in partnership with

Mr. Alan Rux - University of Massachusetts

presents

Oscillators , Timers

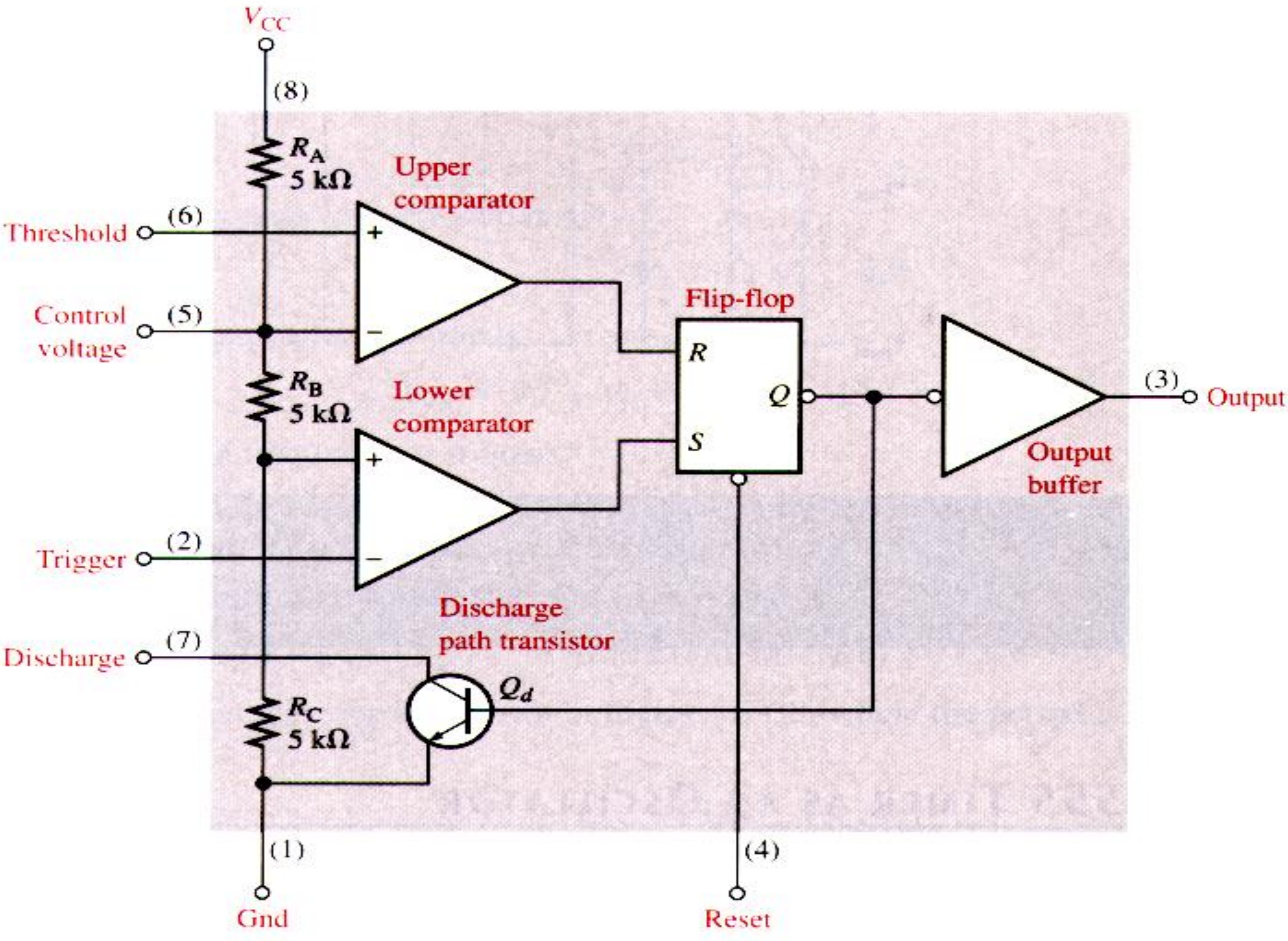
&

Analog Discovery Kit

lecture 2

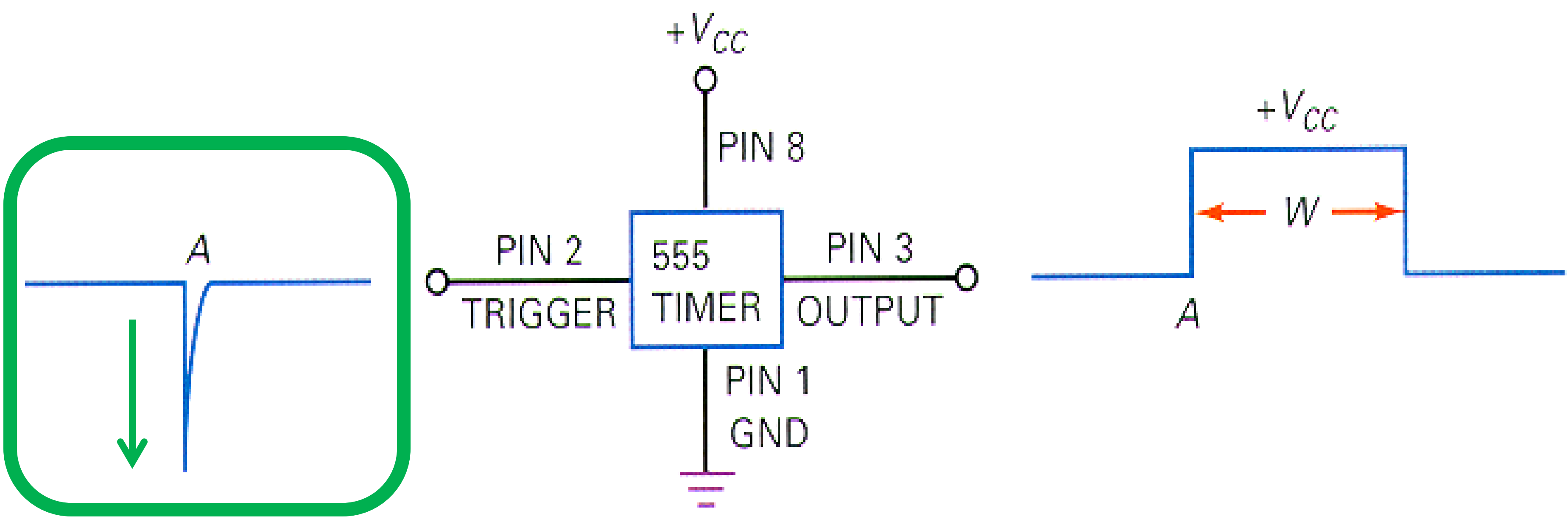
learning by doing

555 Timer



V_{CC}
(8)
R_A
5 kΩ
Upper
comparator
Threshold
(6)
+
Control
voltage
(5)
−
Flip-flop
R
Q
S
R_B
5 kΩ
Lower
comparator
+
(3)
Output
Output
buffer
Trigger
(2)
−
Discharge
path transistor
Discharge
(7)
Q_d
R_C
5 kΩ
(1)
(4)
Gnd
Reset

555 Timer Modes
Monostable (one-shot)

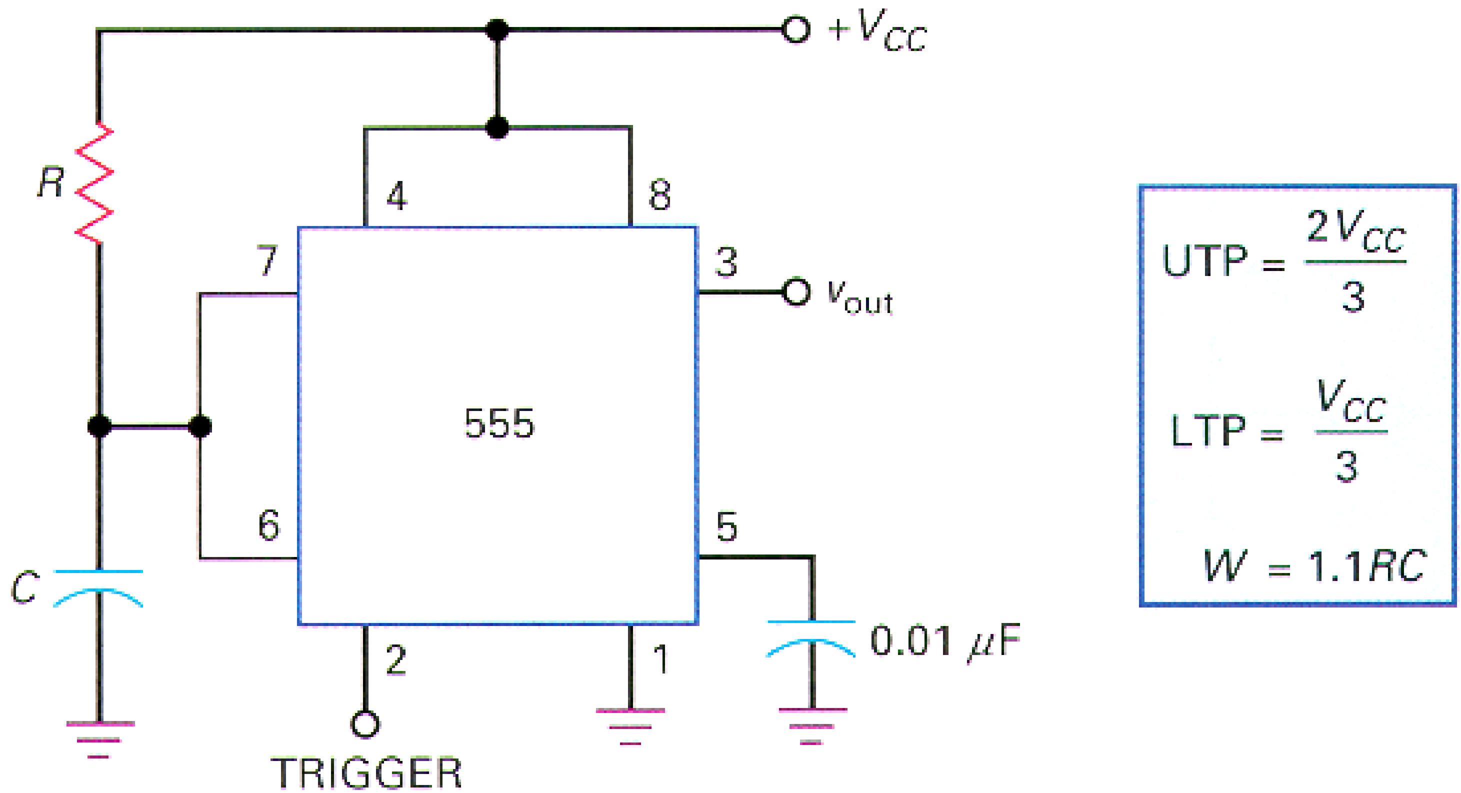


Negative trigger → Pulse

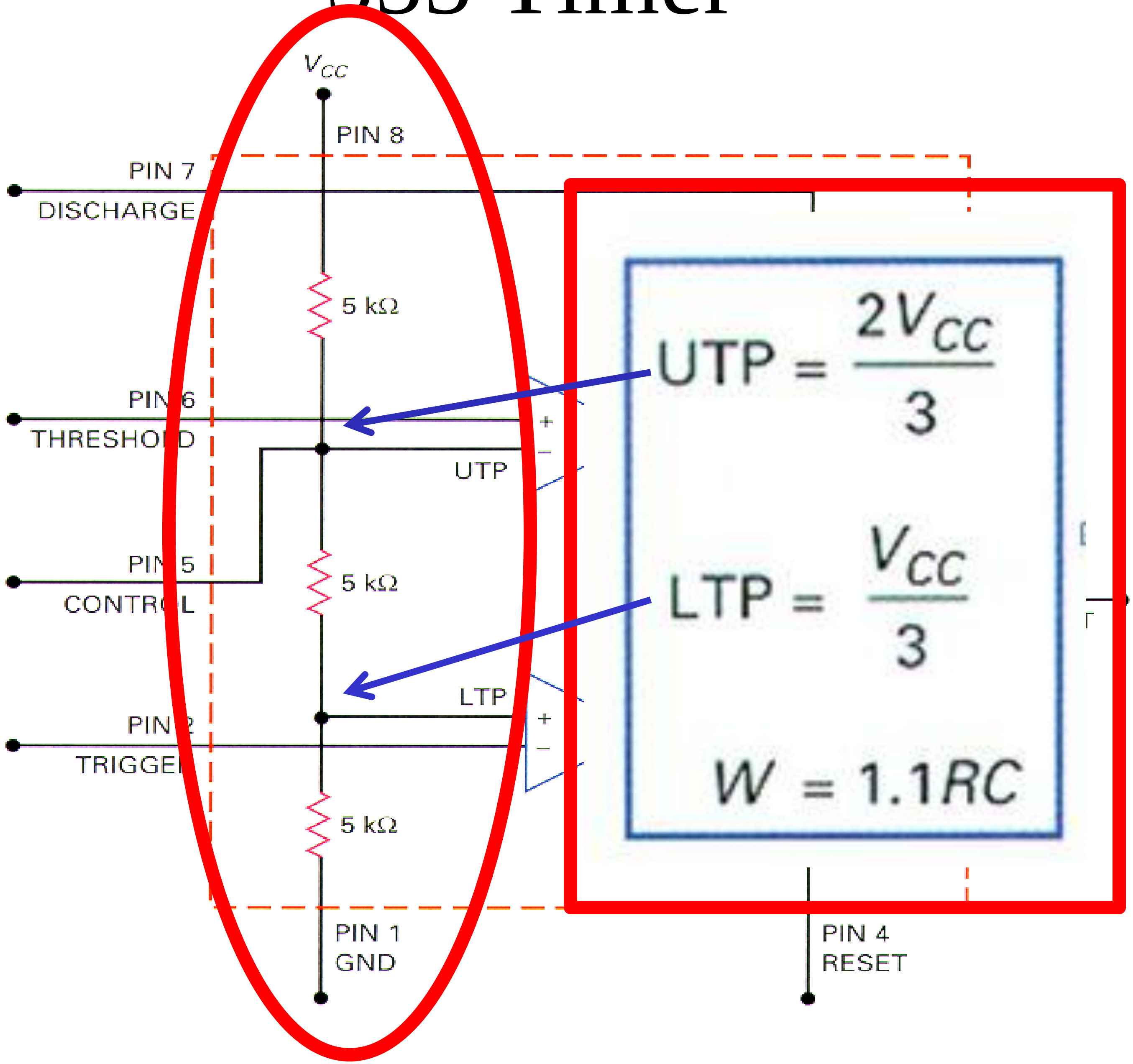
Monostable (one-shot)

- have only **ONE** stable state (hence their name: “Mono”), and produce a single output pulse when it is triggered externally
- return back to their first original and stable state after a period of time determined by the time constant of the RC coupled circuit
- One main disadvantage of “monostable multivibrators” is that the time between the application of the next trigger pulse has to be greater than the preset RC time constant of the circuit to allow the capacitor time to charge and discharge

