Lesson 17
EET 150

CHARACTERISTICS OF PULSE AND SQUARE WAVES

Learning Objectives

In this lesson you will:
compare idea waveforms to actual waveforms
define pulse rise and fall times
see pulse and square wave signal not based at zero volts
define the parameters pulse width and duty cycle
see pulse tilt, undershoot, overshoot, and ringing

Ideal versus Actual Pulse Waveforms

Idea waveforms are a theoretical concept

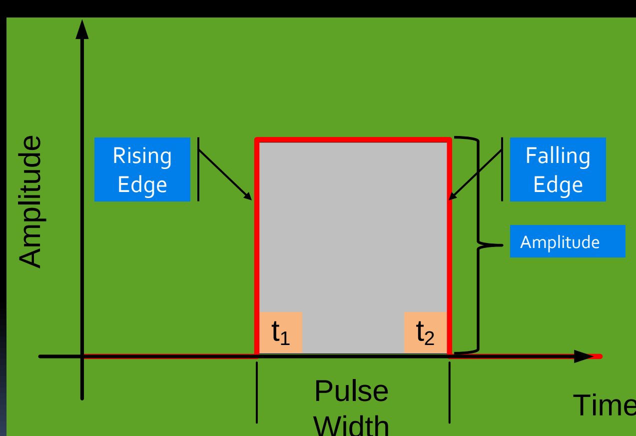
Function generators produce non-ideal waves that approximate theoretical shapes

The Comparison

Ideal (Theoretical)	Actual (Generated)
Levels can change Instantaneously	Levels change requires a finite time
Waveforms have no harmonic distortion	Harmonic distortion adds small amounts of other frequencies
Waveforms have unlimited amplitude	Amplitudes limited to capabilities of generator

Pulse Waveform Characteristics

An Ideal Pulse

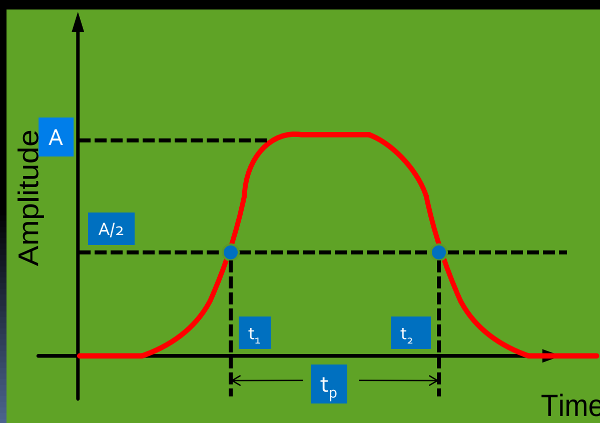


Ideal pulse width, $t_p = t_2 - t_1$

Pulse Width

An Actual Pulse

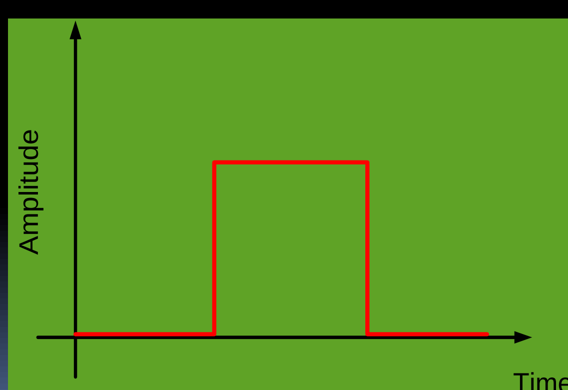
Definition : Pulse width, t_p, is the time difference between the 50% amplitudes of the rising and falling edges.



