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SCIENCES

Oscillators , Timers
&
Analog Discovery Kit

Harald **Bluetooth** (910 -985)

unifying the various Danish tribes into one Danish kingdom around 970

The name Bluetooth wasn't originally necessarily meant to be the final name of the wireless standard. When they first named it thus, it was just a code name for the technology. It ultimately ended up sticking though and became the official name of the standard.

- the wireless Bluetooth standard was developed to be ultra low power and short range
- a maximum range of around 30 feet.
- using short-wavelength in the ISM band from 2.4 to 2.485 GHz
- Nearly 95% of all mobile phones have Bluetooth capabilities.
- The Bluetooth logo is a merging the (Hagell) (ᚼ) and (Bjarkan) (ᛒ), Harald's initials.

- Bluetooth operates in the range of 2400–2483.5 MHz This is in the globally unlicensed Industrial, Scientific and Medical (ISM) 2.4 GHz short-range radio frequency band. Bluetooth uses a radio technology called Frequency-Hopping Spread Spectrum. The transmitted data are divided into packets and each packet is transmitted on one of the 79 designated Bluetooth channels. Each channel has a bandwidth of 1 MHz. Bluetooth 4.0 uses 2 MHz spacing which allows for 40 channels. The first channel starts at 2402 MHz and continues up to 2480 MHz in 1 MHz steps. It usually performs 1600 hops per second, with Adaptive Frequency-Hopping (AFH) enabled.

VISHNU UNIVERSAL LEARNING

SVES Sri Vishnu Educational Society ESTD 1992

ENGINEERING SCIENCES

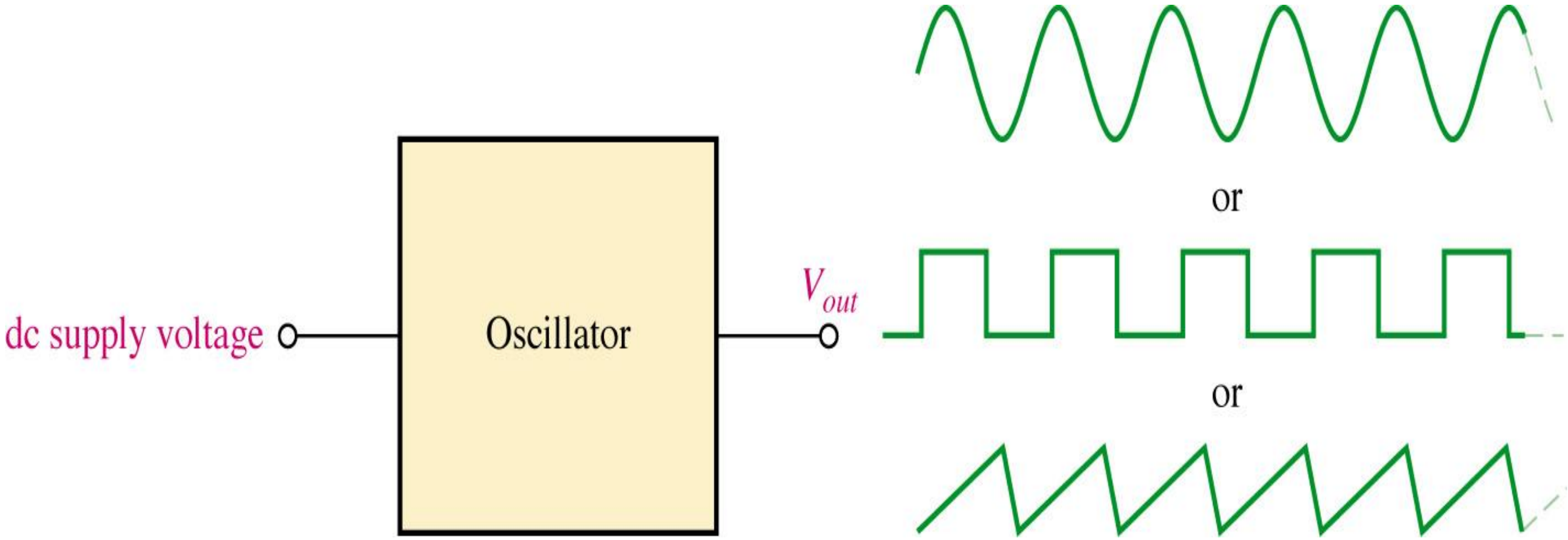
in partnership with

Mr. Alan Rux - University of Massachusetts

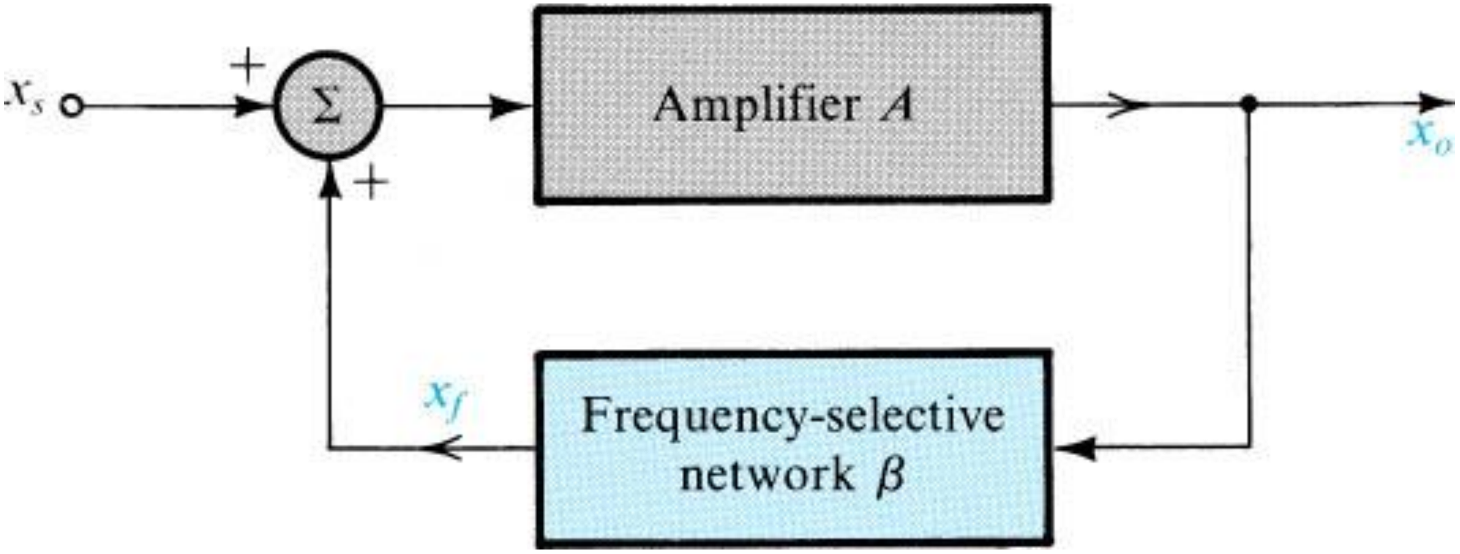
presents

Oscillators , Timers & Analog Discovery Kit

The **basic oscillator** concept showing three common types of **output waveforms**.