Monostable Timer Circuit



555 Timer

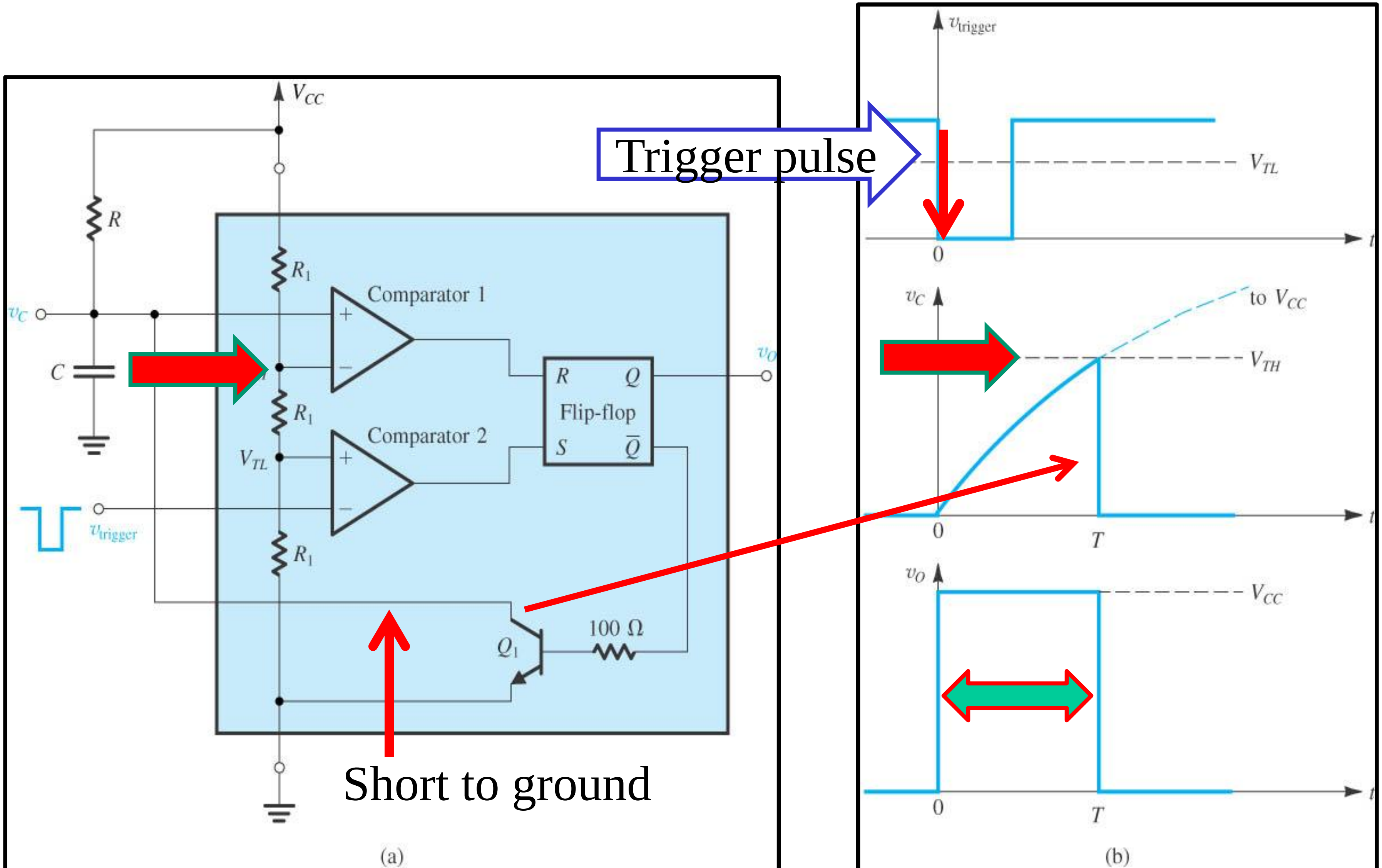


$$UTP = \frac{2V_{CC}}{3}$$

$$LTP = \frac{V_{CC}}{3}$$

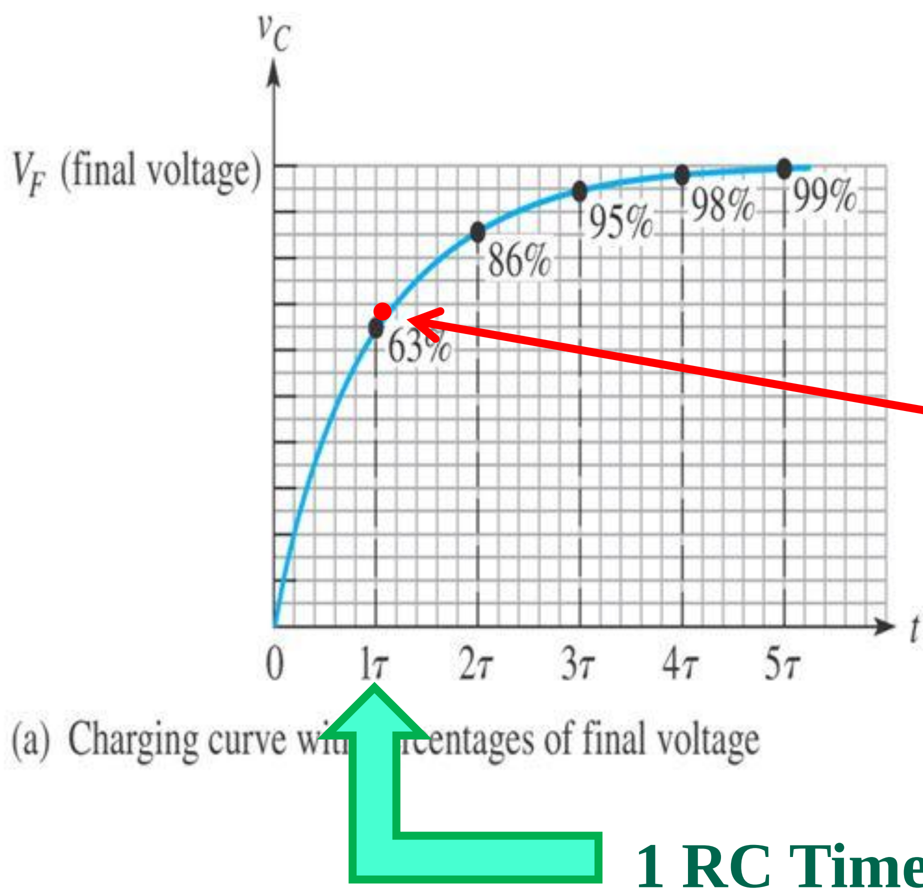
$$W = 1.1RC$$

(a) The 555 timer connected to implement a monostable multivibrator. (**b**) Waveforms of the circuit in (a).

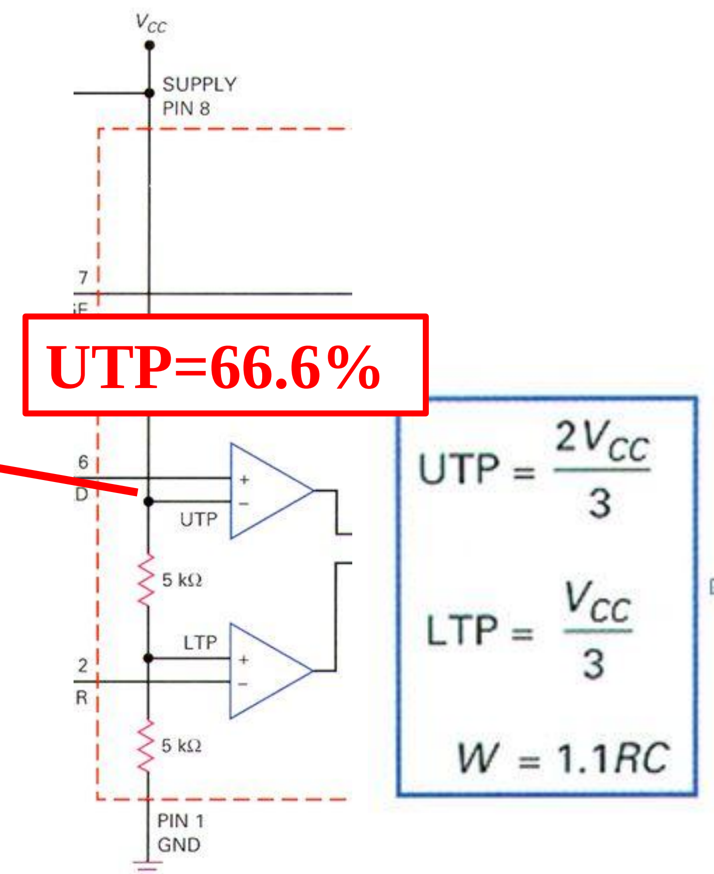


(pulse width) W = 1.1 RC

capacitor voltage in an *RC* circuit



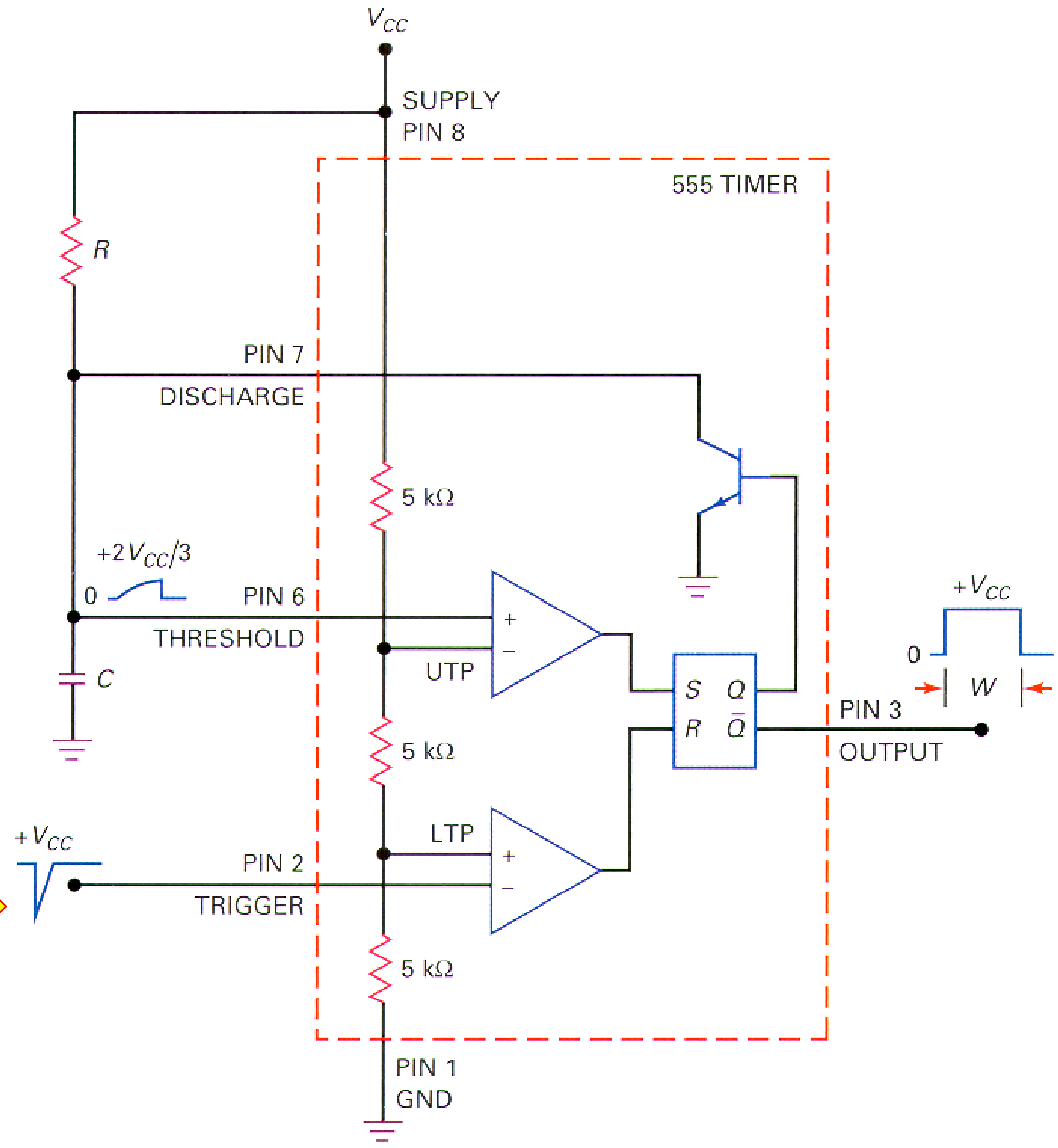
1 RC Time = 63%

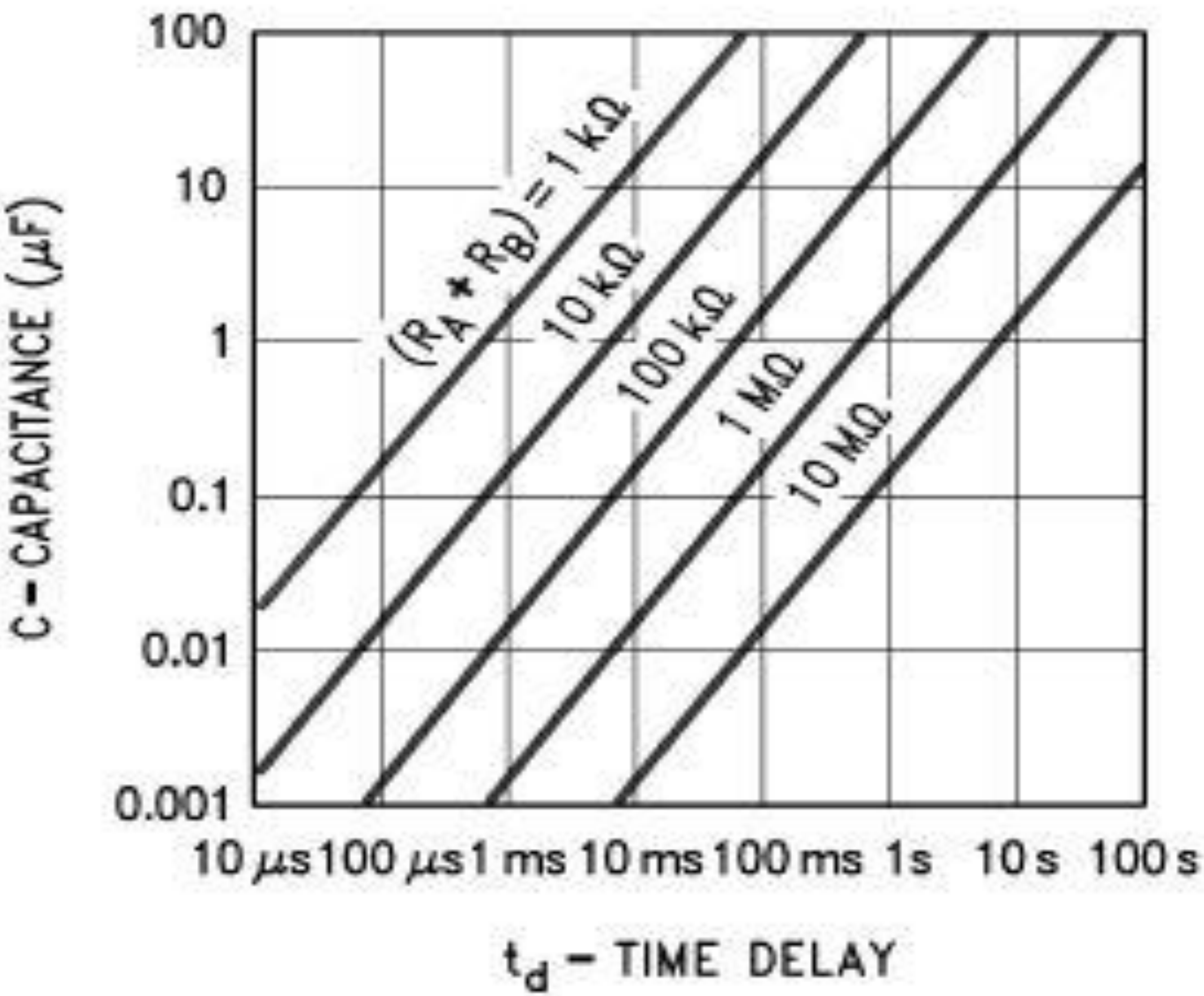


Monostable Operation

pulse width
W=1.1RC

ADK trigger pulse

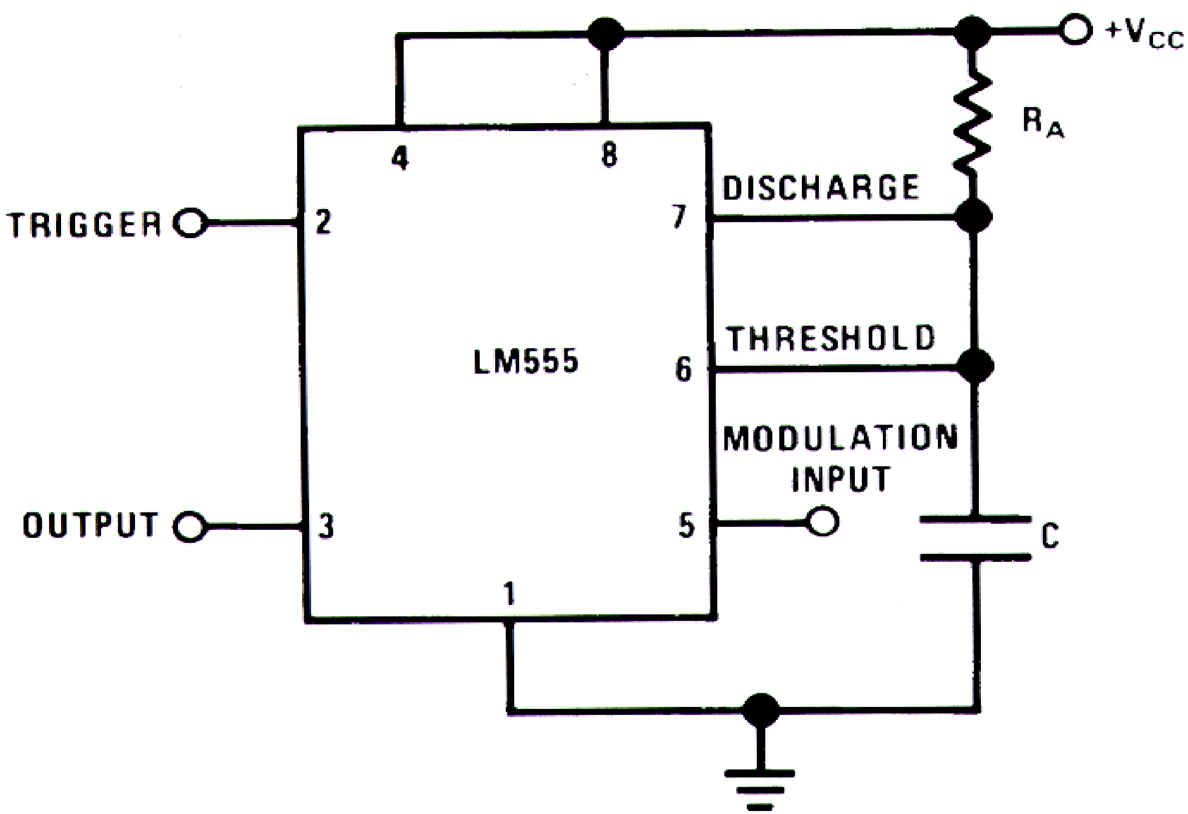




PULSE WIDTH Table

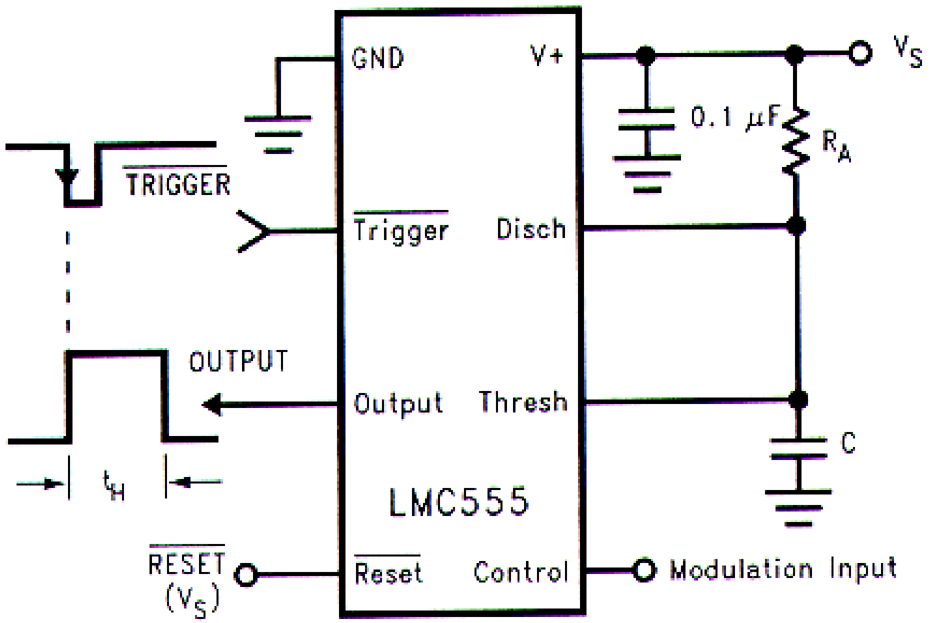
PULSE WIDTH MODULATOR

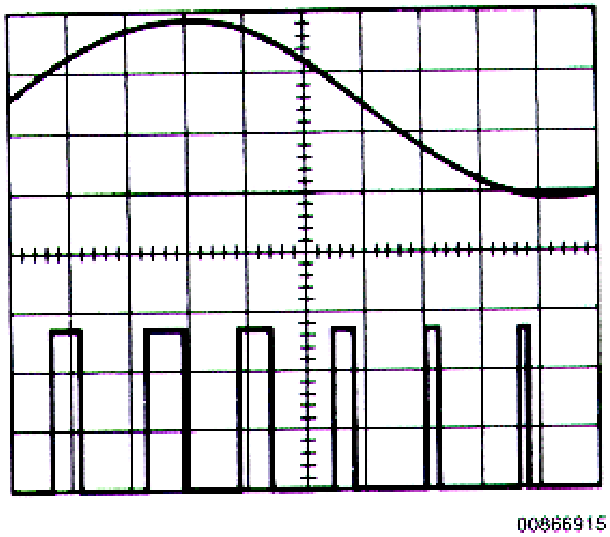
When the timer is connected in the monostable mode and triggered with a continuous pulse train, the output pulse width can be modulated by a signal applied to pin 5. *Figure 8* shows the circuit, and in *Figure 9* are some waveform examples.



