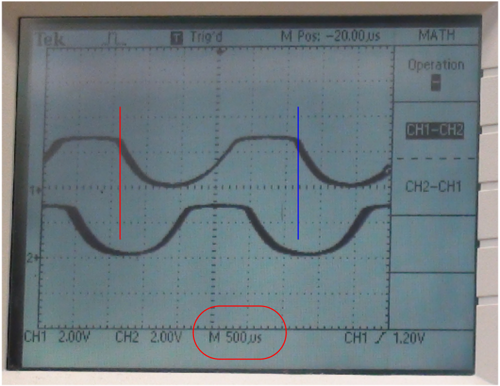
One direction



Other direction

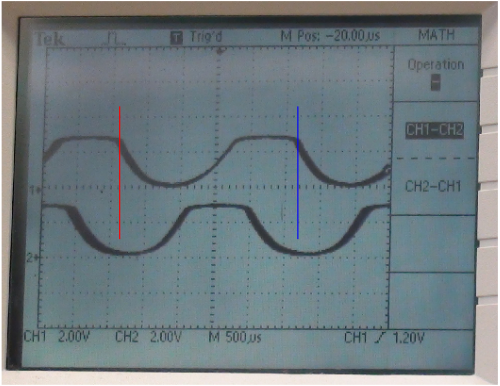


Period is 5 divisions



Period is 5 divisions

Time scale is 500μS per division



Period is 5 divisions $\rightarrow 2500\mu$S $= 2.5$mS

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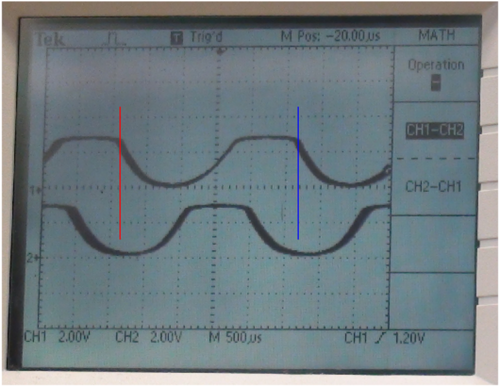
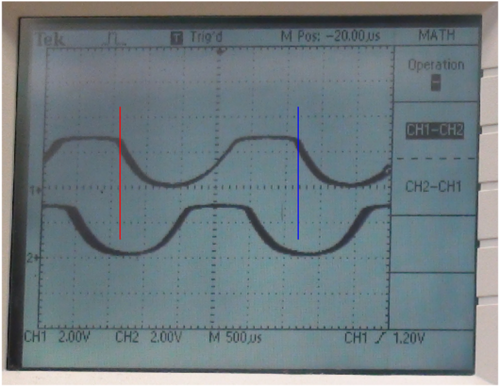


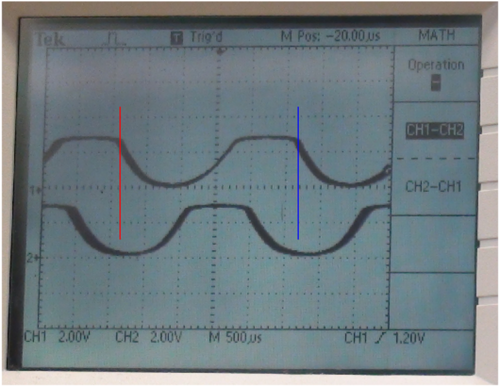
Period is 5 divisions $\rightarrow 2500\mu S = 2.5mS$