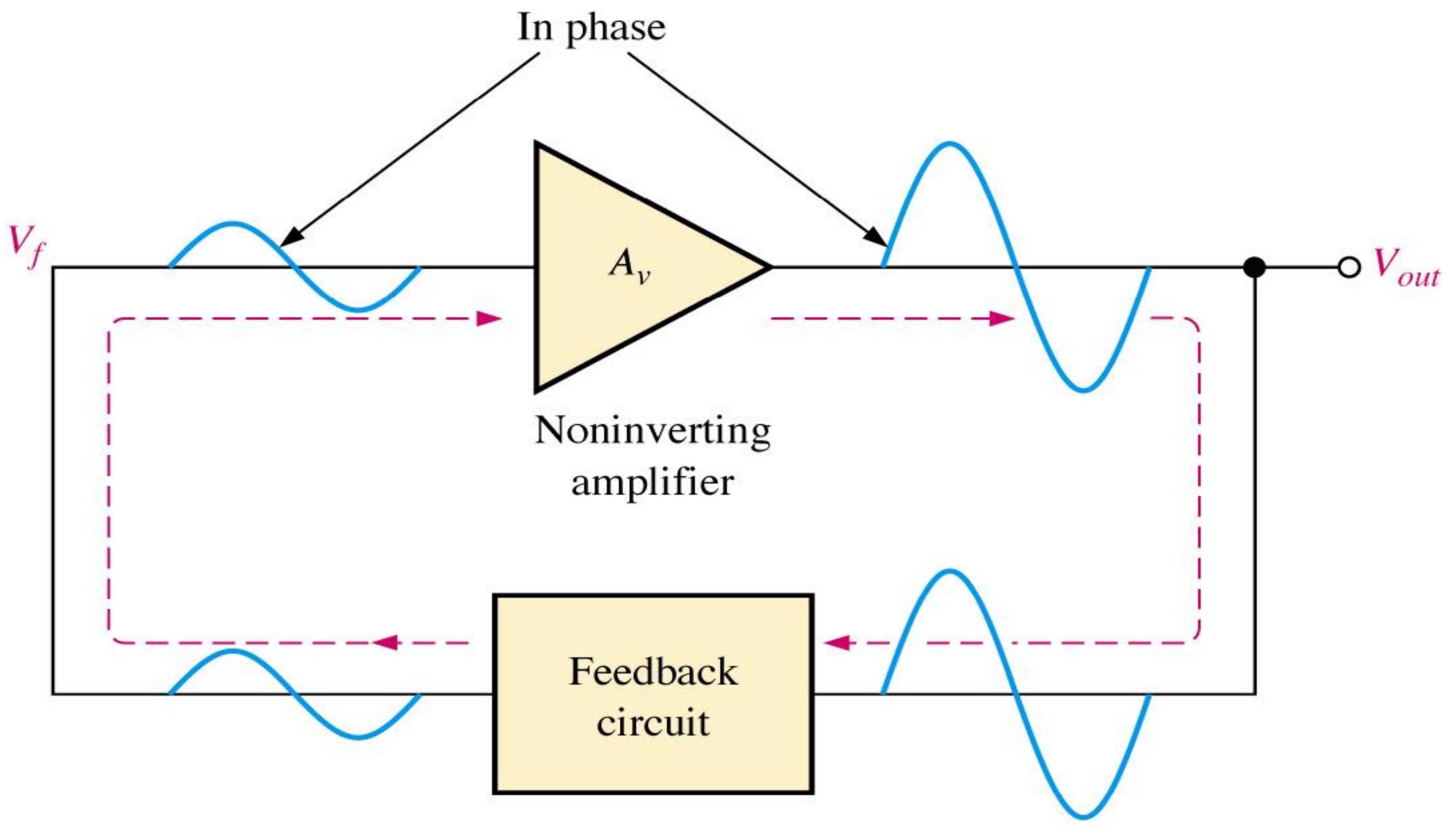


The basic structure of oscillator. a **positive-feedback loop** is formed by an amplifier and a frequency-selective network. In an actual oscillator circuit, no input signal will be present; here an input signal x_s is employed to help explain the principle of operation.



Feedback Oscillator Principles

Positive feedback produces oscillation. The feedback loop is indicated by the dashed arrows.