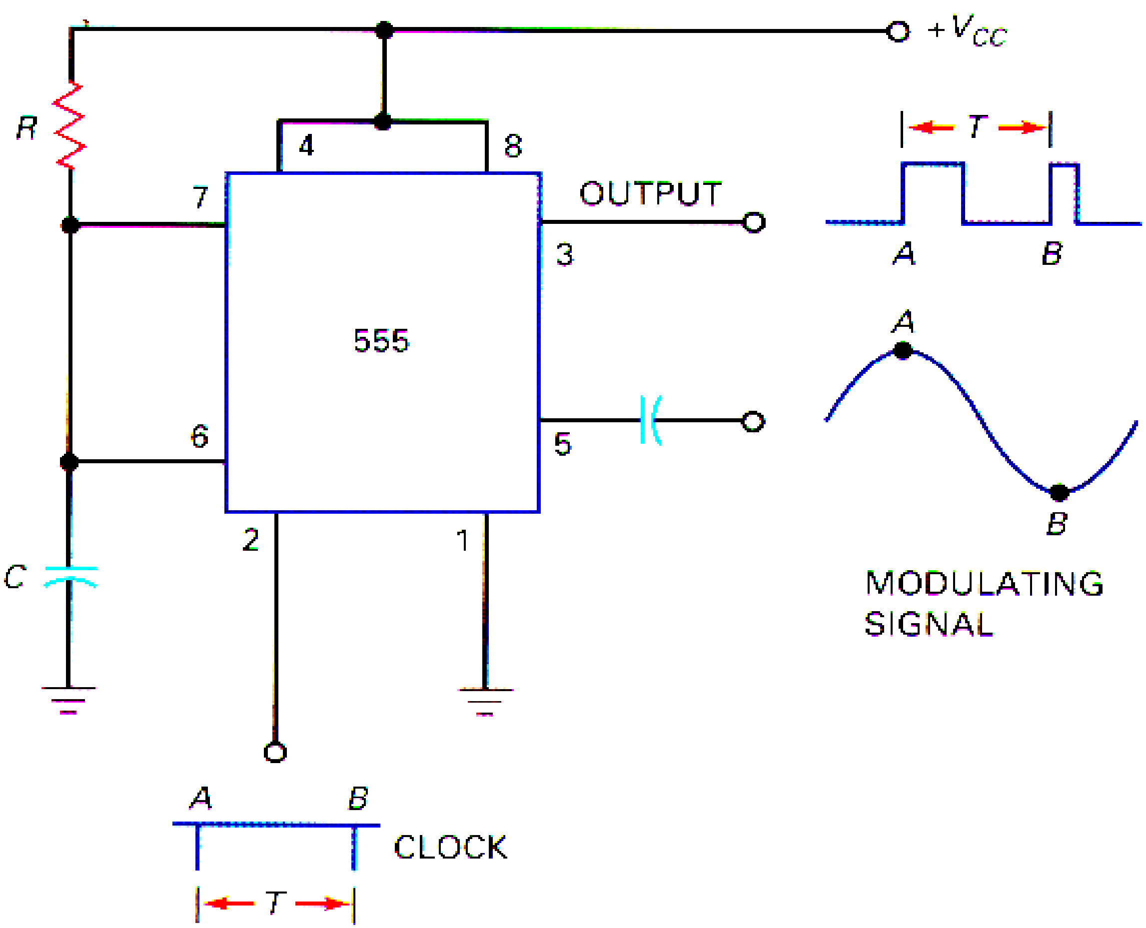
Pulse Width Modulation using LM555

Pulse Width Modulator





Pulse - Width Modulator



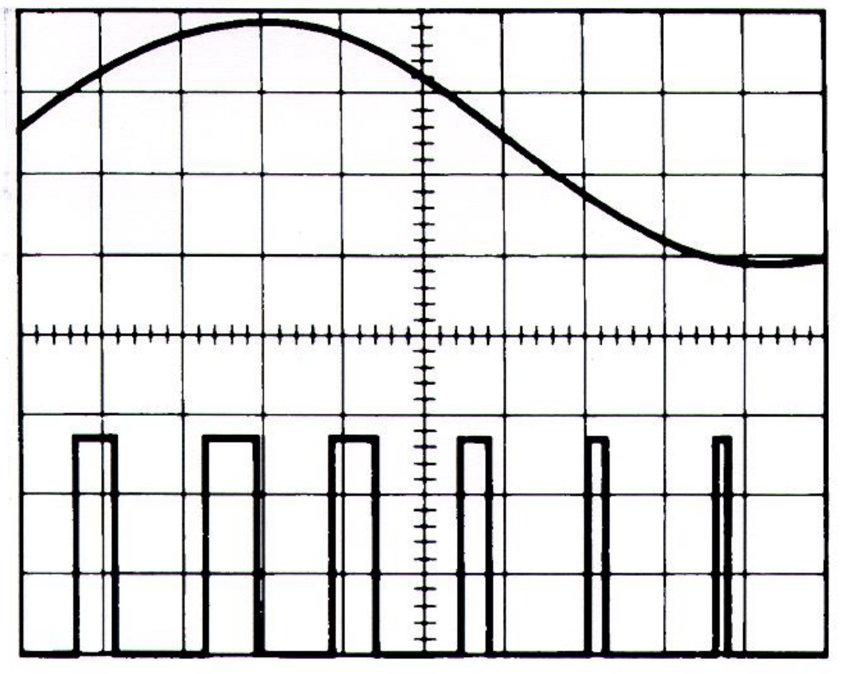
$$T = \frac{1}{f_{\text{clock}}}$$

$$\text{UTP} = \frac{2V_{CC}}{3} + v_{\text{mod}}$$

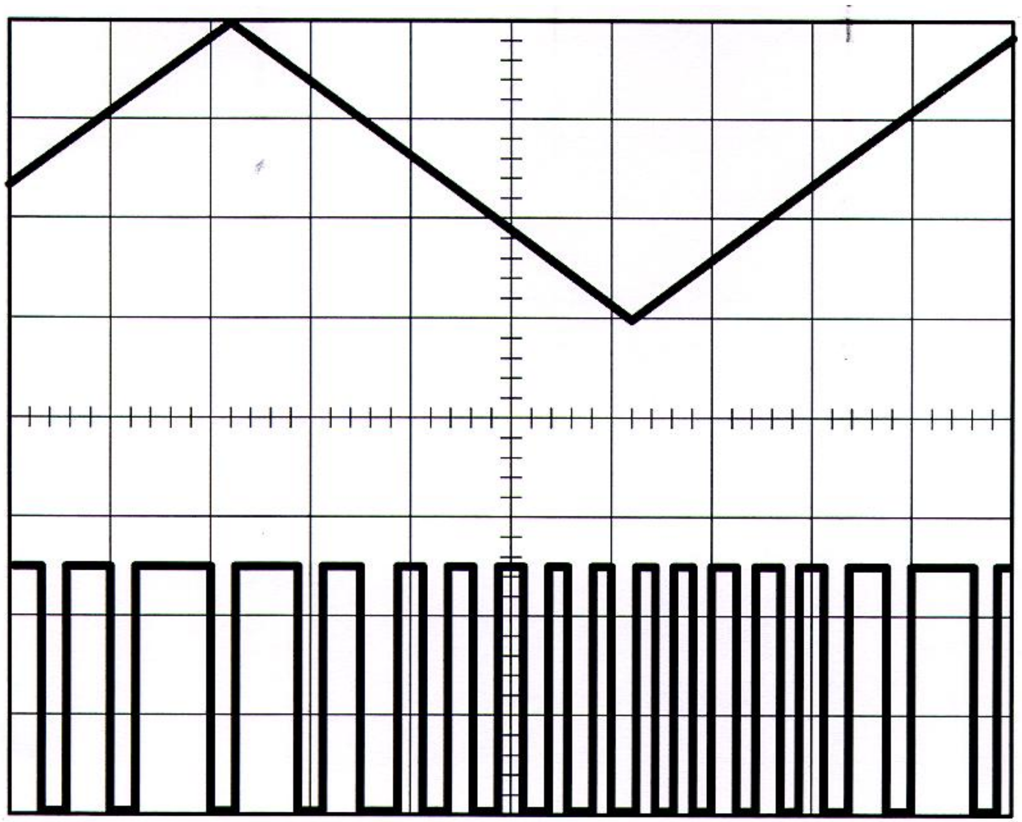
$$W = -RC \ln\left(1 - \frac{\text{UTP}}{V_{CC}}\right)$$

$$D = \frac{W}{T}$$

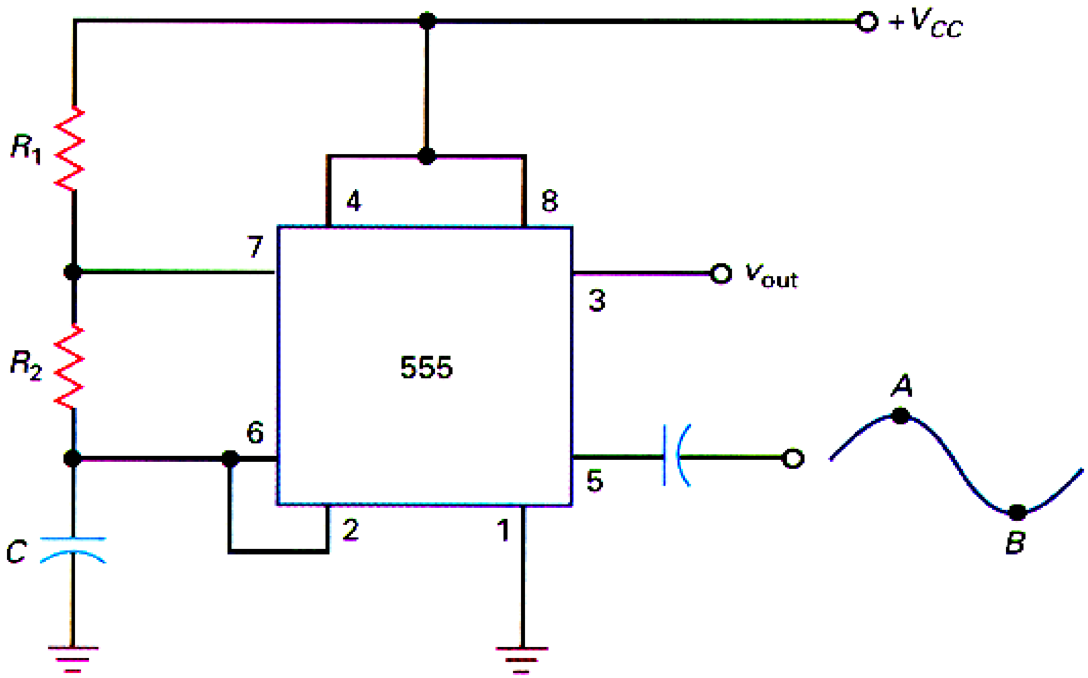
Pulse Width Modulation



Pulse Width Modulation



Pulse - Position Modulator



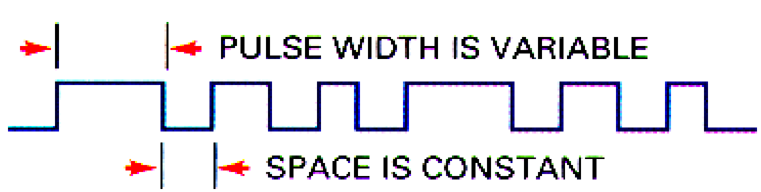
(a)

$$\mathrm{UTP} = \frac{2V_{CC}}{3} + v_{mod}$$

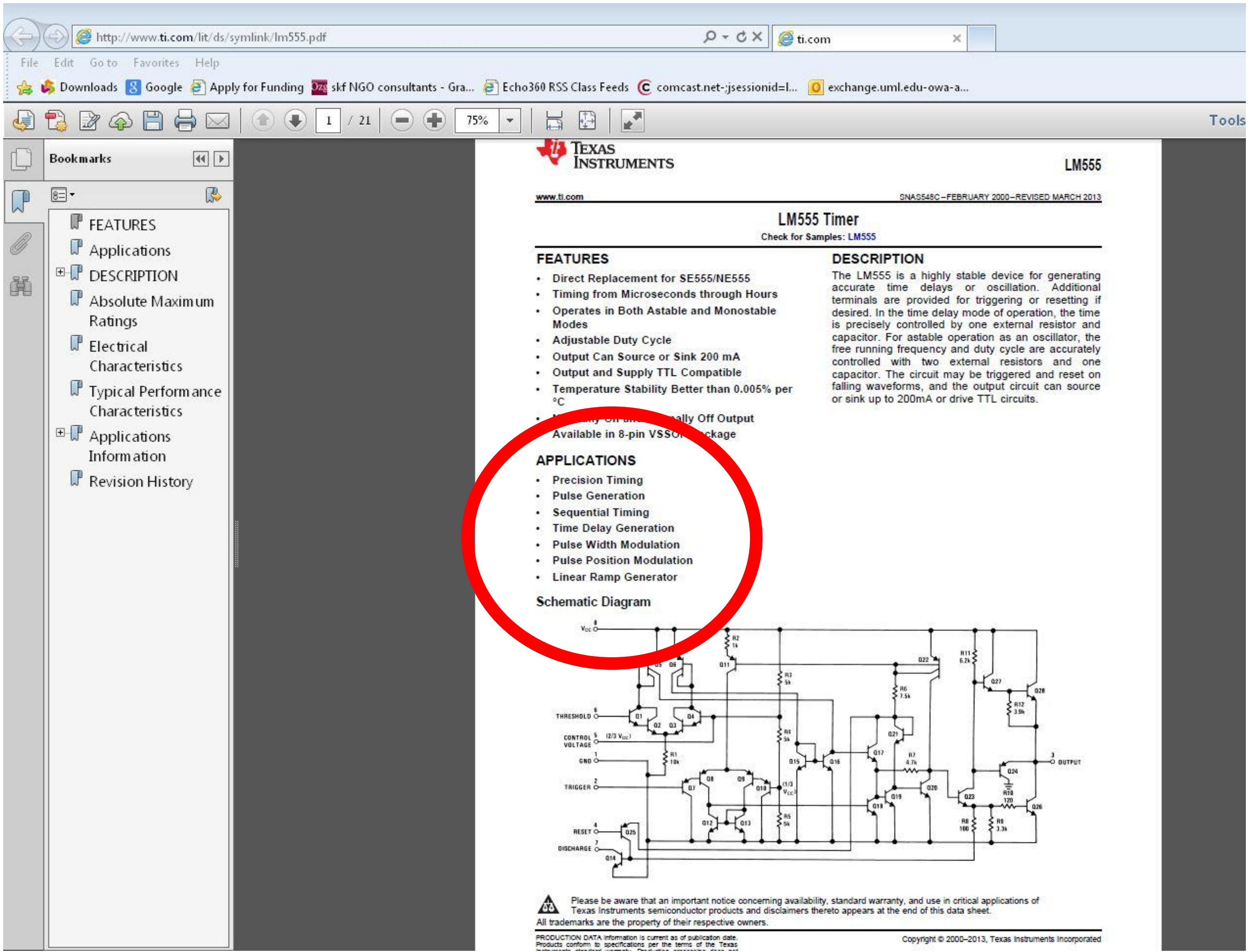
$$W = -(R_1 + R_2)C \ln \frac{V_{CC} - \mathrm{UTP}}{V_{CC} - 0.5\mathrm{UTP}}$$

$$T = W + 0.693R_2C$$

$$\text{Space} = 0.693R_2C$$



T I Data Sheet



www.ti.com SNAS548C – FEBRUARY 2000 – REVISED MARCH 2013

LM555 Timer

Check for Samples: LM555

FEATURES

- Direct Replacement for SE555/NE555
- Timing from Microseconds through Hours
- Operates in Both Astable and Monostable Modes
- Adjustable Duty Cycle
- Output Can Source or Sink 200 mA
- Output and Supply TTL Compatible
- Temperature Stability Better than 0.005% per °C
- Normally On and Normally Off Output
- Available in 8-pin VSSOP Package

