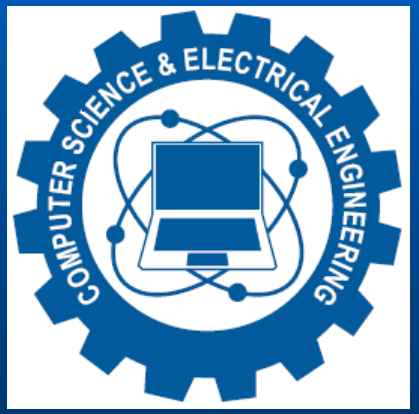
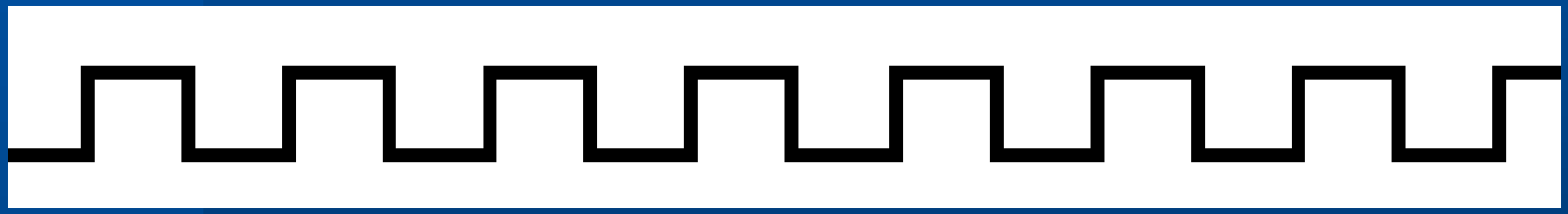
Pulse Waveforms



Free Running Pulse Train

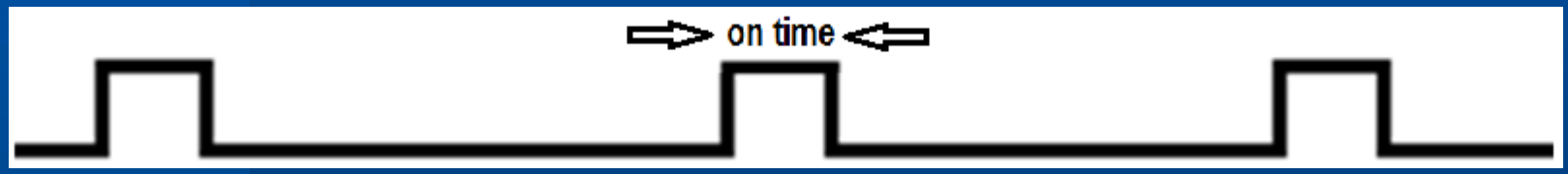
Also known as a square wave. Your lab bench **function generators** can do this.



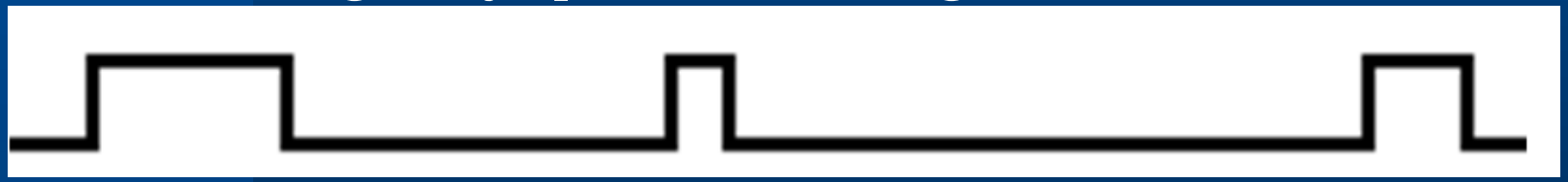
One-Shot

"One shot" means one pulse, and that's it.