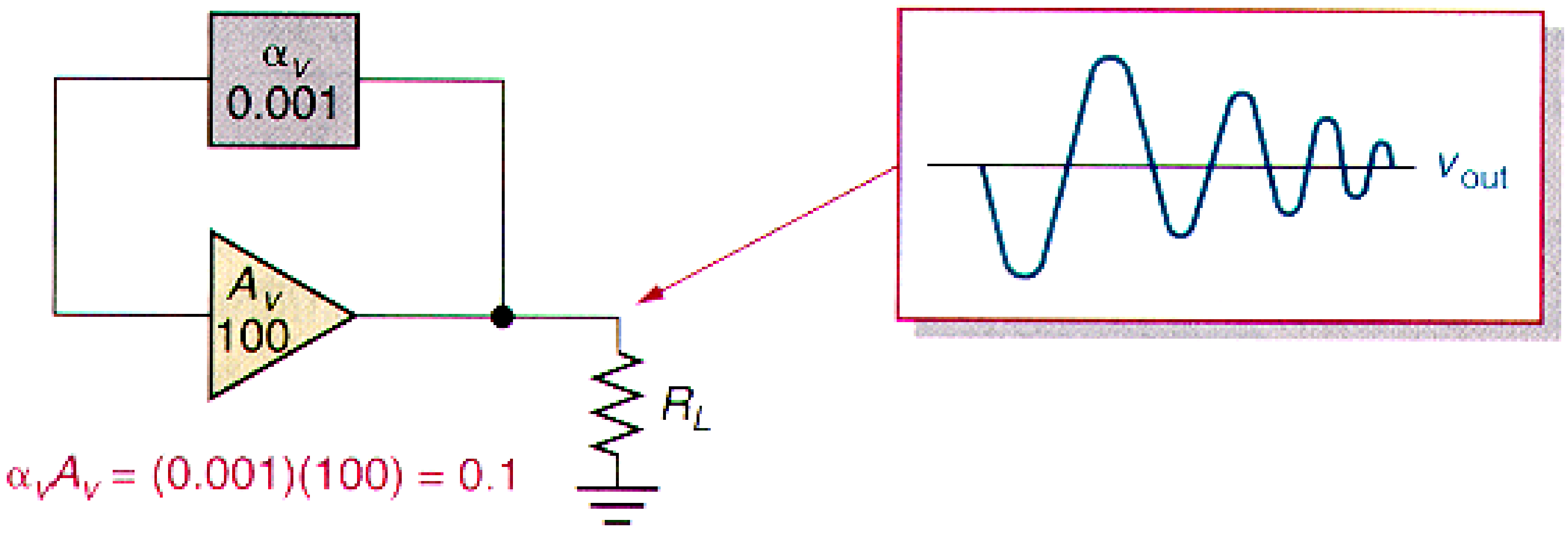


Barkhausen Criterion

- The relationship between the circuit feedback factor required and voltage gain required for proper operation

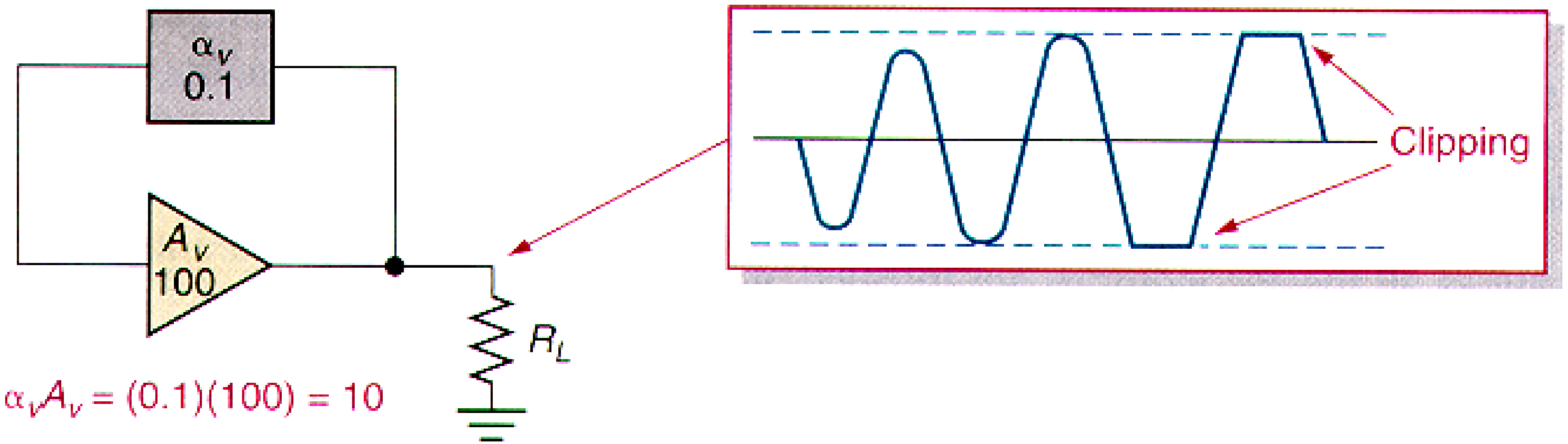
- Feedback voltage from the feedback network *times* the amplification of the amplifier must equal **1** (one)

Barkhausen Criterion



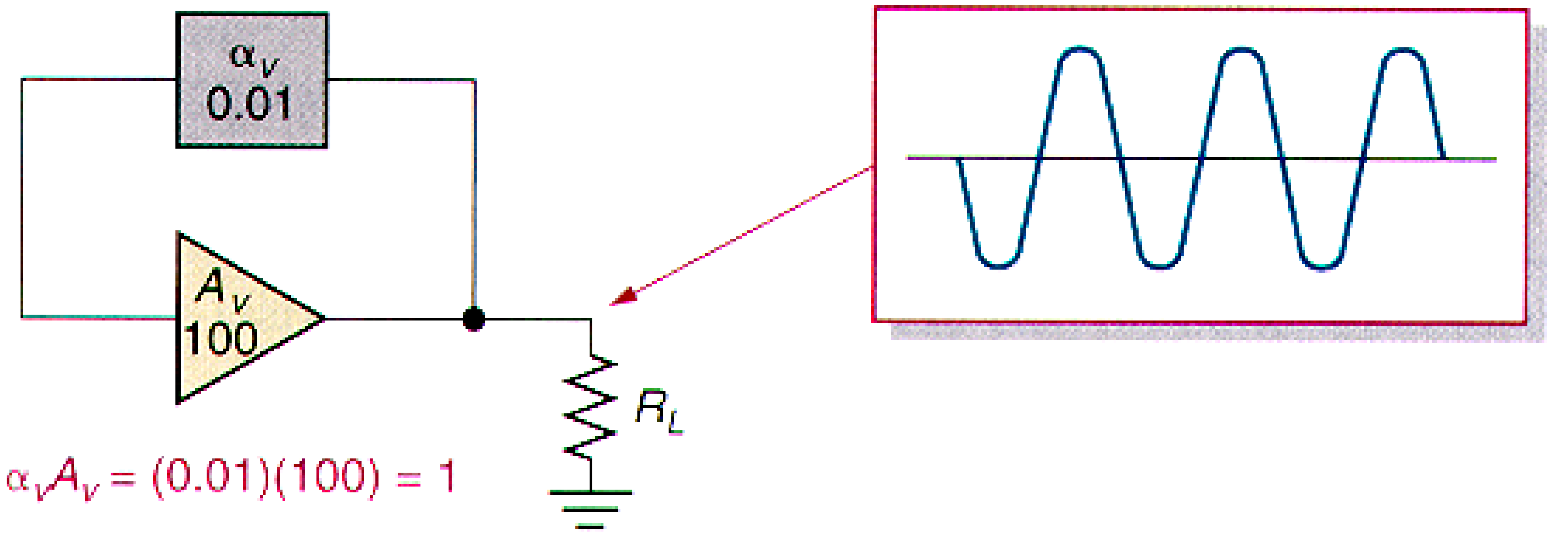
(a) The output fades out when $\alpha_v A_v < 1$.