APPLICATIONS

- Precision Timing
- Pulse Generation
- Sequential Timing
- Time Delay Generation
- Pulse Width Modulation
- Pulse Position Modulation
- Linear Ramp Generator

DESCRIPTION

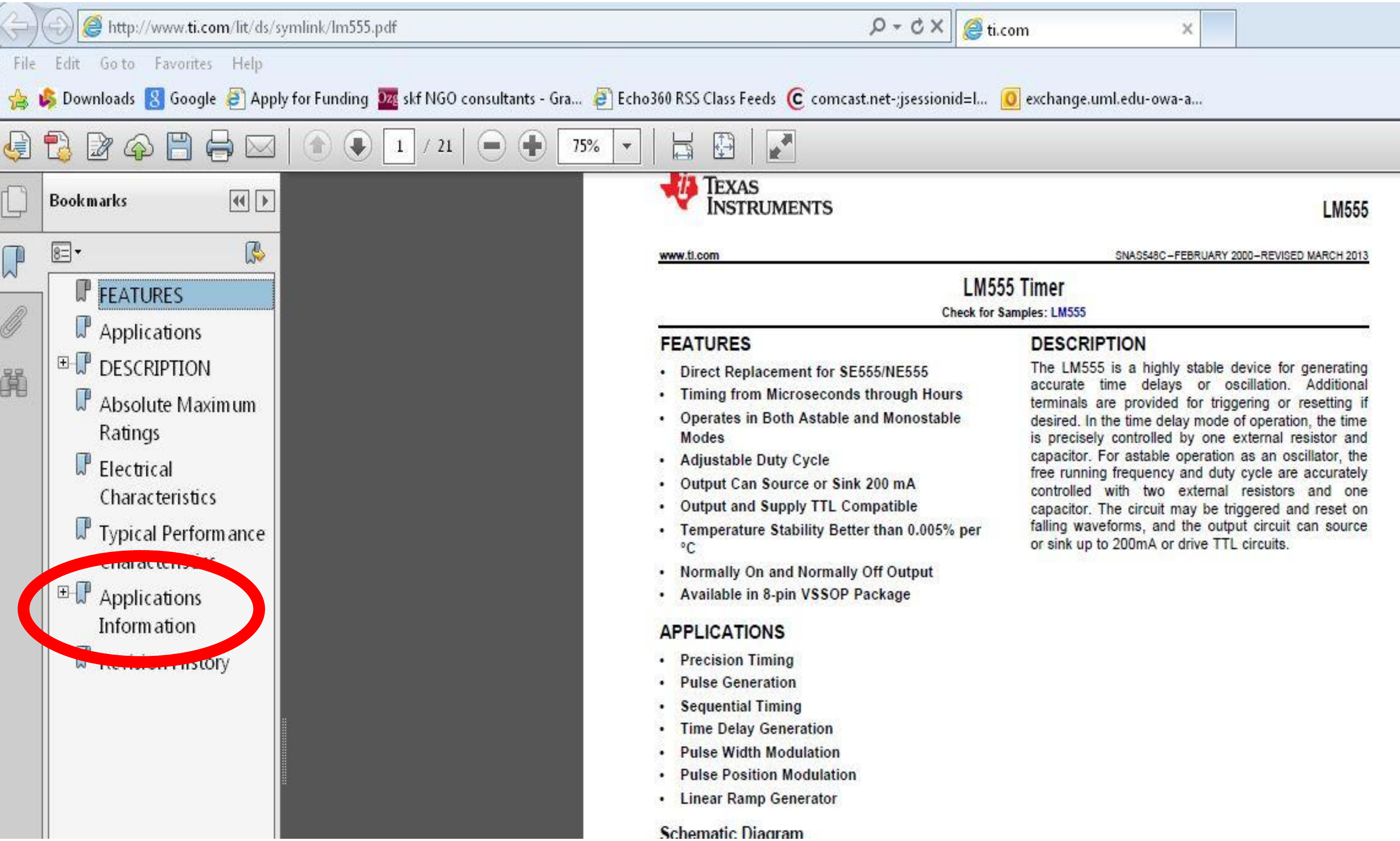
The LM555 is a highly stable device for generating accurate time delays or oscillation. Additional terminals are provided for triggering or resetting if desired. In the time delay mode of operation, the time is precisely controlled by one external resistor and capacitor. For astable operation as an oscillator, the free running frequency and duty cycle are accurately controlled with two external resistors and one capacitor. The circuit may be triggered and reset on falling waveforms, and the output circuit can source or sink up to 200mA or drive TTL circuits.

T I Data Sheet

APPLICATIONS

- Precision Timing
- Pulse Generation
- Sequential Timing
- Time Delay Generation
- Pulse Width Modulation
- Pulse Position Modulation
- Linear Ramp Generator

T I Data Sheet



T I Data Sheet page 9 & 10

PULSE WIDTH MODULATOR

When the timer is connected in the monostable mode and triggered with a continuous pulse train, the output pulse width can be modulated by a signal applied to pin 5. Figure 19 shows the circuit, and in Figure 20 are some waveform examples.

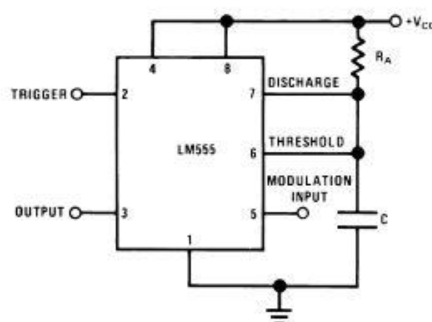
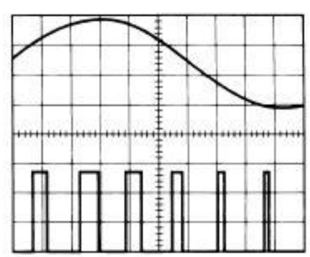


Figure 19. Pulse Width Modulator



T I Data Sheet page 9 & 10

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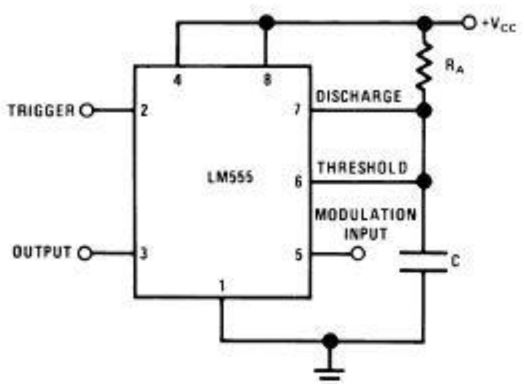
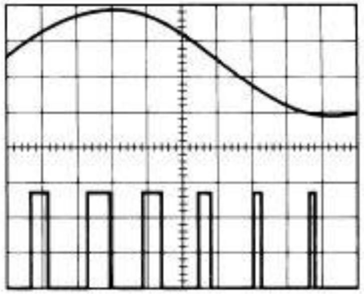


Figure 19. Pulse Width Modulator



V_{CC} = 5V
TIME = 0.2 ms/DIV.
R_A = 9.1kΩ
C = 0.01μF

Top Trace: Modulation 1V/Div.
Bottom Trace: Output Voltage 2V/Div.

Figure 20. Pulse Width Modulator

T I Data Sheet page 10

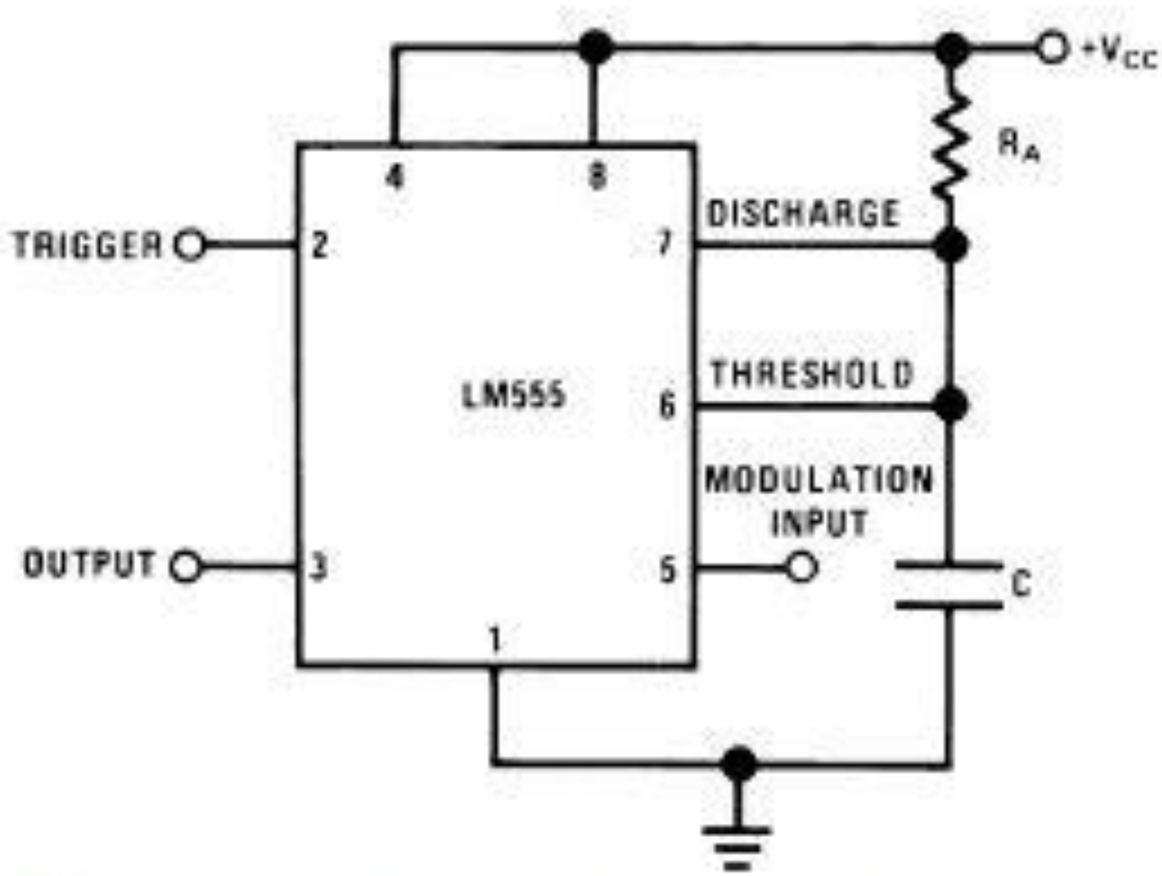


Figure 19. Pulse Width Modulator

T I Data Sheet page 10

F = 1 / T

F = 1 / .3ms

F = 3,333.3 Hz

F = 3.3 kHz

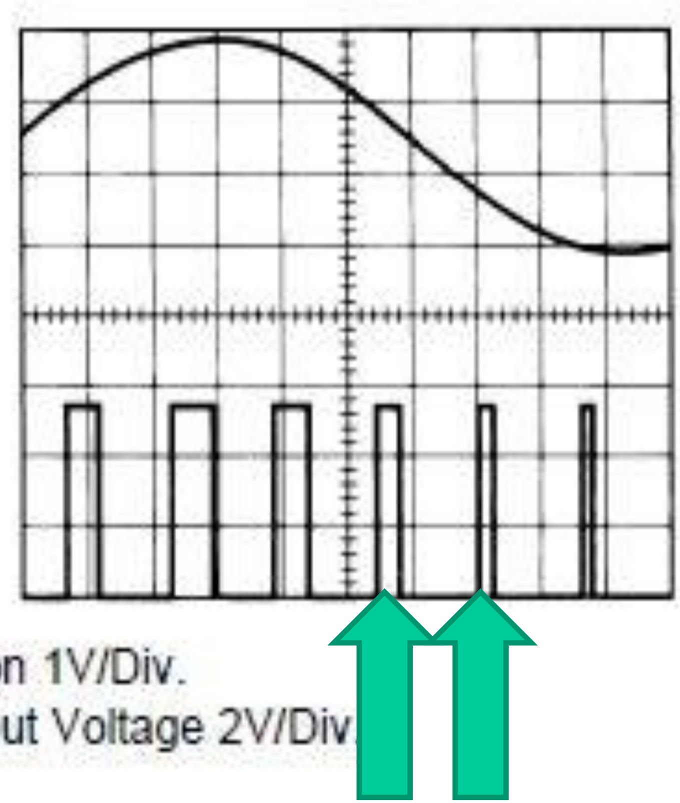


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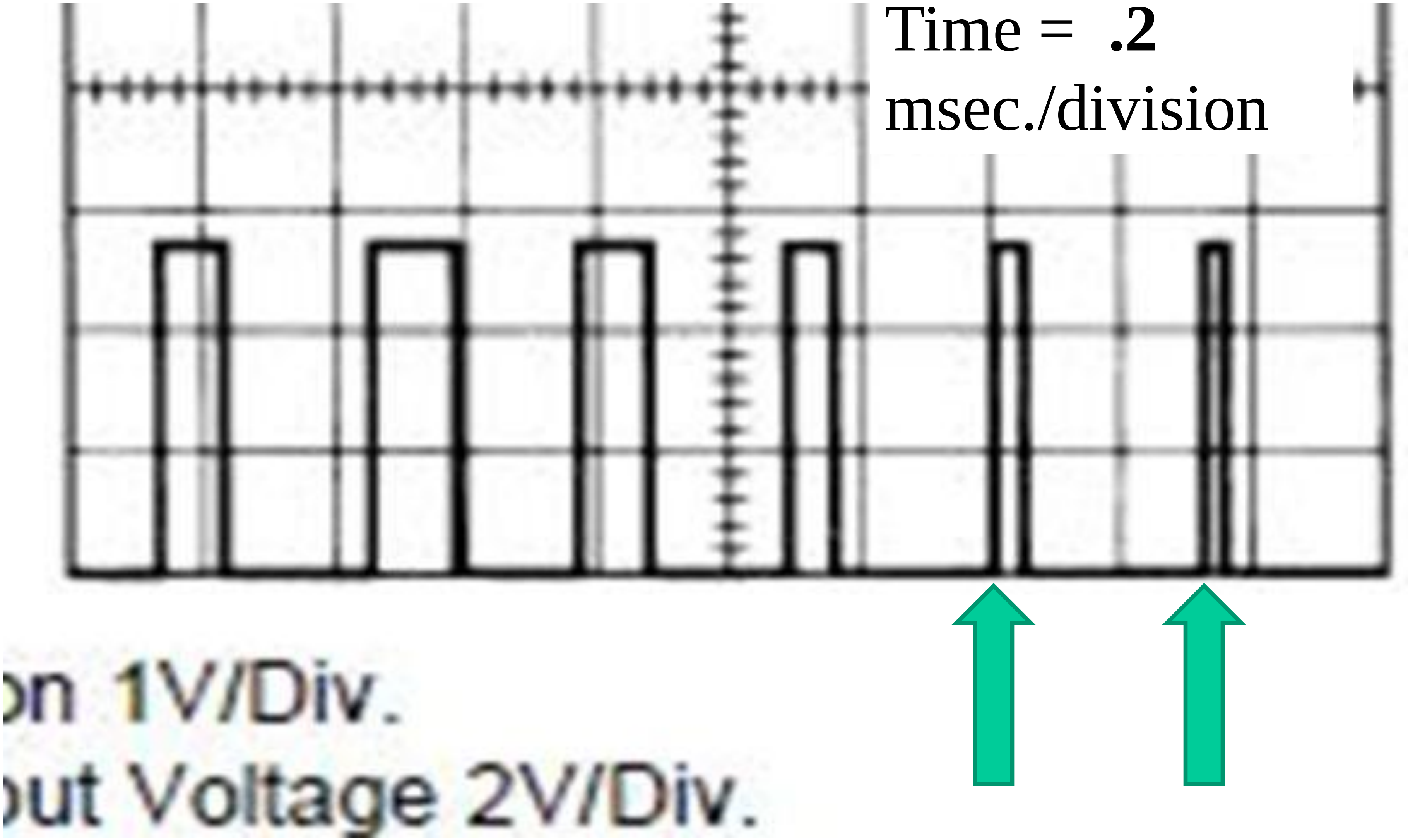
Figure 20. Pulse Width Modulator

T I Data Sheet page 10



Fairchild Data Sheet

FAIRCHILD
SEMICONDUCTOR®

January 2013

LM555
Single Timer

Features

- High-Current Drive Capability: 200 mA
- Adjustable Duty Cycle
- Temperature Stability of 0.005%/°C
- Timing From µs to Hours
- Turn off Time Less Than 2 µs

Applications

- Precision Timing
- Pulse Generation
- Delay Generation
- Sequential Timing

Description

The LM555 is a highly stable controller capable of producing accurate timing pulses. With a monostable operation, the delay is controlled by one external resistor and one capacitor. With astable operation, the frequency and duty cycle are accurately controlled by two external resistors and one capacitor.

8-DIP

8-SOIC

Fairchild Data Sheet

4. Pulse Width Modulation

The timer output waveform may be changed by modulating the control voltage applied to the timer's pin 5 and changing the reference of the timer's internal comparators. Figure 10 illustrates the pulse width modulation circuit.
When the continuous trigger pulse train is applied in the monostable mode, the timer output width is modulated according to the signal applied to the control terminal. Sine wave, as well as other waveforms, may be applied as a signal to the control terminal. Figure 11 shows the example of pulse width modulation waveform.