3 one-shots with short on time:



Could be irregularly spaced, with irregular on time:



Using One Shot Example

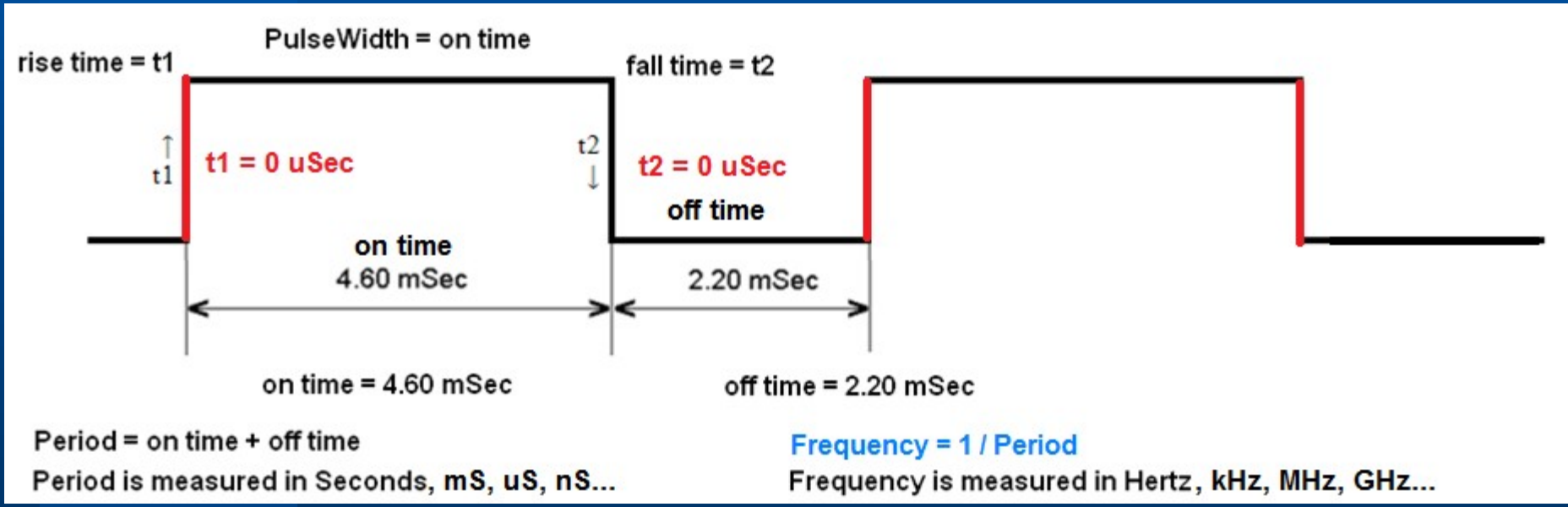
Fans coming into Dodger Stadium. They don't come in on a rhythm, and some stay longer in the turnstiles than others. *Extended to 16 bits, **your lab counter can get one game's attendance**. They'll count one-shots.*

2 One-Shots with long on time

We don’t know how long that third pulse will be on.

Pulse Waveform Characteristics Theoretical or Ideal

The **"Ideal"** thing is that the **pulse rises and falls in zero time**. *Hah! That's a fairy tale.*



Frequency and Period

See that frequency formula at the bottom right of last slide?

Frequency = 1 / Period

Frequency is measured in Hertz, kHz, MHz, GHz…

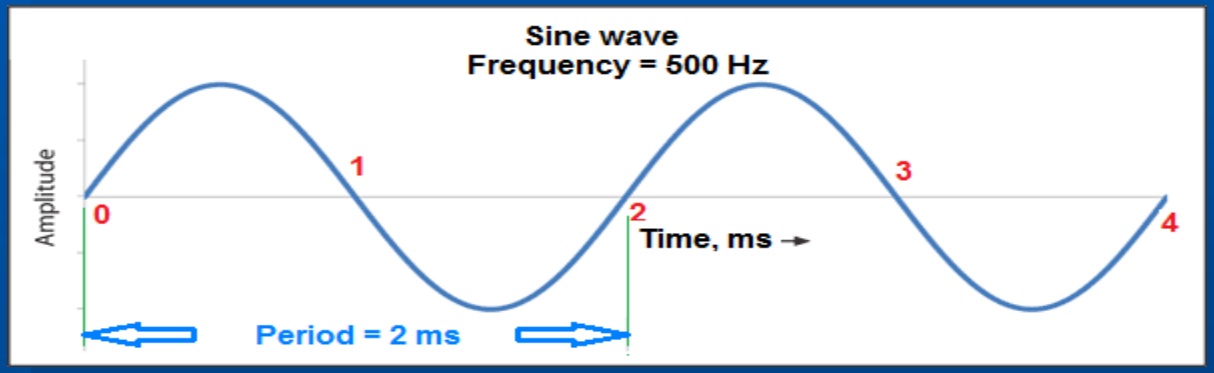
So, by algebra,

Period = 1 / Frequency

Period is time! It's ns, µs, ms, seconds, minutes… years…

Well, It's Not So Simple…

Frequency = 1 / Period only for a pure sine wave.