Barkhausen Criterion



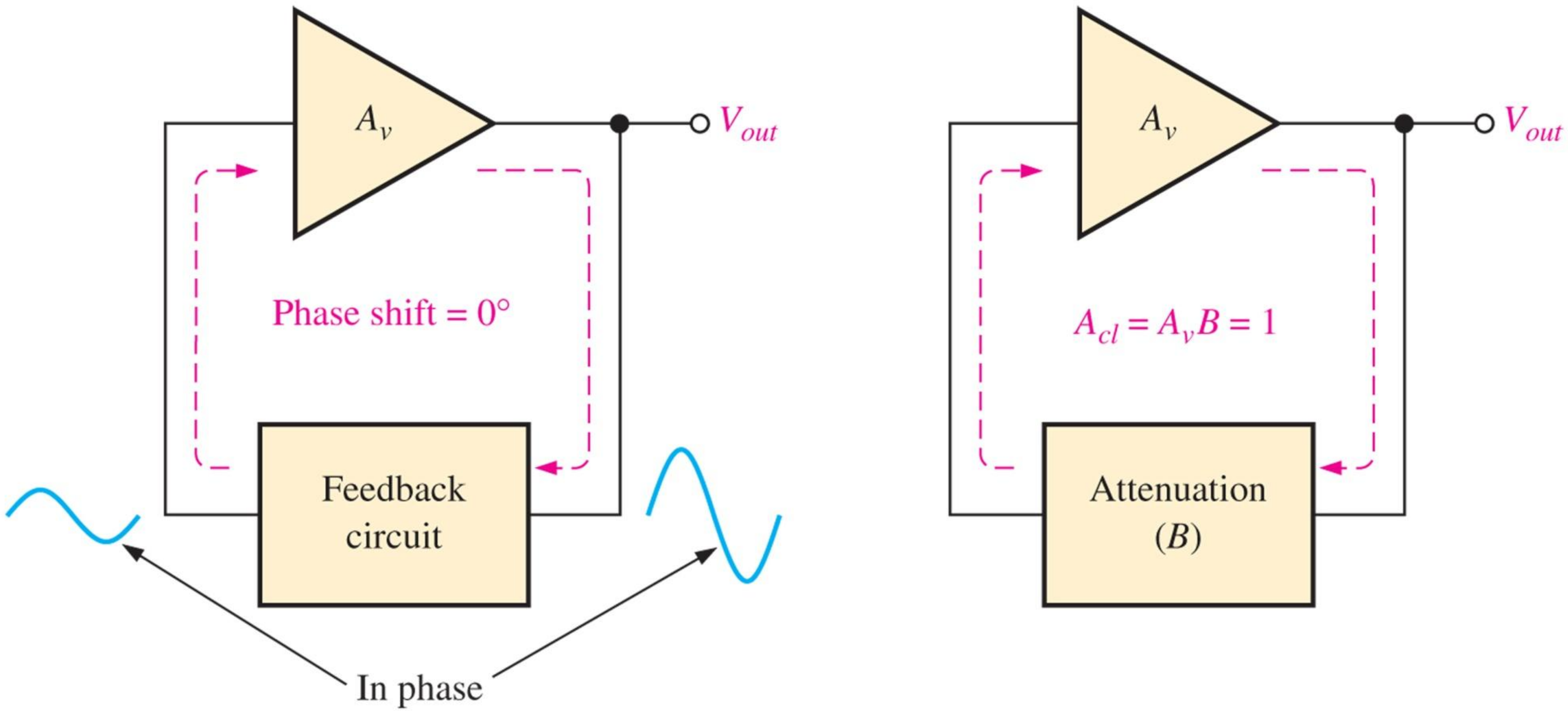
(b) The output is driven into clipping when $\alpha_v A_v > 1$.

Barkhausen Criterion



(c) A constant-amplitude output is produced when $\alpha_v A_v = 1$.

Conditions for oscillation.

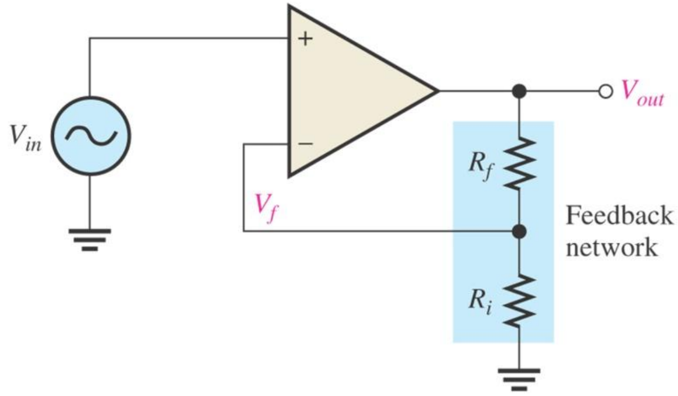


(a) The phase shift around the loop is 0°.

(b) The closed loop gain is 1.

Review - Op-amp Configurations with Negative Feedback

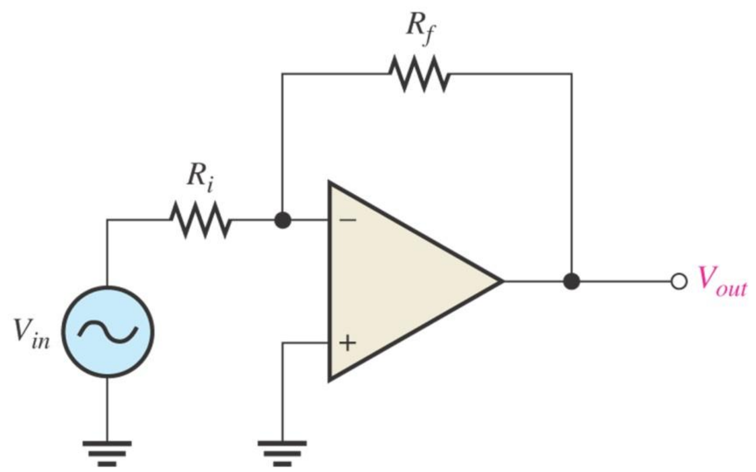
- An op-amp connected as a **non-inverting** amplifier has the input signal applied to the noninverting input, and a portion of the output applied back to the inverting input through the feedback network



Review - Op-AMP Configurations with Negative Feedback

- An op-amp connected as an **inverting** amplifier
  - Closed-loop gain is:

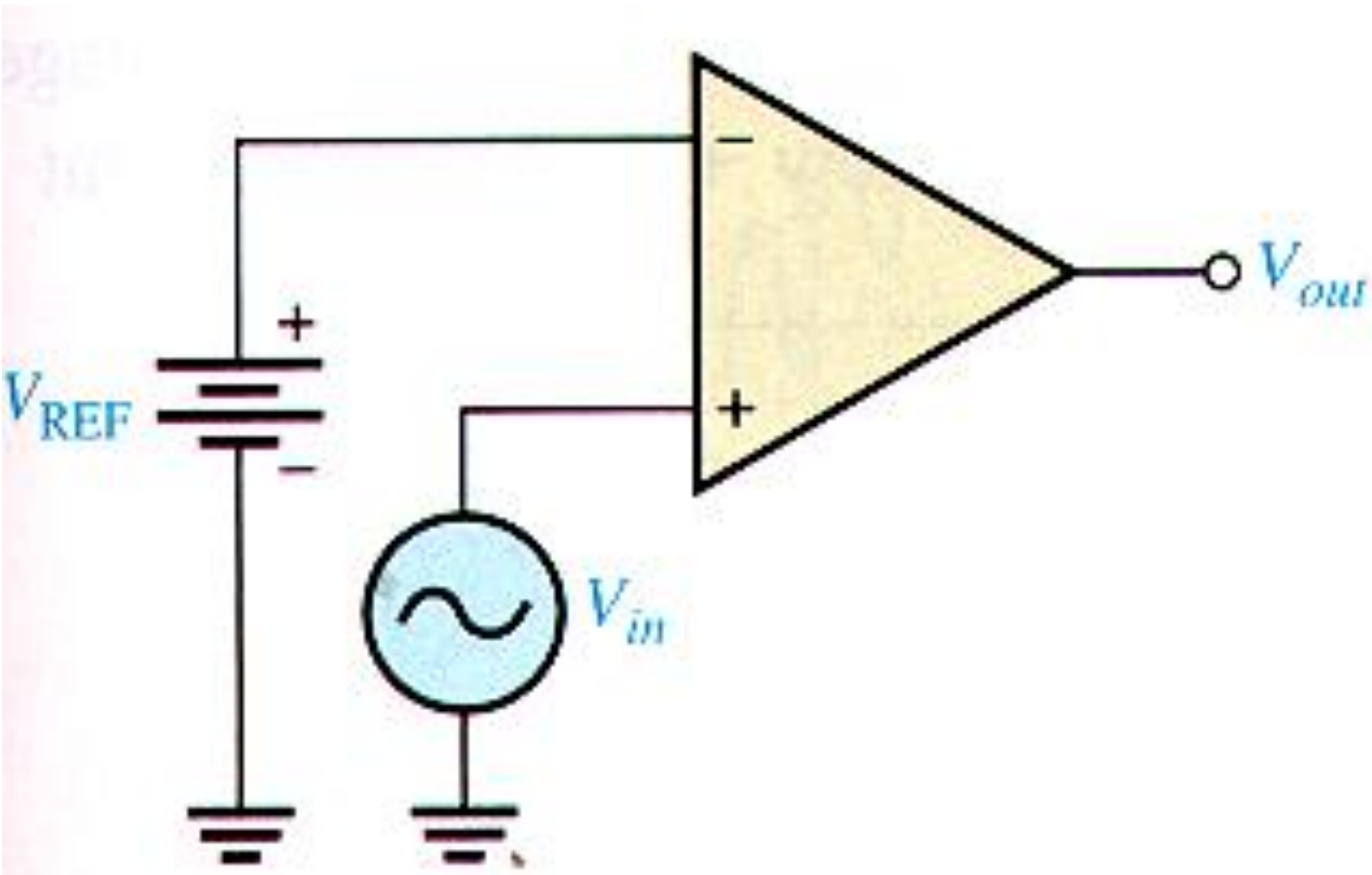
    $A_{cl(I)} = - R_f / R_i$
  - Closed-loop gain is independent of the op-amp's internal open-loop gain



Review - Comparators

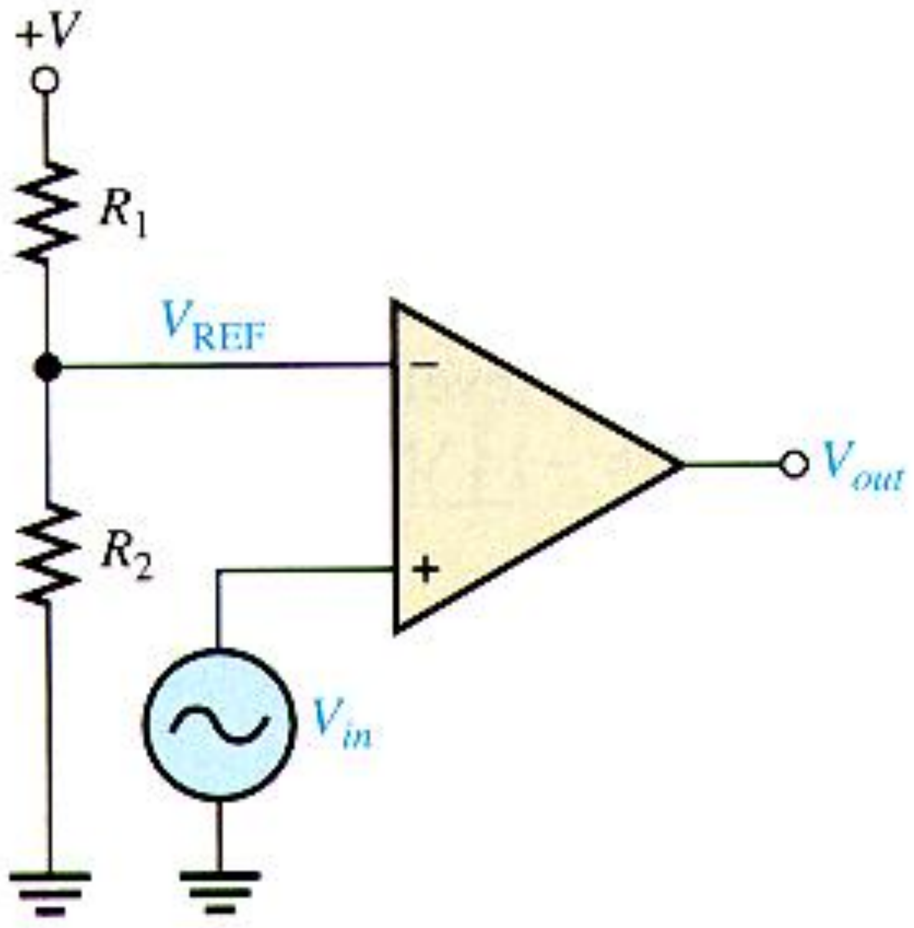
- One application of the op-amp used as a ***comparator*** is to determine when an input voltage exceeds a certain level
  - The inverting input is tied to a reference voltage (the reference voltage may be ground, or a voltage level), and the signal is applied to the non-inverting input
  - Because of the high open-loop gain, a very small difference voltage between the two inputs drives the amplifier into saturation, causing the output voltage to go to its limit