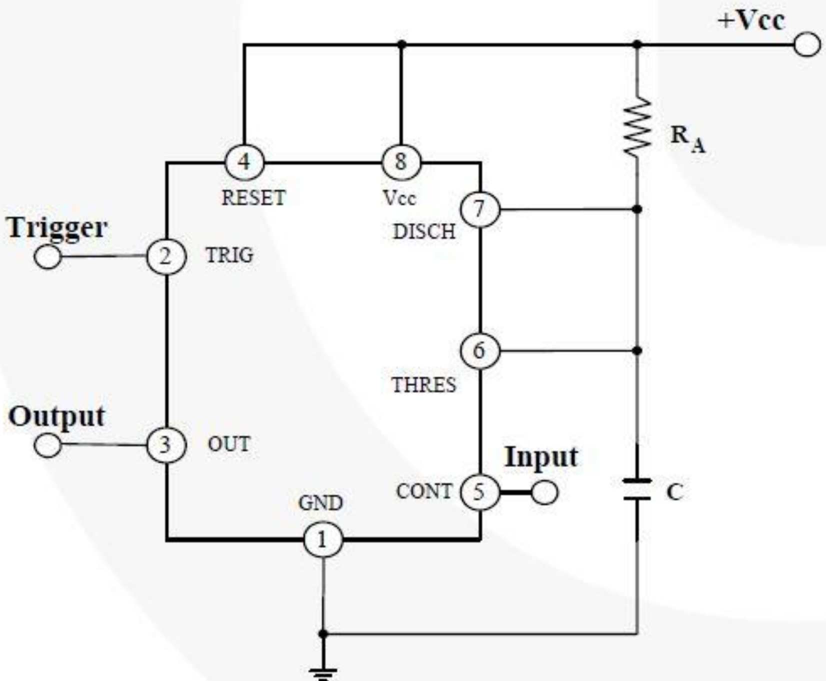


Figure 10. Circuit for Pulse Width Modulation

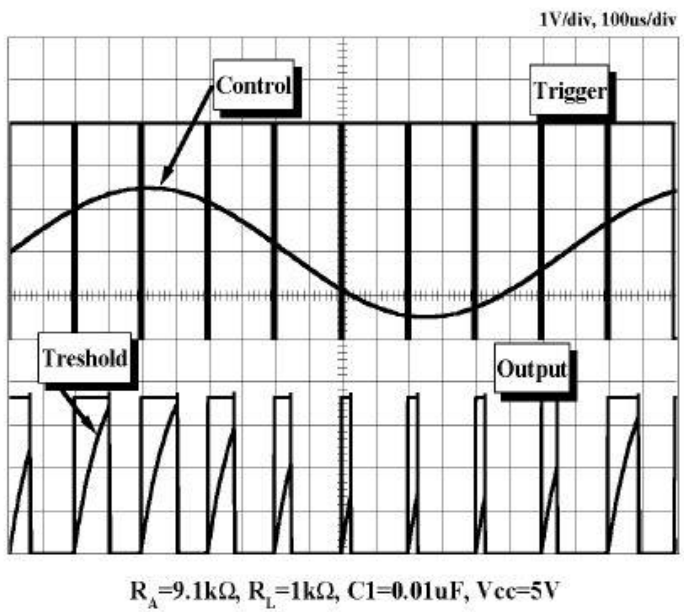


Figure 11. Waveforms of Pulse Width Modulation

Fairchild Data Sheet

4. Pulse Width Modulation

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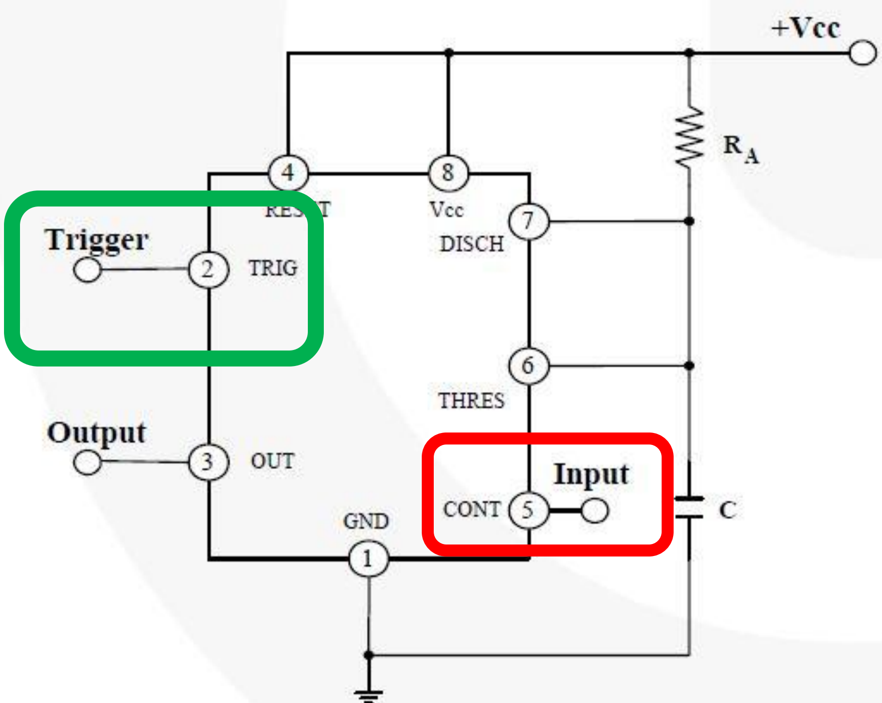

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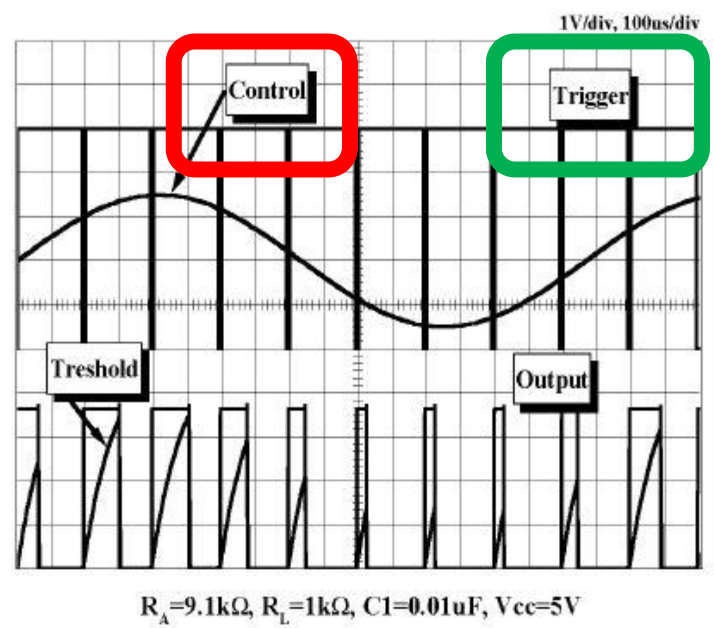

Figure 11. Waveforms of Pulse Width Modulation

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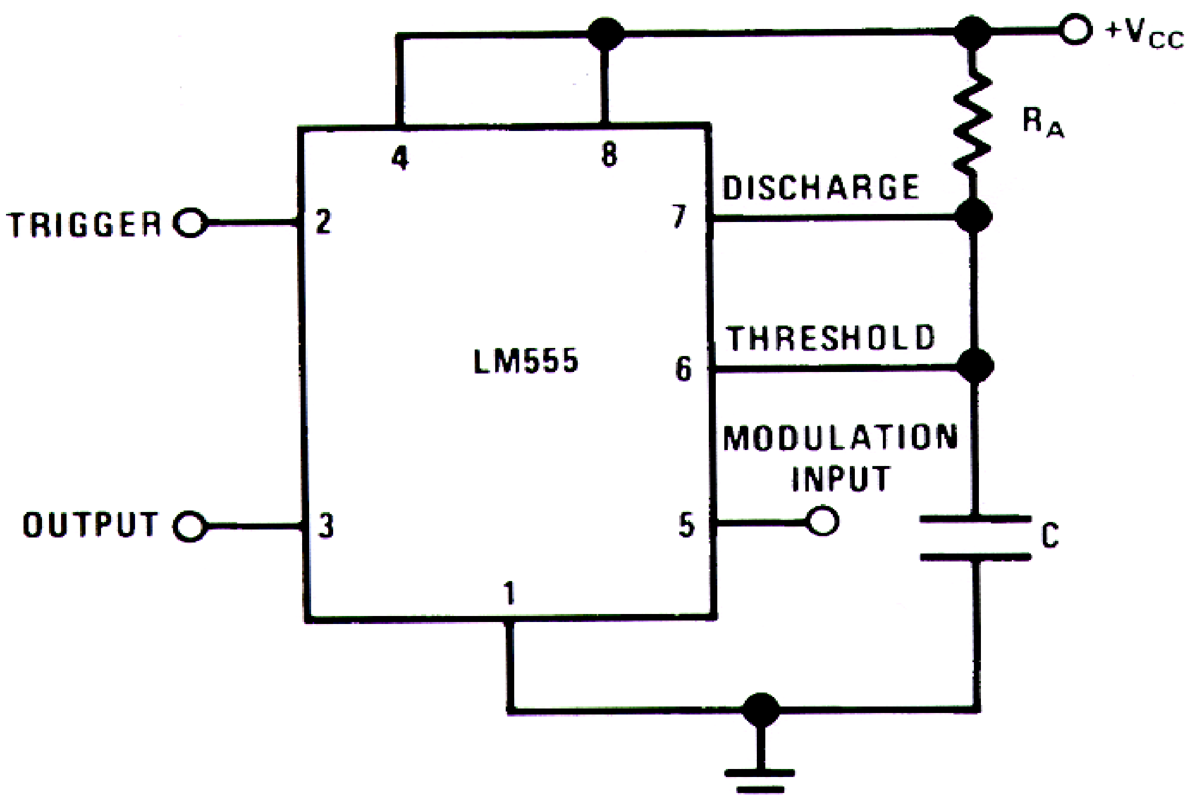
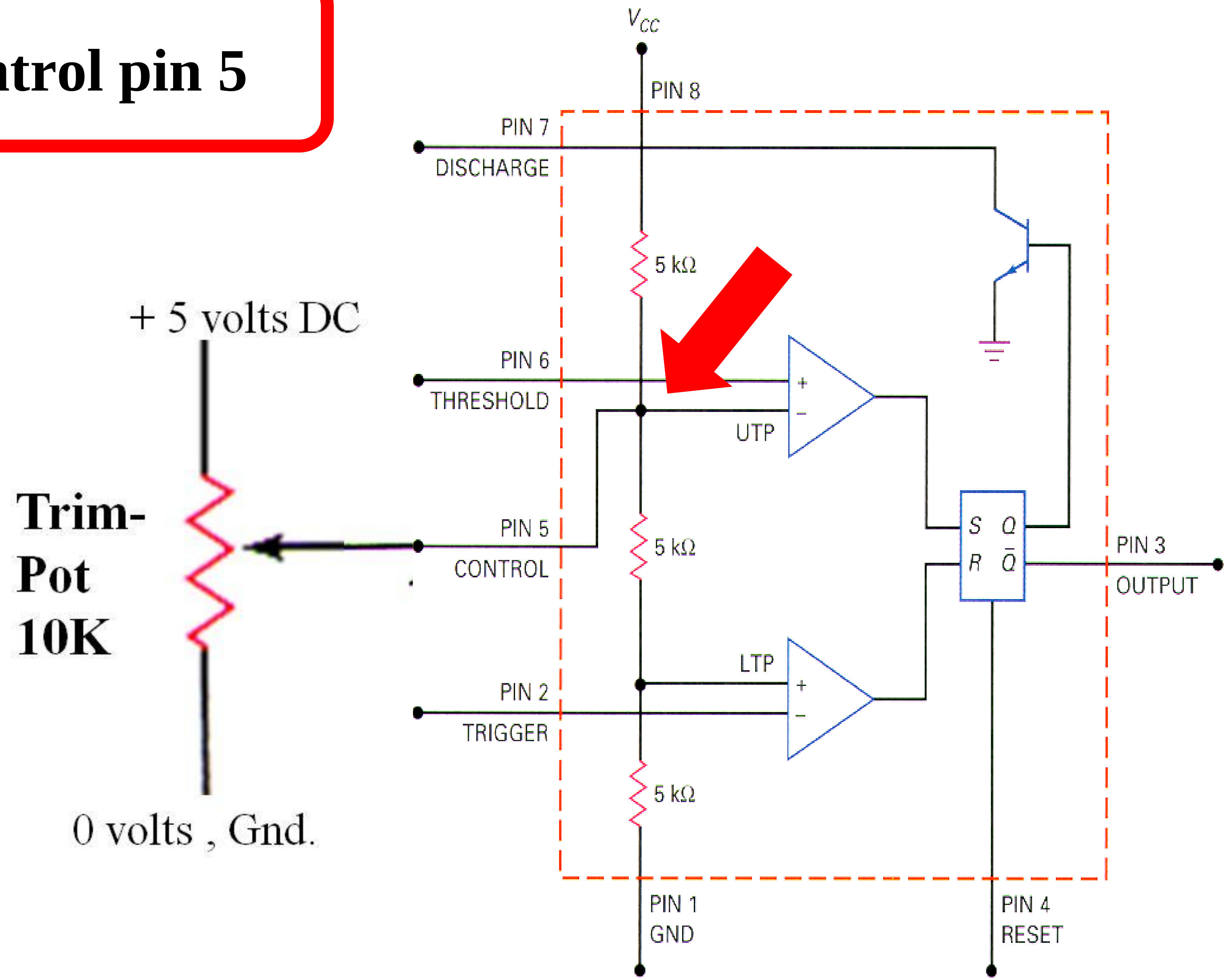
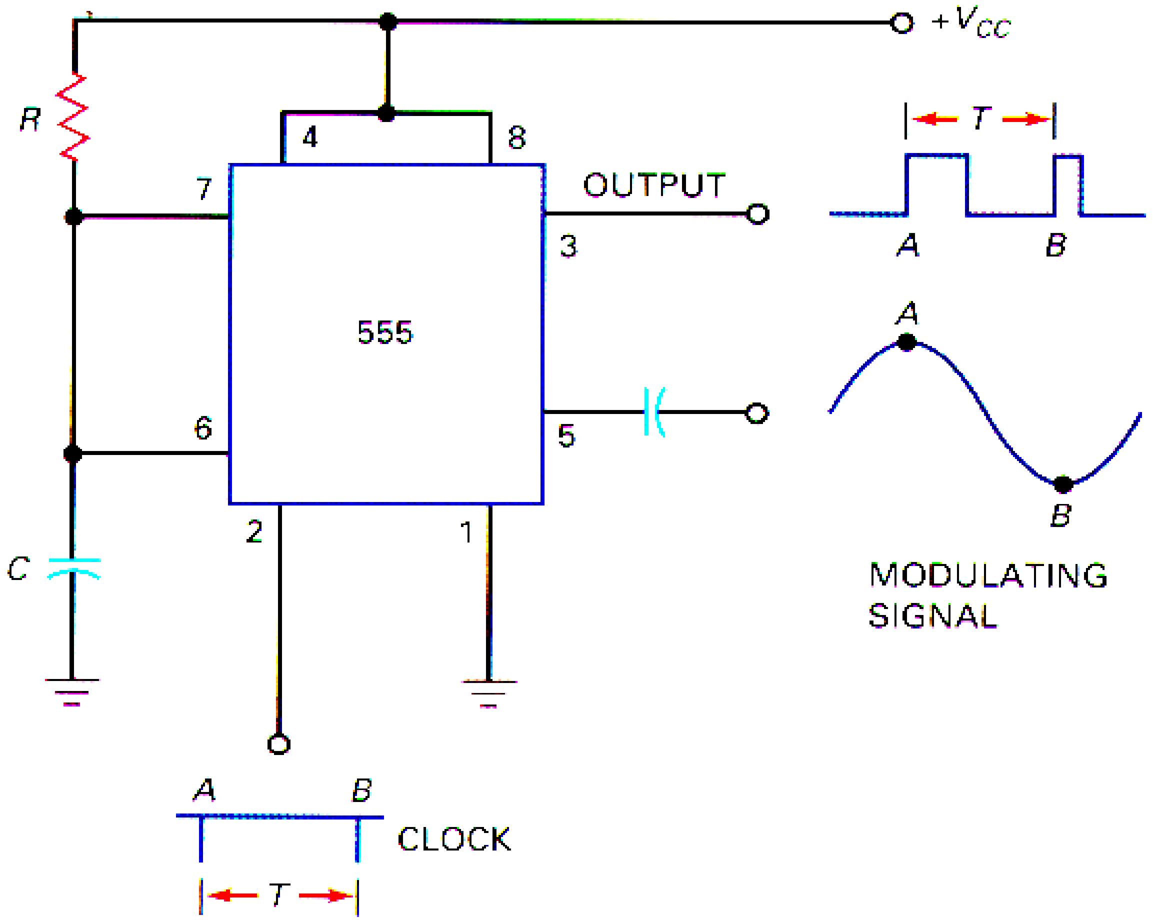