Pulse Characteristics

Positive and Negative Pulses

Positive pulses increase from baseline voltage



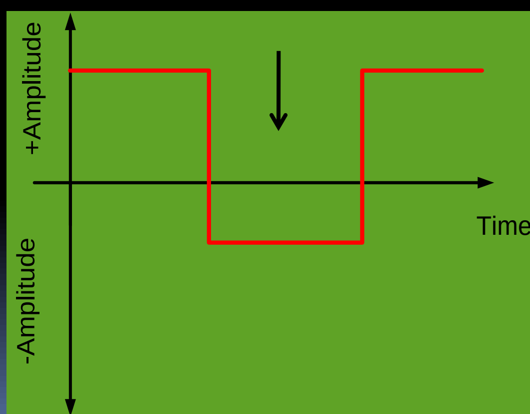
V baseline >0

V baseline =0

Pulse Characteristics

Positive and Negative Pulses

Negative pulses decrease from baseline voltage

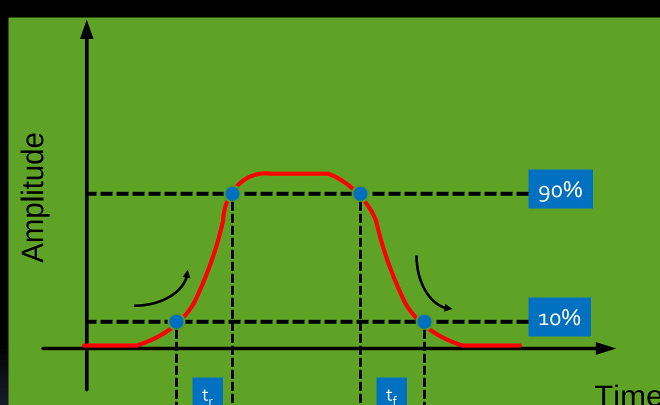


Negative pulse with positive base voltage

Negative pulse with negative base voltage

Pulse Characteristics

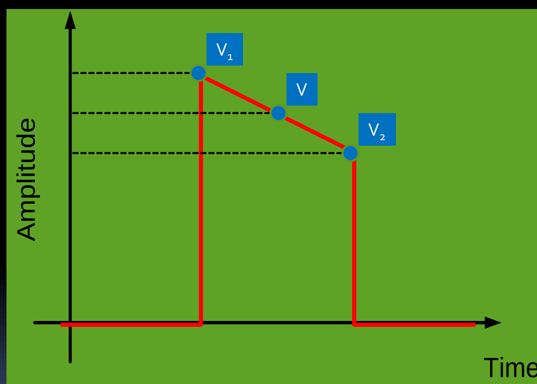
Pulse rise-time and fall-time



Rise-time, t_r, = time required for rising edge of pulse to go from 10% to 90% of amplitude

Fall-time, t_f, = time required for falling edge of pulse to go from 90% to 10% of amplitude

Pulse Characteristics
Pulse Tilt

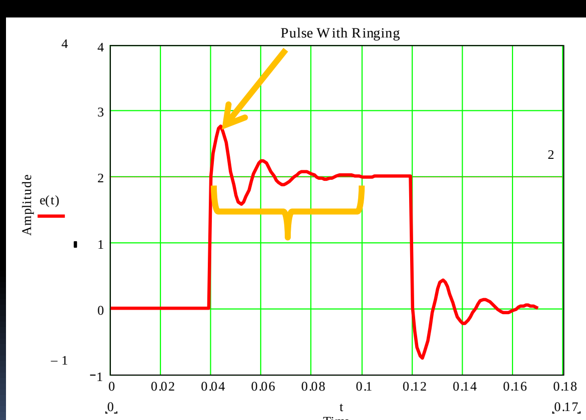


$$V = \frac{V_1 + V_2}{2}$$

V is the average of max and min values

$$\%Tilt = \frac{V_1 - V_2}{V} \times 100\%$$

Pulse Characteristics
Overshoot and Ringing

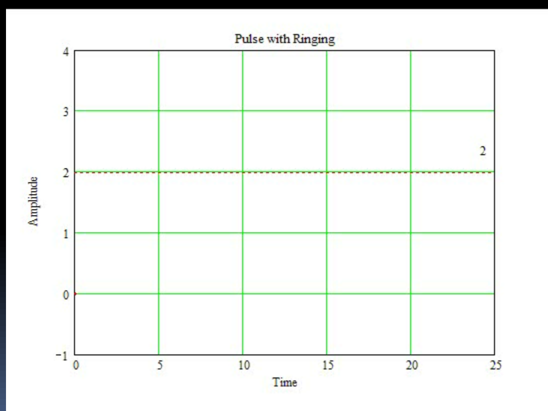


Overshoot occurs on rising and falling edges when the waveform exceeds the desired value.