Review - Comparators
reference & input signal

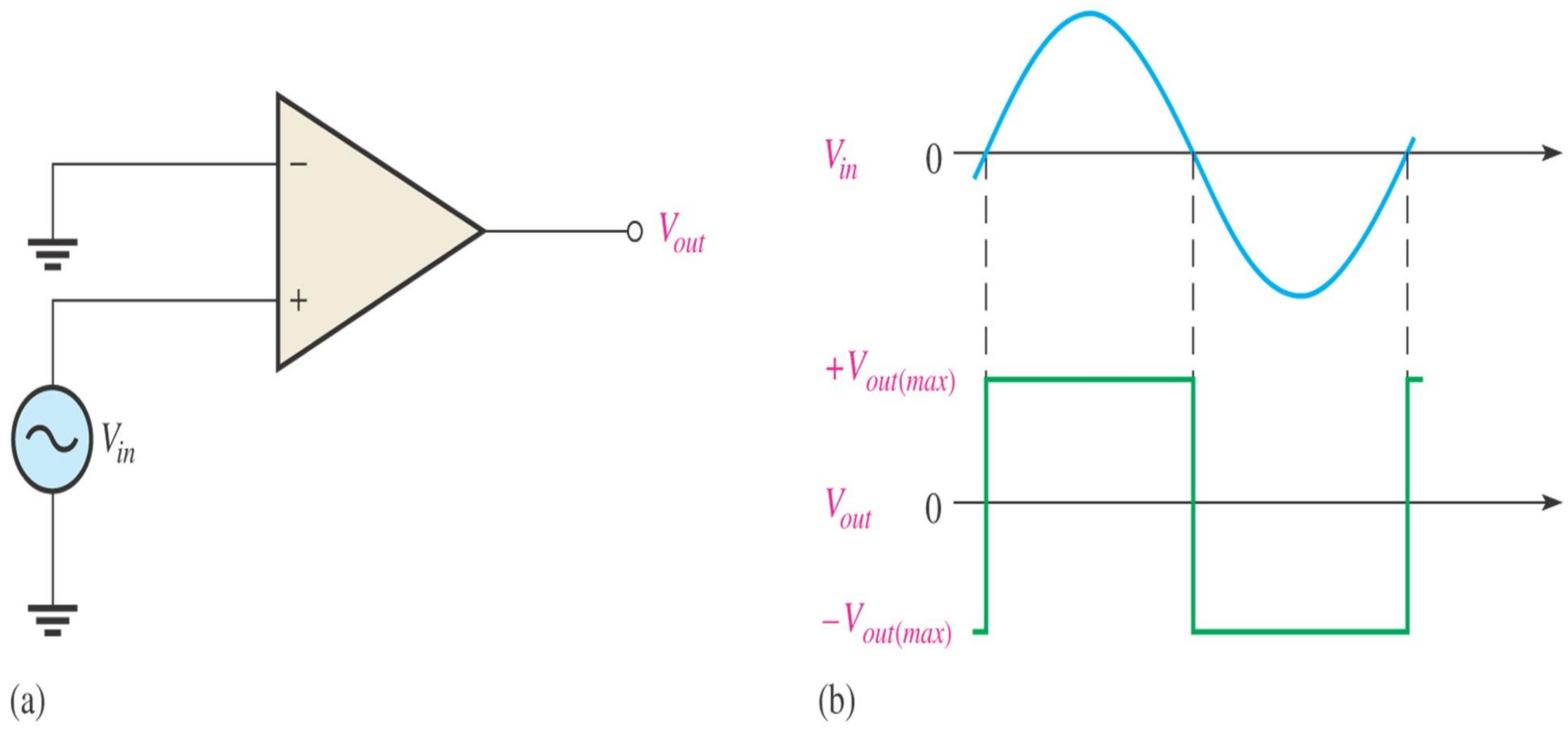


Review - **Comparators**

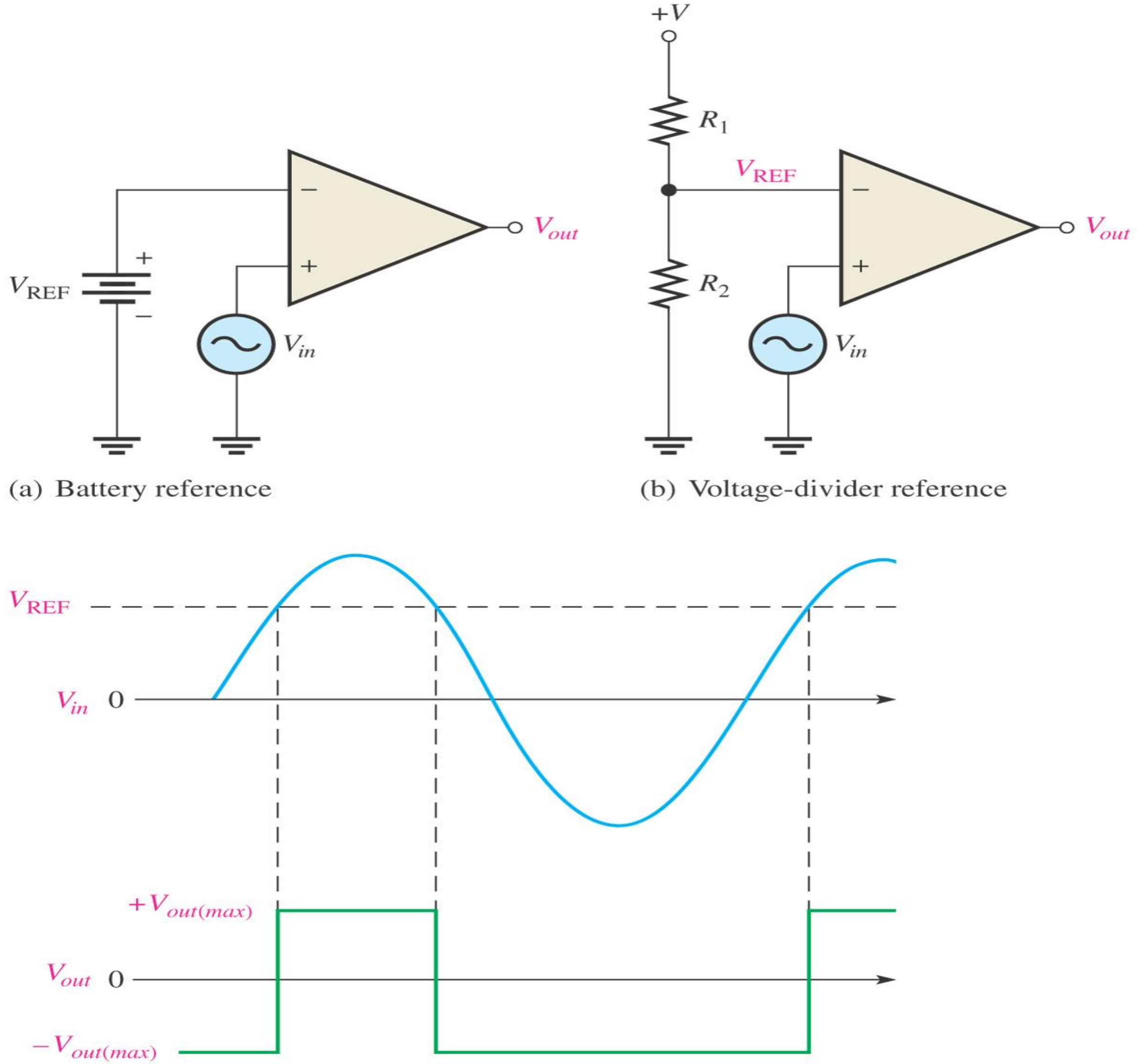
voltage divider reference & input signal