Control pin 5



Pulse - Width Modulator



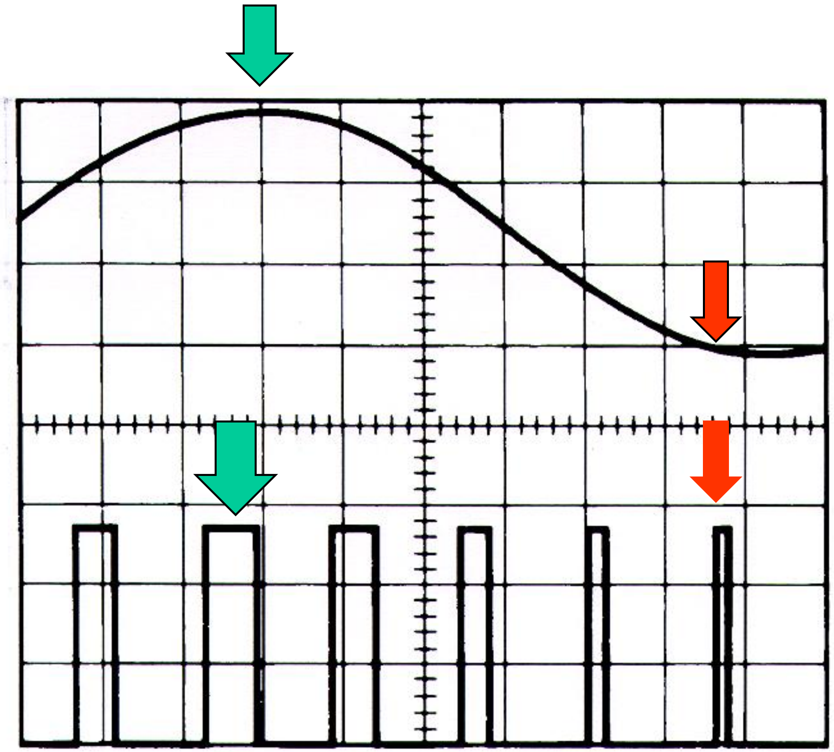
$$T = \frac{1}{f_{clock}}$$

$$UTP = \frac{2V_{CC}}{3} + v_{mod}$$

$$W = -RC \ln\left(1 - \frac{UTP}{V_{CC}}\right)$$

$$D = \frac{W}{T}$$

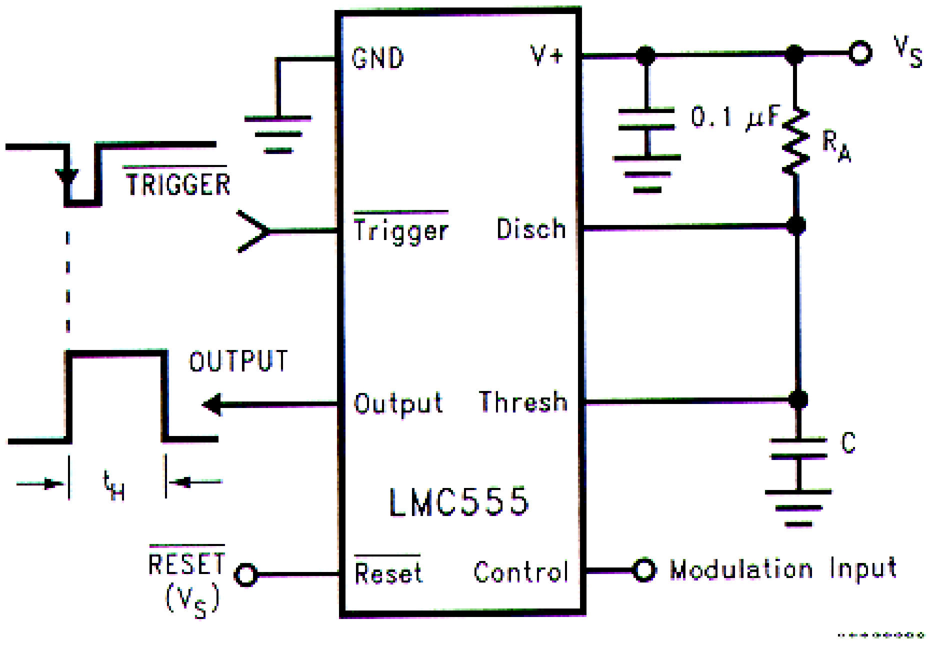
Pulse Width Modulation

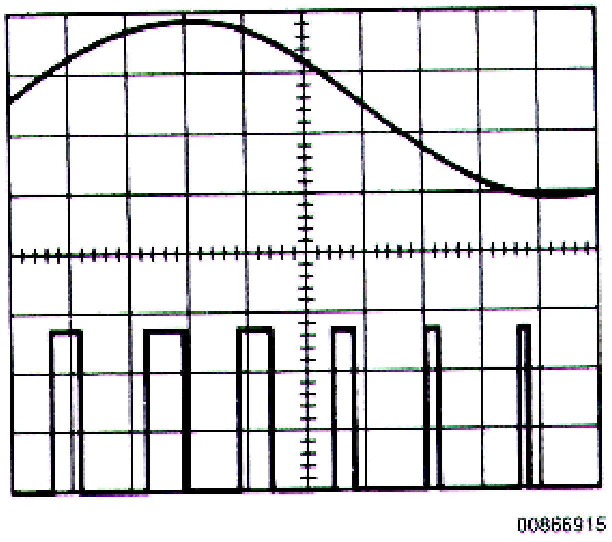


The higher the modulation voltage the wider the pulse
The lower the modulation voltage the narrower the pulse

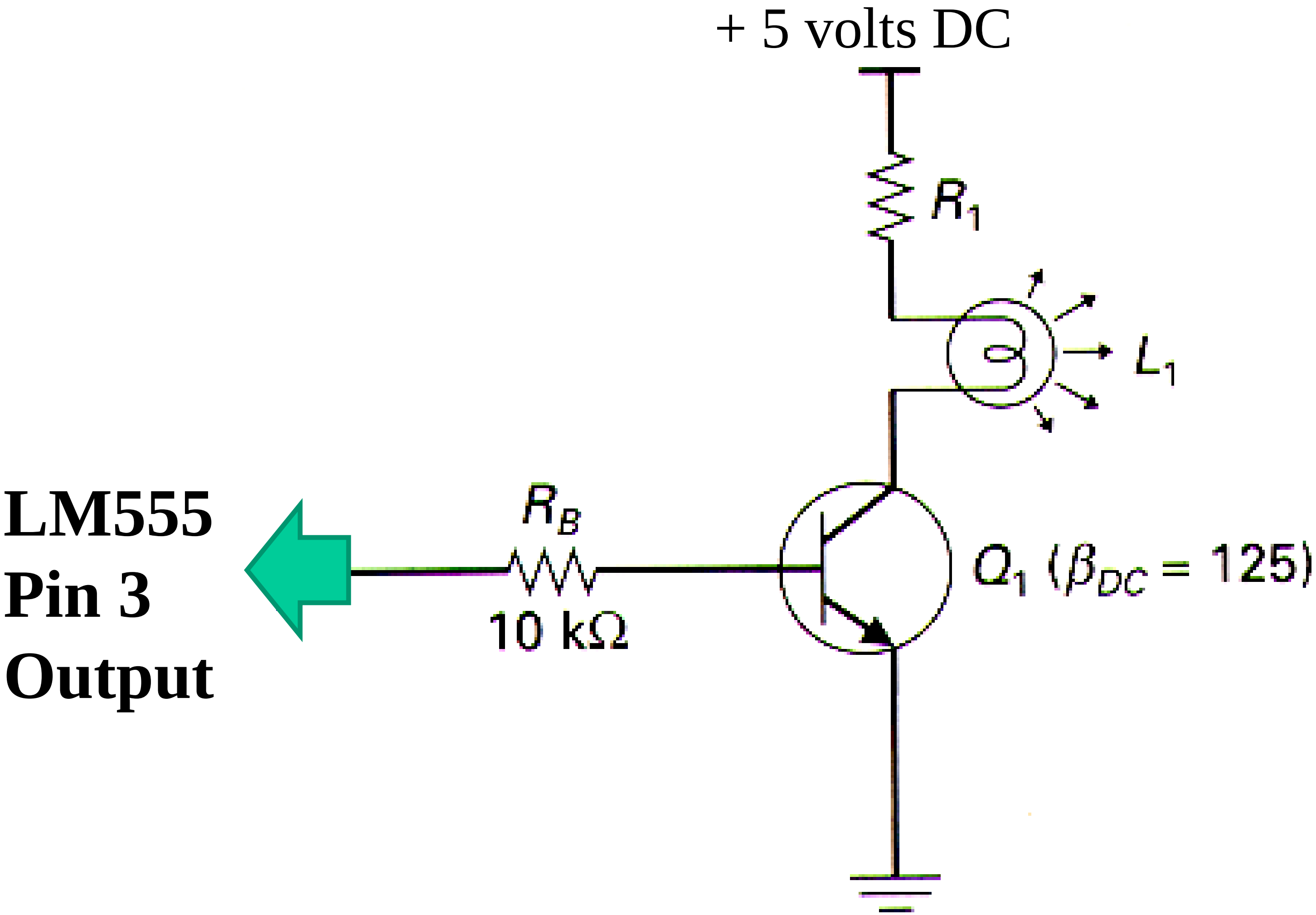
Pulse Width Modulation using LM555

Pulse Width Modulator





“Lamp Driver Circuit”



DEVICE: 2N3903 and 2N3904—NPN Silicon Switching and Amplifier Transistors

Maximum continuous
collector current (I_c) = 200 mA.

MAXIMUM RATINGS

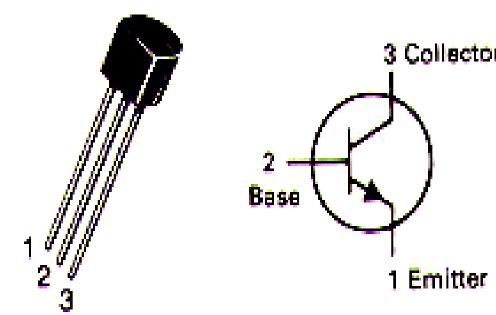
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltge	V_{CBO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	Vdc
Collector Current — Continuous	I_C	200	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	mW mW/°C
*Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

***THERMAL CHARACTERISTICS**

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

2N3903
2N3904*

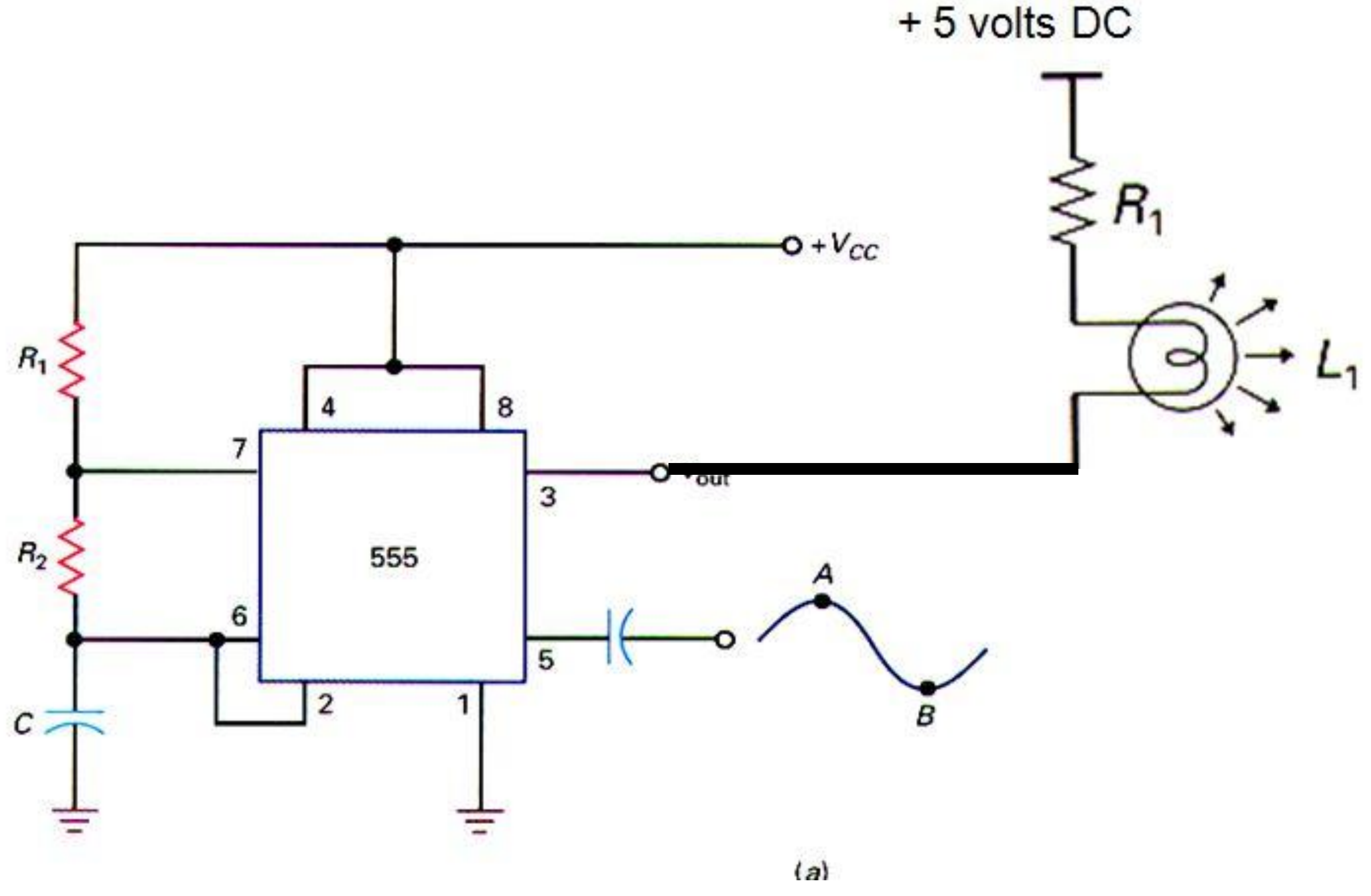
CASE 29-04, STYLE 1
TO-92 (TO-226AA)



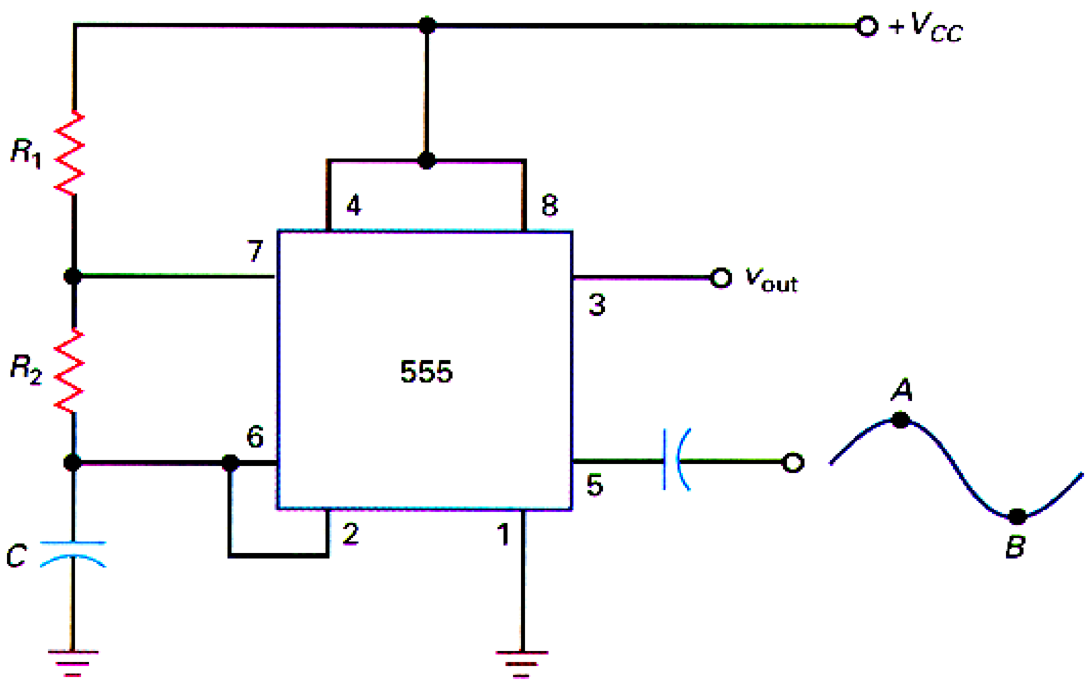
GENERAL PURPOSE TRANSISTORS

NPN SILICON

PWM Lamp brightness voltage control



Pulse - Position Modulator



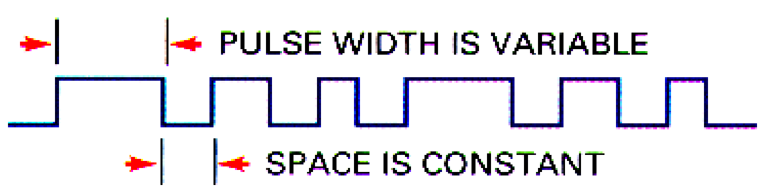
(a)