But for our square pulses,

Frequency = n / Period
Where n = 1 is the fundamental; n = 2 is the 2nd harmonic…

Let's Look at Those Pulses…

Frequency = n / Period
Where n = 1 is the fundamental; n = 2 is the 2nd harmonic…

But for our square pulses,

Frequency = n / 0.0068 s
= 147 Hz, 294 Hz, 441 Hz, 588 Hz…

Frequency and Period Example

- Period = half a second. What is the fundamental frequency?

- Frequency = 1 / period
  = 1 / 0.5s
  = 2 Hz

- *For a quiz, you only need to know fundamentals. In 4th year and college, you'll do the others.*

Frequency and Period Example (2)

- Fundamental frequency = 1 kHz. What is the period? *Remember what kilo means…*

- Period = 1 / frequency
  = 1 / 1000 Hz
  = 1 ms

Remember what milli means?

Frequency and Period Example (3)

- Fundamental frequency = 146.52 MHz. What is the period?

- Period = 1 / frequency
  = 1 / 146,520,000 Hz
  = 6.825 ns

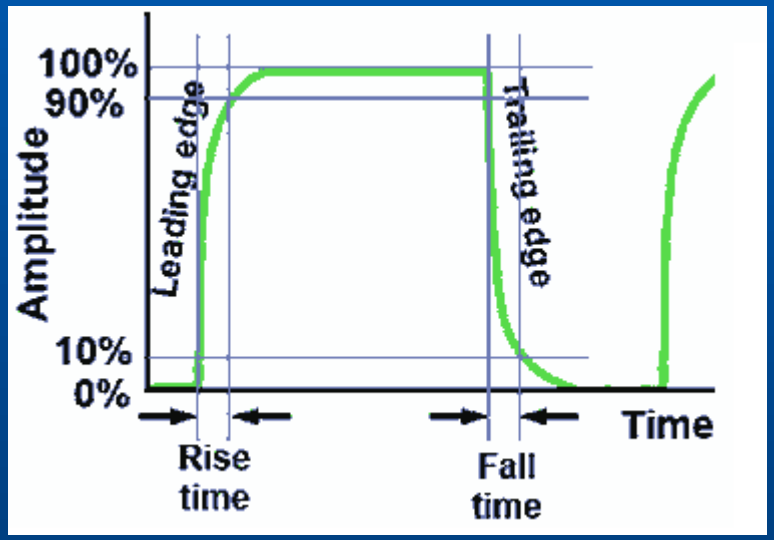
146.52 MHz is the national ham radio 2-meter simplex calling frequency. We DON'T want the 2nd harmonic, which would interfere with garage door openers using 293.04 MHz.

Practical Pulse Waveform

This is "Practical" because the **pulse takes some time to rise and fall**. *That's the real world, baby…*

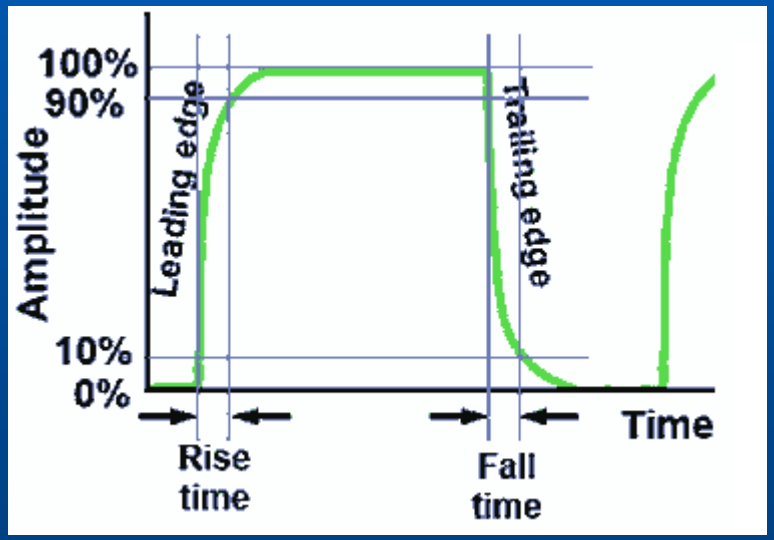
*Note how the **last halves of the rise and fall take more time** than the earlier half…*