Review - The op-amp as a **zero-level detector**.



Review - Non-zero-level detectors

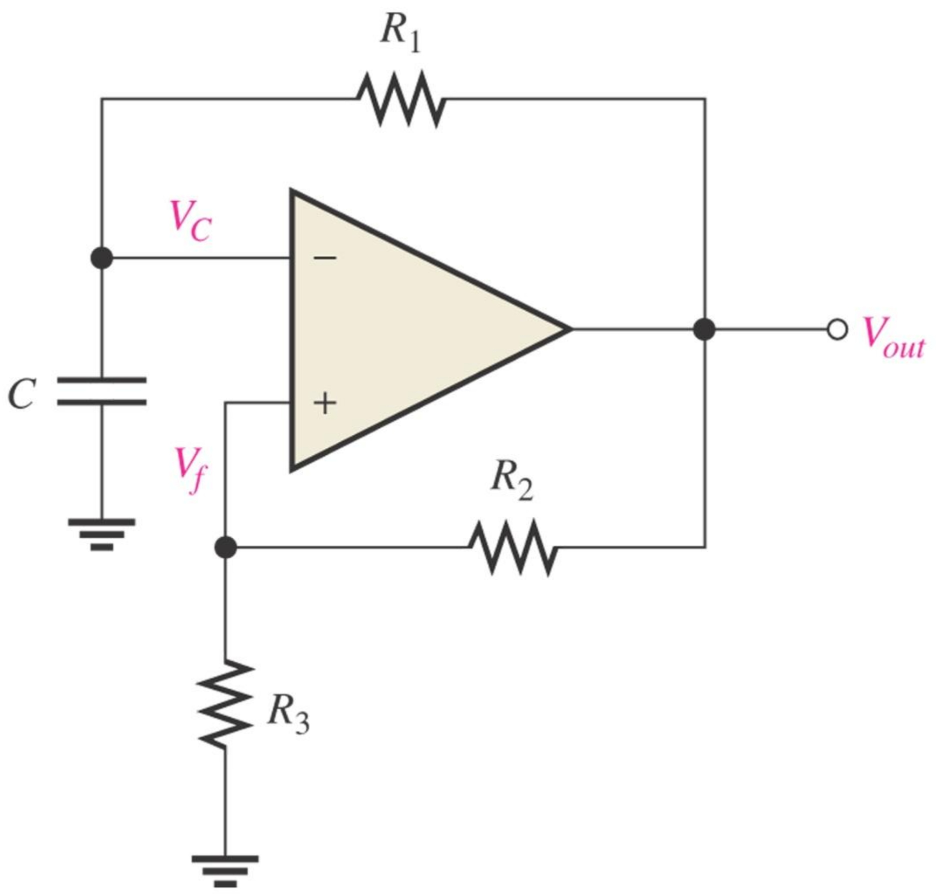


(a) Battery reference (b) Voltage-divider reference

(c) Waveforms

Square Wave Oscillators

- The basic square-wave oscillator shown is a type of **"relaxation oscillator"** because its operation is based on the charging and discharging of a capacitor



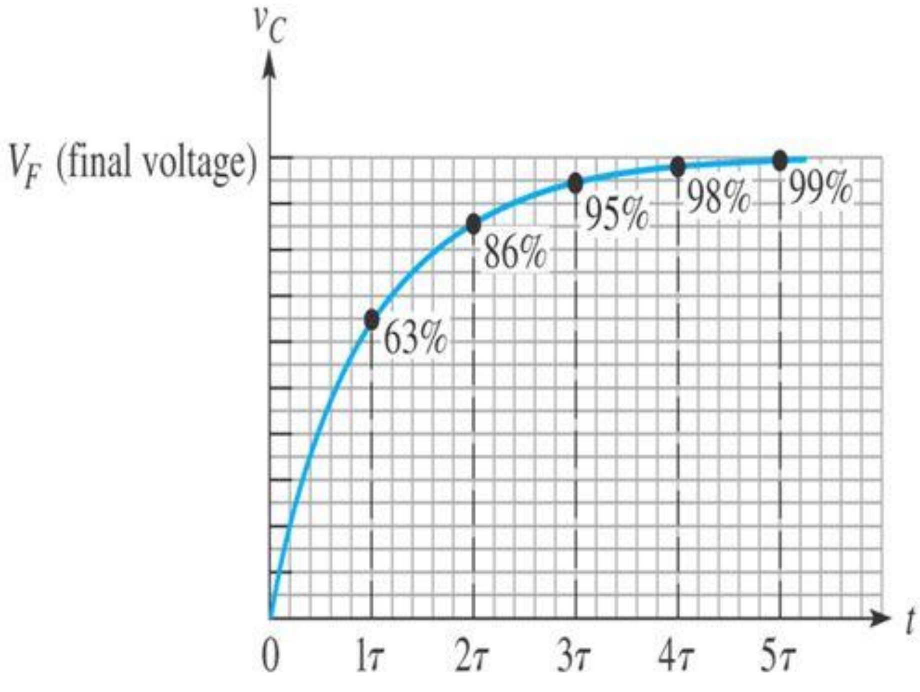
Review RC Time Constant

- The voltage across a capacitor cannot change instantaneously because a finite time is required to move charge from one point to another (limited by circuit resistance)
- The time constant of a series RC circuit is a time interval that equals the product of the resistance and the capacitance