$$\text{UTP} = \frac{2V_{CC}}{3} + v_{mod}$$

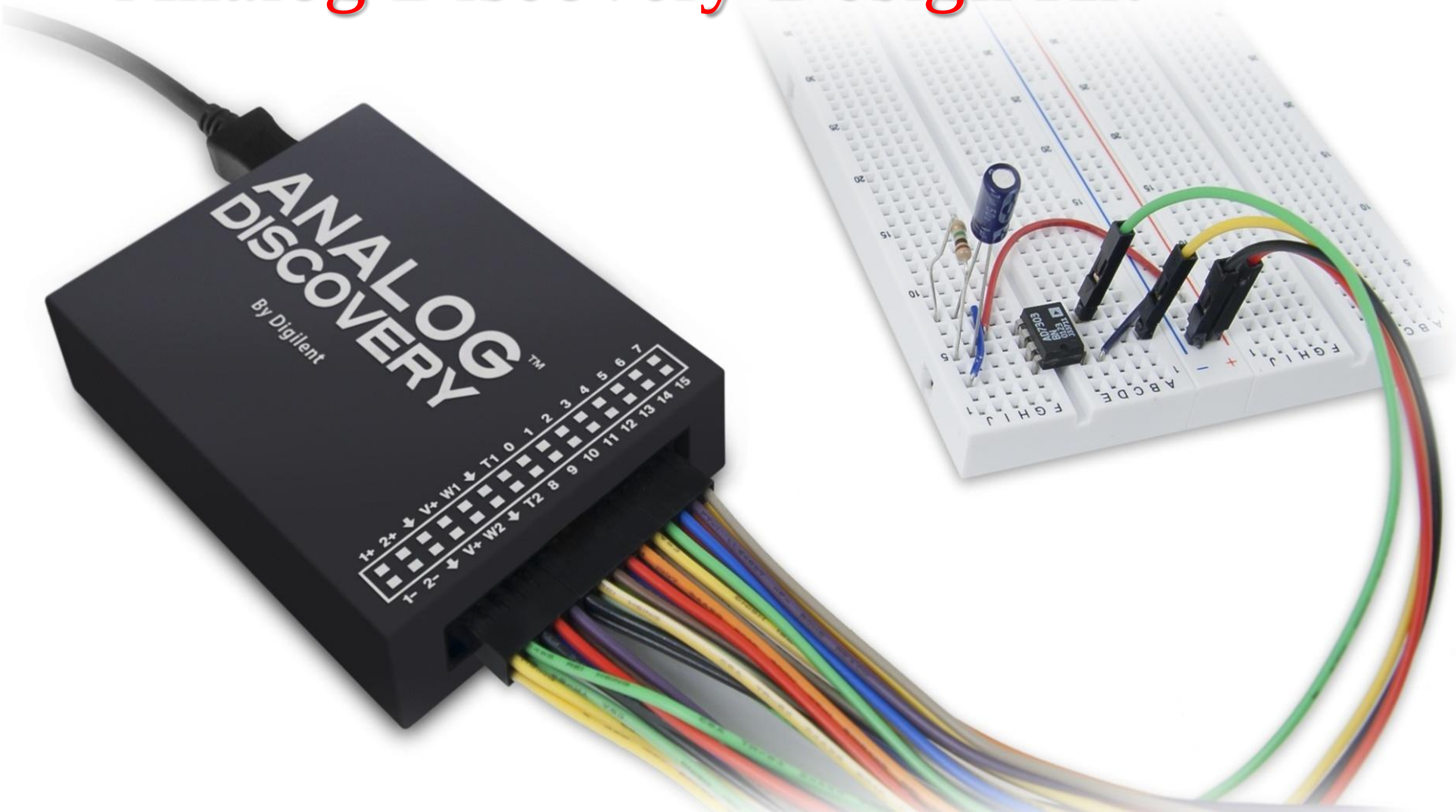
$$W = -(R_1 + R_2)C \ln \frac{V_{CC} - \text{UTP}}{V_{CC} - 0.5\text{UTP}}$$