Practical or Real Pulse Waveform Characteristics



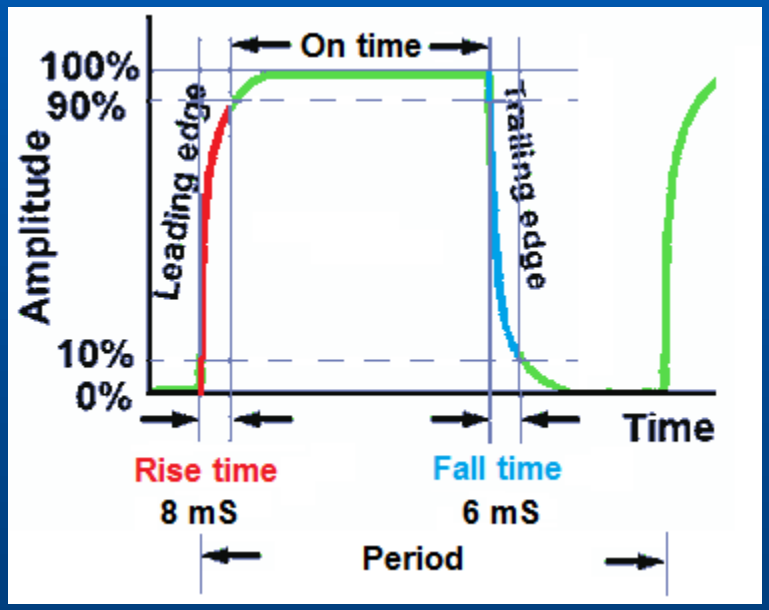
Getting **90% of the max** pulse voltage is high enough to be "on".
Dropping to 10% of the max pulse voltage is low enough to be "off".

Practical or Real Pulse Waveform Characteristics (2)



So, we don’t wait for the rise to get to 100% or down to 0%. 90% or 10% is enough.

Practical or Real Pulse Waveform Characteristics (3)



Rise time = 8 mSec

Fall time = 6 mSec. They don't have to be equal.

Duty Cycle

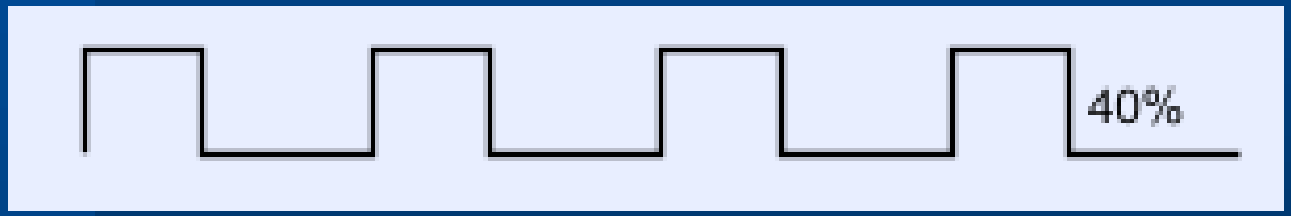
- Ratio of On Time to Period
- Percentage (%) of the waveform's period

$$\frac{\text{on time (sec)}}{\text{period (sec)}} \times 100 = \text{Duty Cycle (\%)}$$

Duty Cycle Example

- On time = 40 ns. Off time = 60 ns. How long is the period?

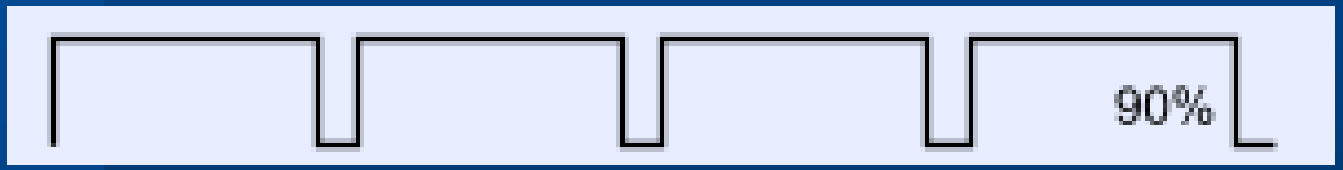
- Duty cycle = on time / period
  = 40ns / (40ns + 60ns) x 100%
  = 40%



Duty Cycle Example (2)

- On time = 9 hours. Off time = 1 hour. How long is the period?

- Duty cycle = on time / period
  = 9 h / (9 h + 1 h) x 100%
  = 90%



What's your prayer duty cycle?