Ringing occurs on rising and falling edges when the waveform alternates about the desired value.

Pulse Characteristics
Overshoot and Ringing

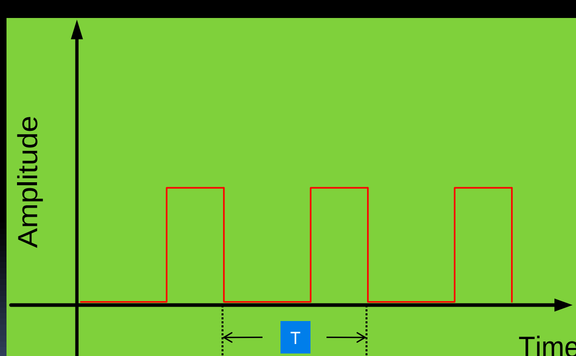
Watch for the overshoot and ring on this graph



Pulse Frequency

Pulse frequency is also known as pulse repetition rate (PRR)

PRR is period in which the pulse pattern repeats



$$PRR = \frac{1}{T}$$

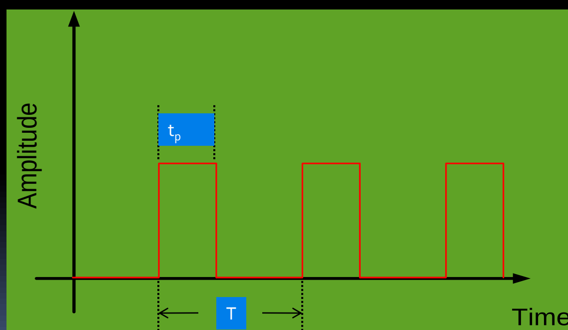
T = Period (Seconds)

PRR = Pulse repetition rate (Hz) or pulses/second

Pulse Duty Cycle

Percent of the period that pulse is at its high level

T = period
t_p = pulse width

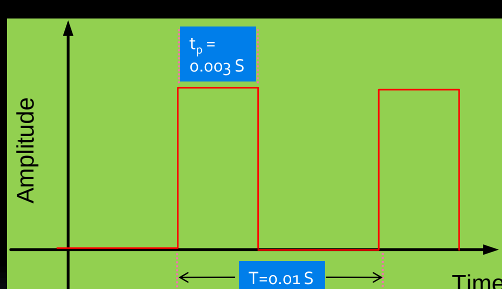


$$\text{Duty Cycle} = \frac{\text{pulsewidth}}{\text{period}} \times 100\%$$

$$\text{Duty Cycle} = \frac{t_p}{T} \times 100\%$$

Pulse Duty Cycle

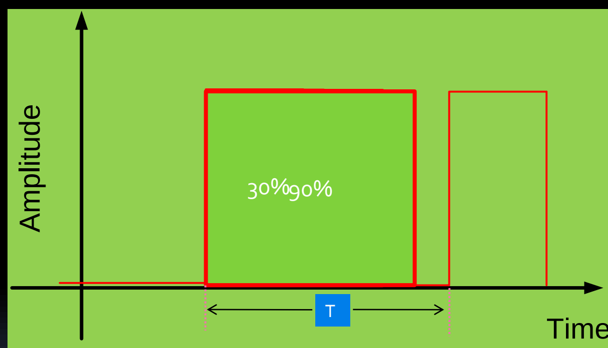
Example



$$\text{Duty Cycle} = \frac{0.003\ \text{S}}{0.01\text{S}} \times 100\%$$

$$\text{Duty Cycle} = 30\%$$

Variable Duty Cycle



$0 \le t_p \le T$

Characteristics of Pulse and Square Waves

End Lesson 17
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Coming Next: Function Generator Controls and Operation