$$T = W + 0.693R_2C$$

$$\text{Space} = 0.693R_2C$$



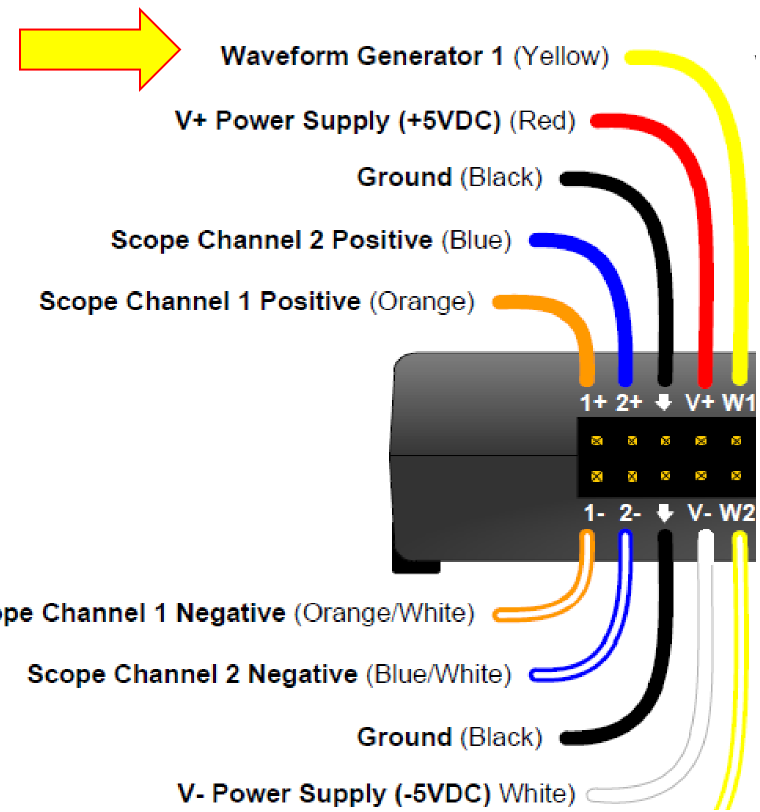
Analog Discovery Design Kit



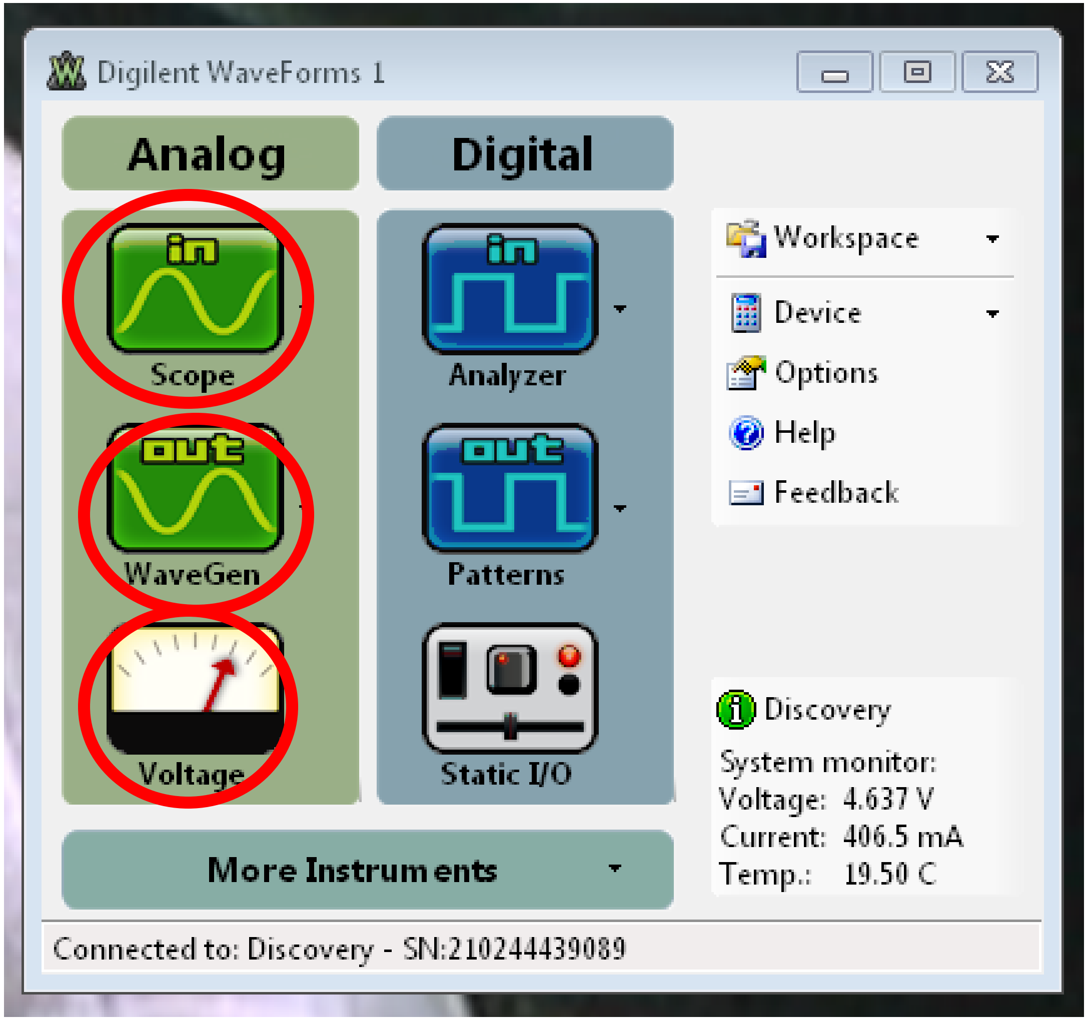
learning by doing

U-Mass, Alan Rux

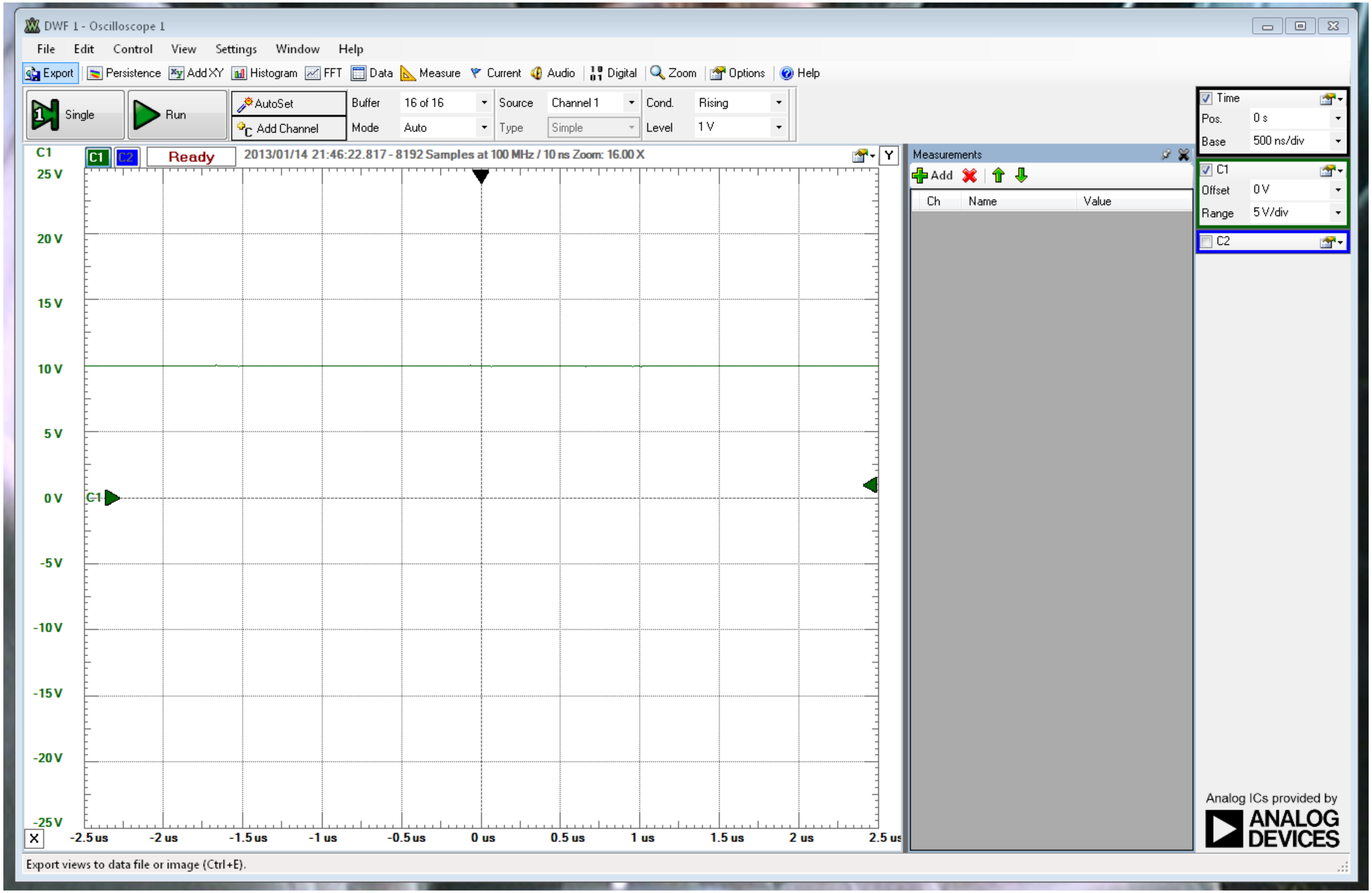
Leads we will be using today



To enable the oscilloscope click on the "Scope - in" icon

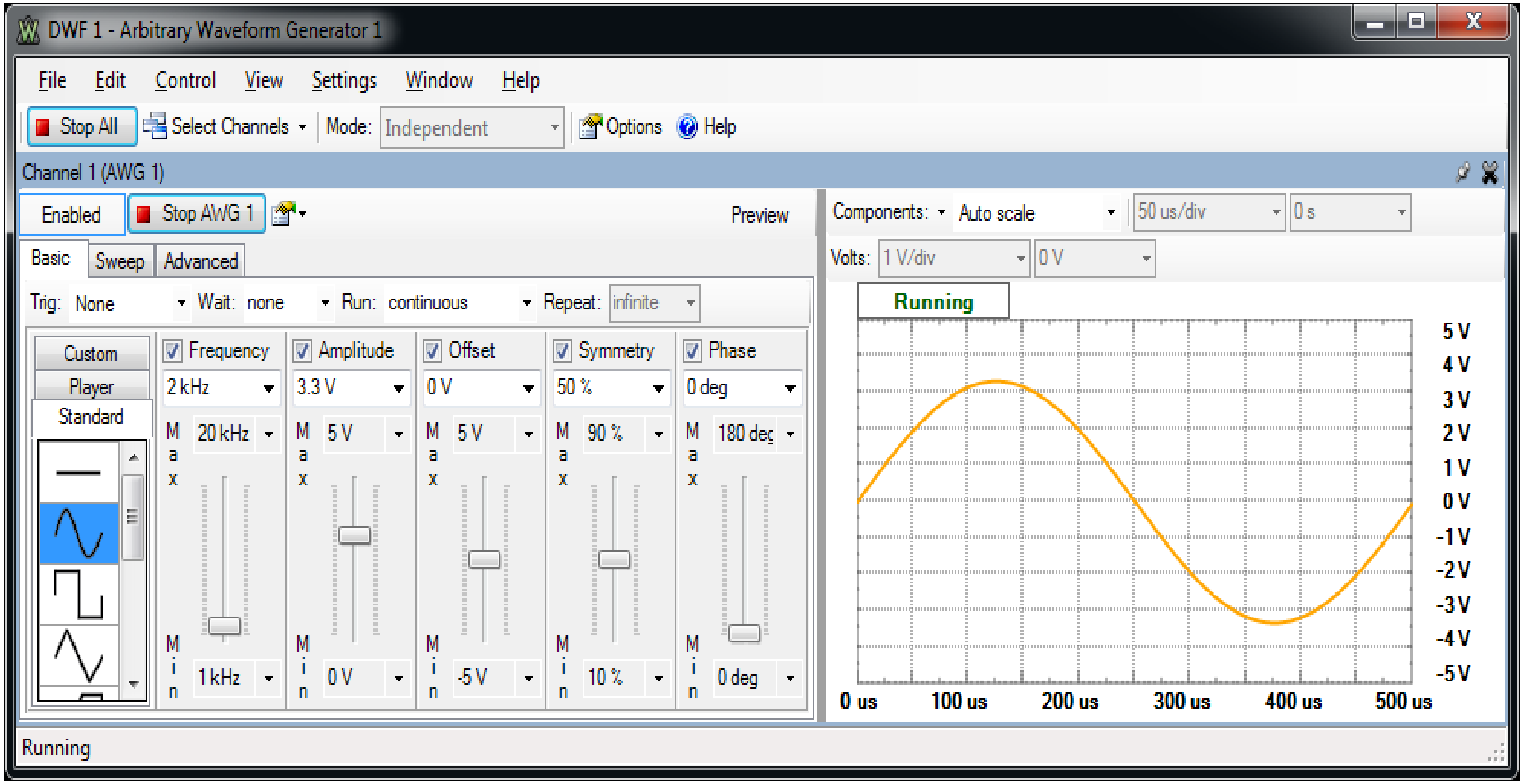


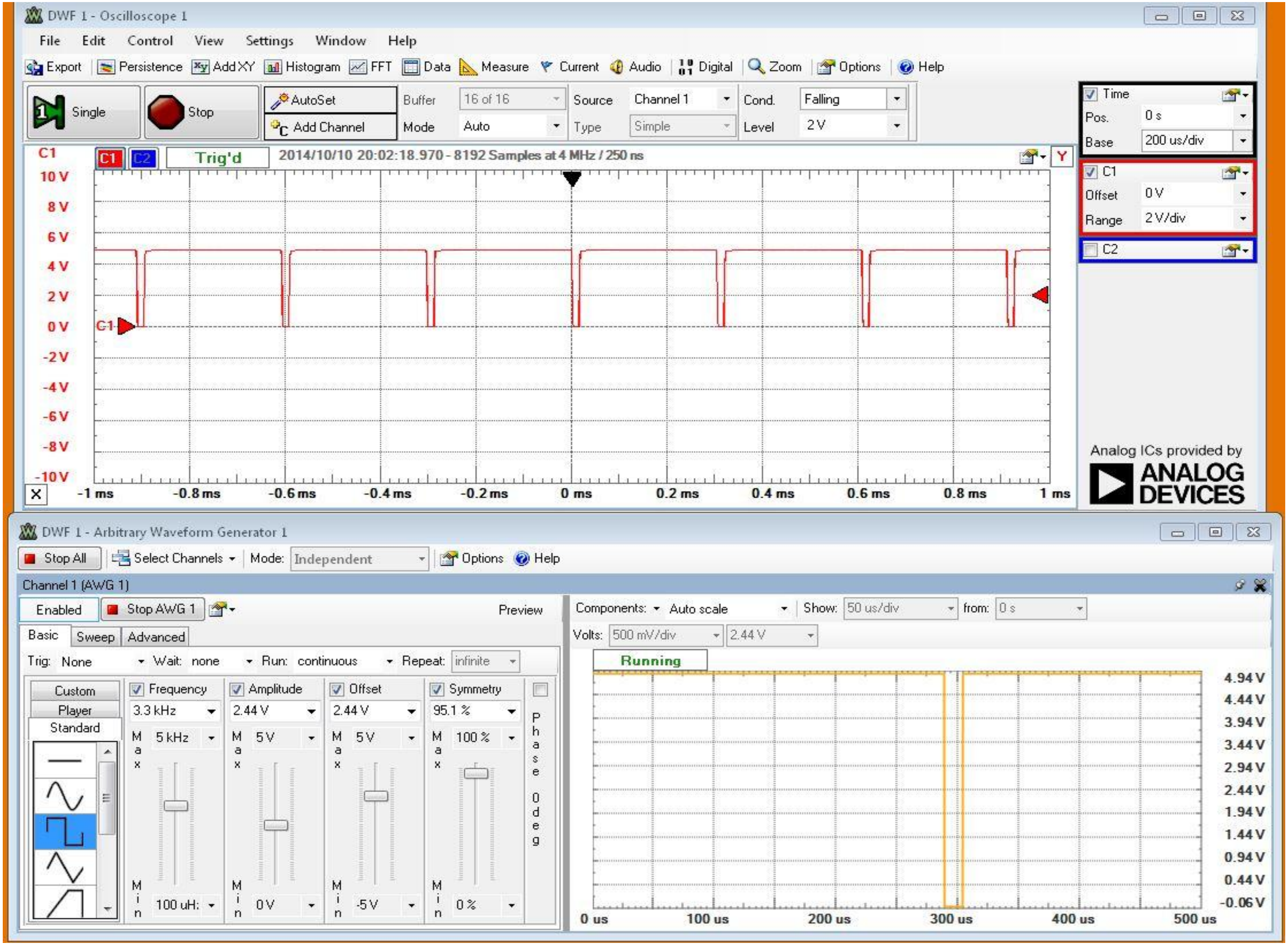
2 Channel Oscilloscope Window



Waveform Generator Window

1 Channel, AWG-1

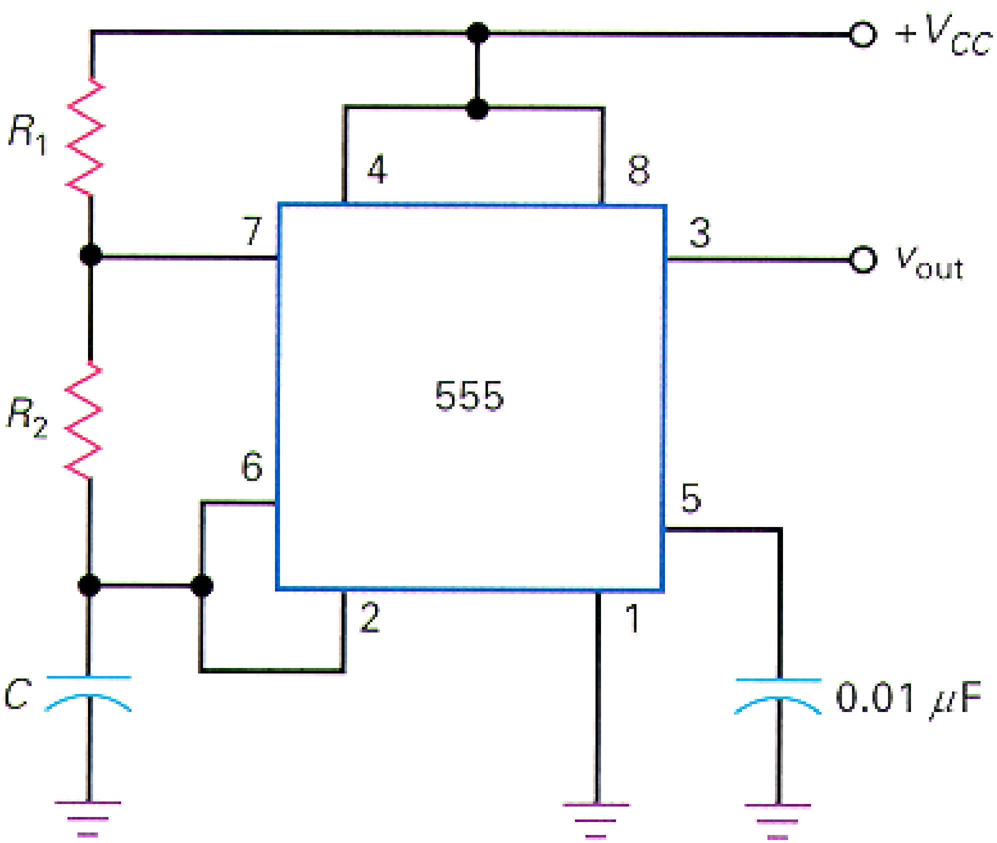



DWF 1 - Oscilloscope 1
File Edit Control View Settings Window Help
Export Persistence Add XY Histogram FFT Data Measure Current Audio Digital Zoom Options Help
Single
Stop
AutoSet
Add Channel
Buffer 16 of 16
Mode Auto
Source Channel 1
Type Simple
Cond. Falling
Level 2 V
Time
Pos. 0 s
Base 200 us/div
C1
Offset 0 V
Range 2 V/div
C2
Trig'd
2014/10/10 20:02:18.970 - 8192 Samples at 4 MHz / 250 ns
10 V
8 V
6 V
4 V
2 V
0 V
-2 V
-4 V
-6 V
-8 V
-10 V
-1 ms
-0.8 ms
-0.6 ms
-0.4 ms
-0.2 ms
0 ms
0.2 ms
0.4 ms
0.6 ms
0.8 ms
1 ms
Analog ICs provided by
ANALOG DEVICES
DWF 1 - Arbitrary Waveform Generator 1
Stop All
Select Channels
Mode: Independent
Options
Help
Channel 1 (AWG 1)
Enabled
Stop AWG 1
Preview
Basic Sweep Advanced
Trig: None
Wait: none
Run: continuous
Repeat: infinite
Custom
Player
Standard
Frequency 3.3 kHz
Max 5 kHz
Min 100 uHz
Amplitude 2.44 V
Max 5 V
Min 0 V
Offset 2.44 V
Max 5 V
Min -5 V
Symmetry 95.1 %
Max 100 %
Min 0 %
Phase 0 deg
Components: Auto scale
Show: 50 us/div
from: 0 s
Volts: 500 mV/div
2.44 V
Running
4.94 V
4.44 V
3.94 V
3.44 V
2.94 V
2.44 V
1.94 V
1.44 V
0.94 V
0.44 V
-0.06 V
0 us
100 us
200 us
300 us
400 us
500 us

DIY ASDE

- Take a 555 running a square wave out with 50 / 50% duty cycle
- Pass the sq. wave through an integrator circuit, need offset on op-amp if using single voltage source, LM324 op-amp.
- Pass integrated triangular wave through op-amp shaping circuit = sine wave, offset also required with single voltage supply

Astable Operation (free-run)



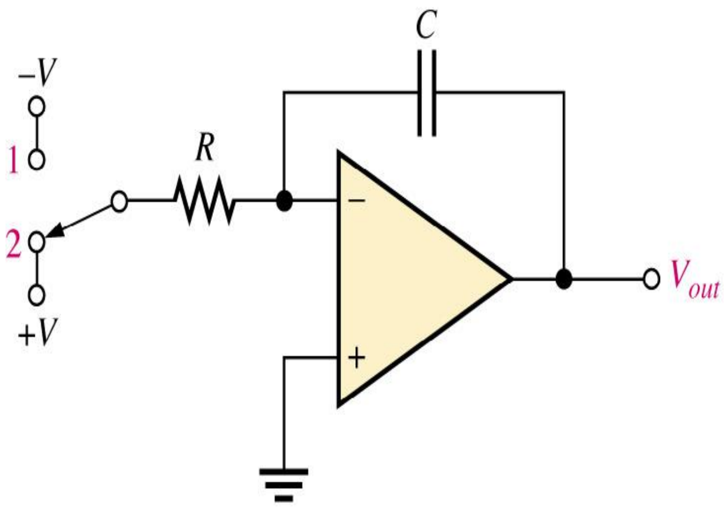
$$W = 0.693(R_1 + R_2)C$$

$$T = 0.693(R_1 + 2R_2)C$$

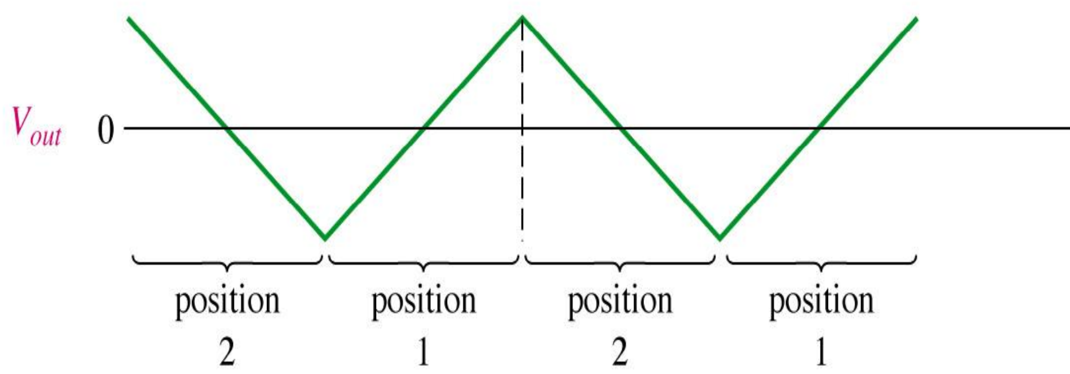
$$f = \frac{1.44}{(R_1 + 2R_2)C}$$

$$D = \frac{R_1 + R_2}{R_1 + 2R_2}$$

Basic triangular-wave generator.

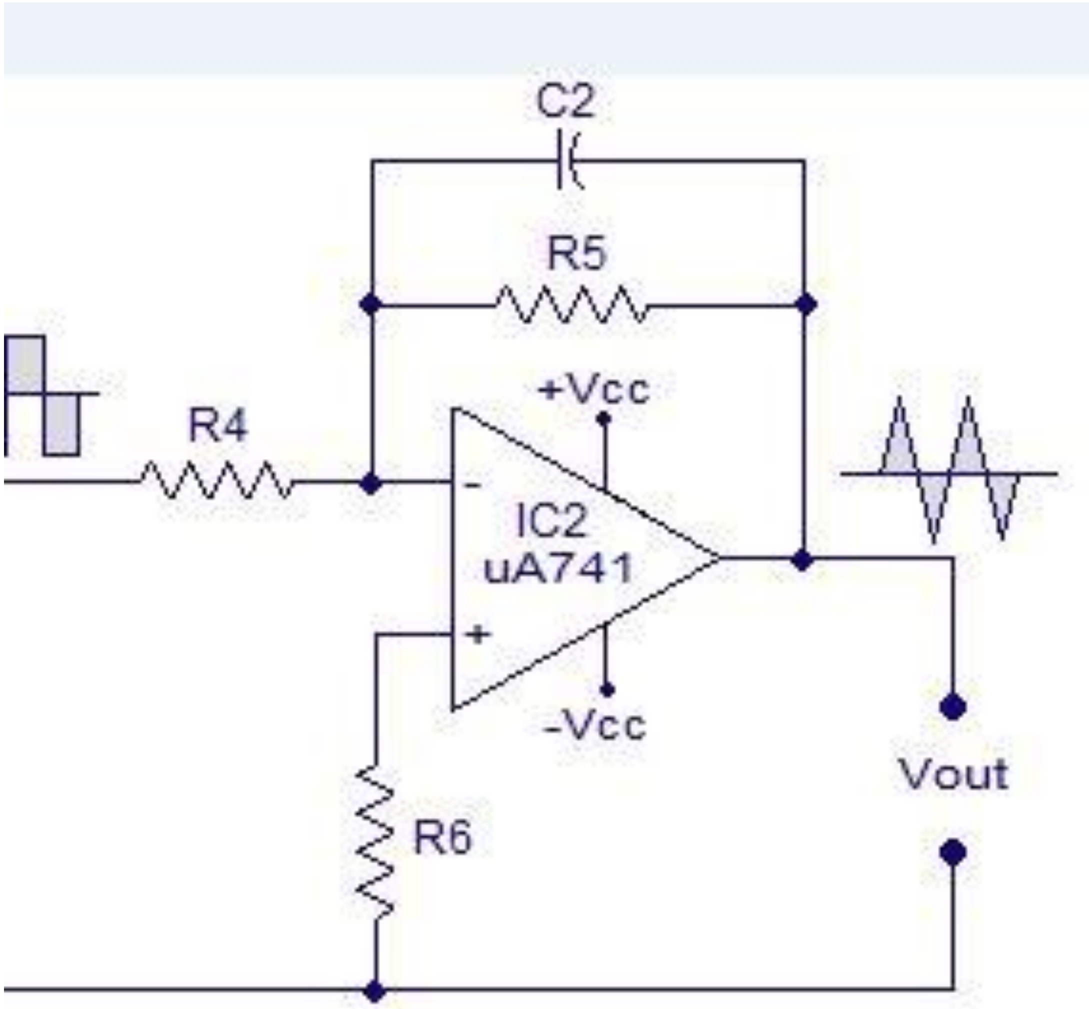


(a)



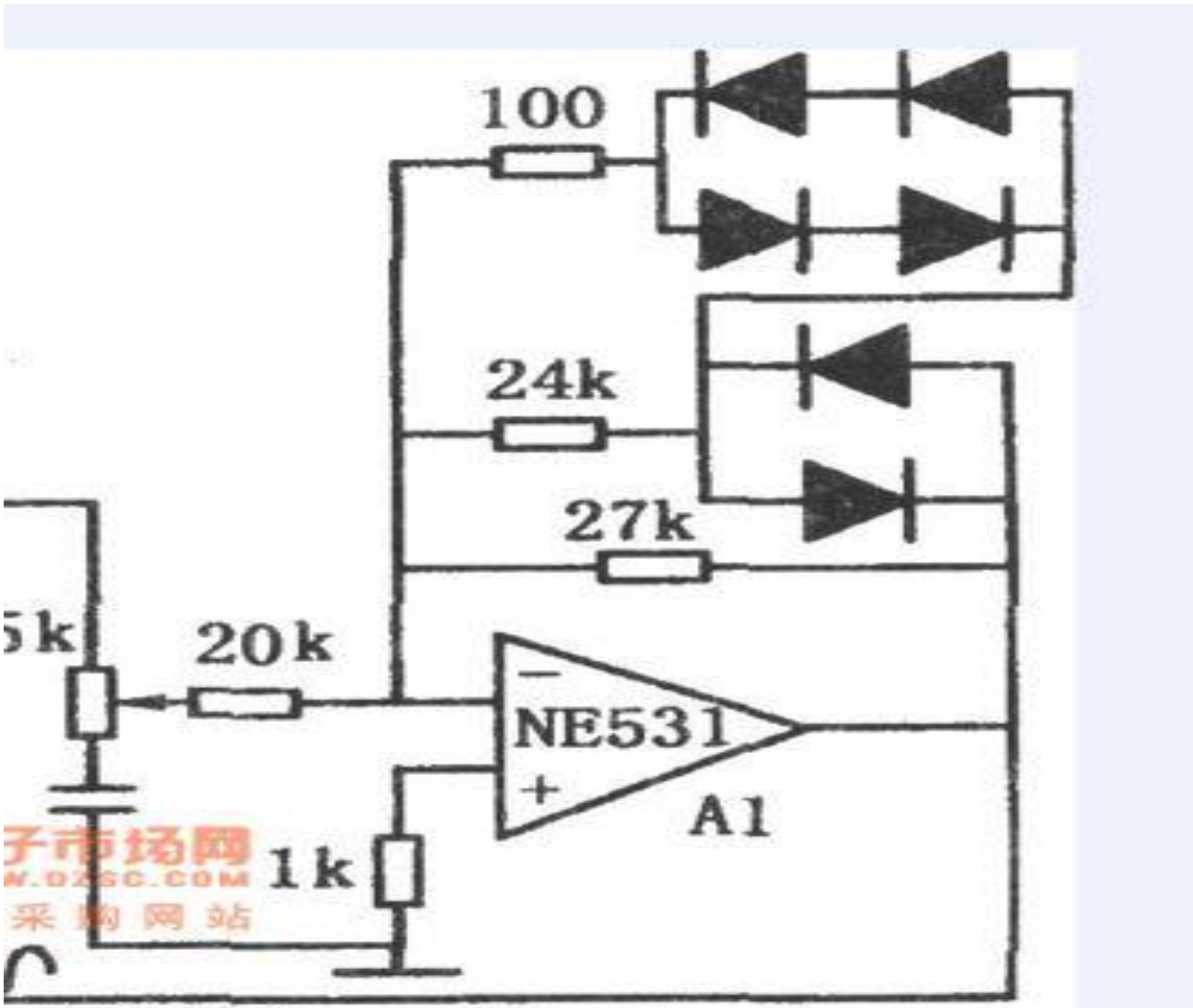
(b) Output voltage as the switch is thrown back and forth at regular intervals

Square wave to triangular wave



DIY

Triangular wave to Sine wave



DIY

Let the ***Fun*** *&* ***Learning Begin***