30 slots per revolution $\times$ 2.5mS



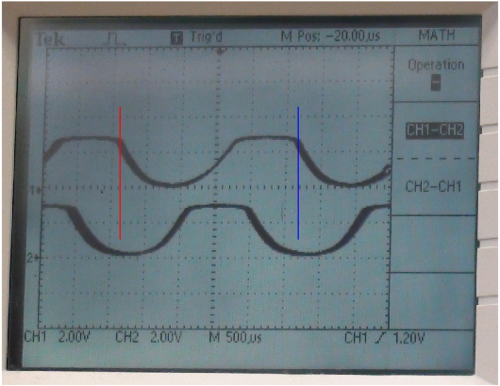
Period is 2.5mS

30 slots per revolution $\times$ 2.5mS $\rightarrow$ 75ms per revolution



Period is 2.5mS $\times$ 30 $\rightarrow$ 75ms per revolution

75/1000 seconds per revolution $\rightarrow$ 13.33 rev./second



Period is 2.5mS $\times$ 30 $\rightarrow$ 75ms per revolution

75/1000 seconds per revolution $\rightarrow$ 13.33 rev./second

$\times$ 60 $\rightarrow$ 800 RPM

Ultrasonic sensors

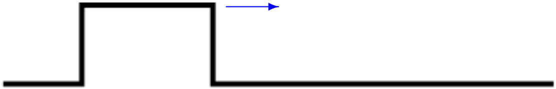
Ultrasonic sensors

- *Transmitter* sends out pulse

Ultrasonic sensors

- *Transmitter* sends out pulse
- *Receiver* registers echo

- **transmit**



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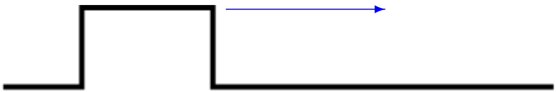

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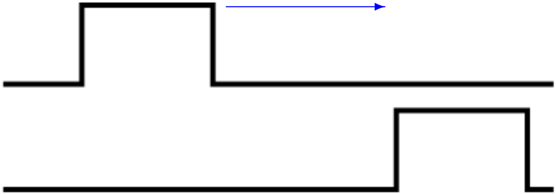
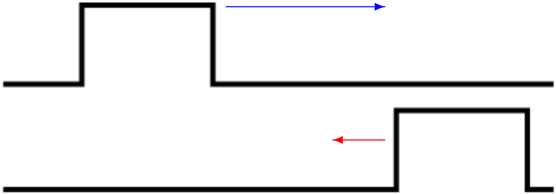


- transmit
- **receive**



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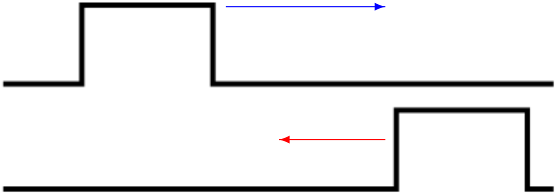

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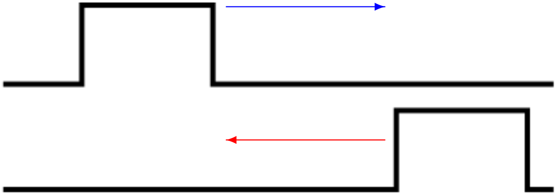

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Why is it $2d$?

V to F and F to V converters

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Python PWM Control

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- **p = GPIO.PWM(*channel*, *frequency*)**
  open channel at given frequency

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- **p.ChangeFrequency(*freq*)**

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  change frequency
- **p.ChangeDutyCycle(*dc*)**

  change duty cycle *(percent)*

Python PWM Control

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  start at given duty cycle *(percent)*
- **p.ChangeFrequency(*freq*)**

  change frequency
- **p.ChangeDutyCycle(*dc*)**

  change duty cycle *(percent)*
- **p.stop()**

  stop PWM

Python PWM sample code

Python PWM sample code

```
import time
import RPi.GPIO as GPIO
GPIO.setmode(GPIO.BOARD)
GPIO.setup(12, GPIO.OUT)
p = GPIO.PWM(12, 50)  # chan=12 freq=50Hz
p.start(0)
try:
    while 1:
        for dc in range(0, 101, 5):
            p.ChangeDutyCycle(dc)
            time.sleep(0.1)
except KeyboardInterrupt:
    pass
p.stop()
GPIO.cleanup()
```

Hardware and Software PWM

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For applications needing more consistent PWM, use the *hardware* PWM pins.

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Raspberry Pi PWM pins

- The Raspberry Pi has 2 built-in hardware PWM *channels*.
- Each *channel* has 2 associated *pins*.

  (So only one *pin* from a channel can be used at a time.)

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Note: These pins are shared with the audio subsystem.