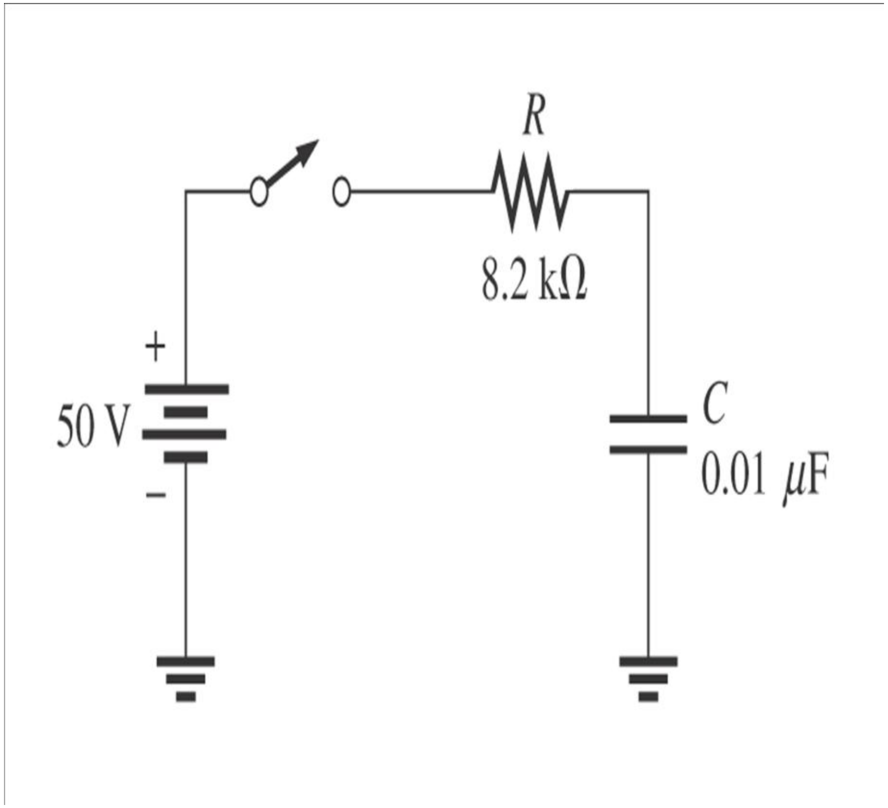
$$\boldsymbol{\tau = RC}$$

Review Charging a Capacitor

capacitor voltage in an *RC* circuit

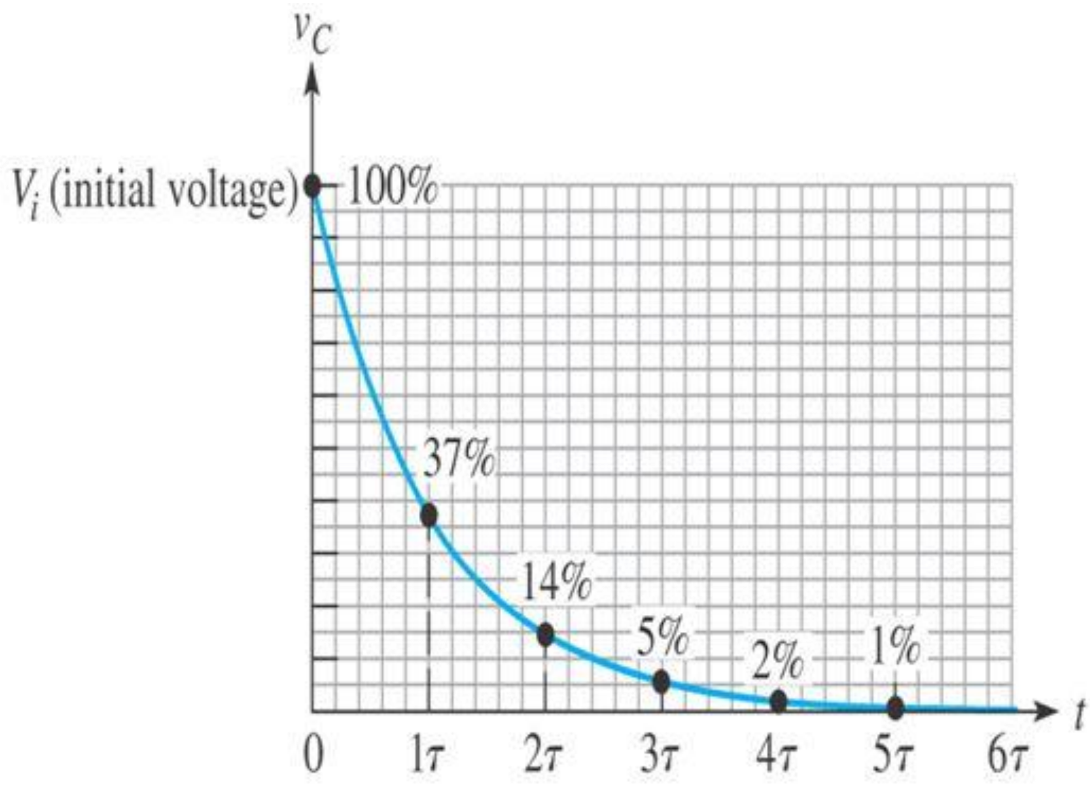


(a) Charging curve with percentages of final voltage

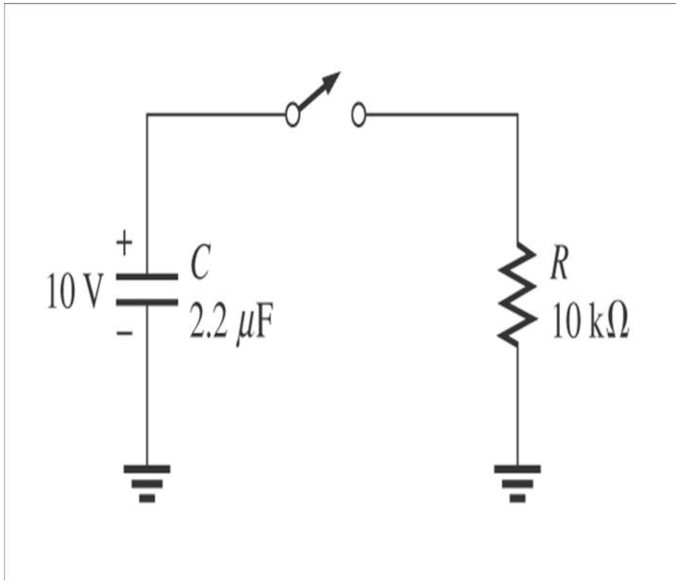


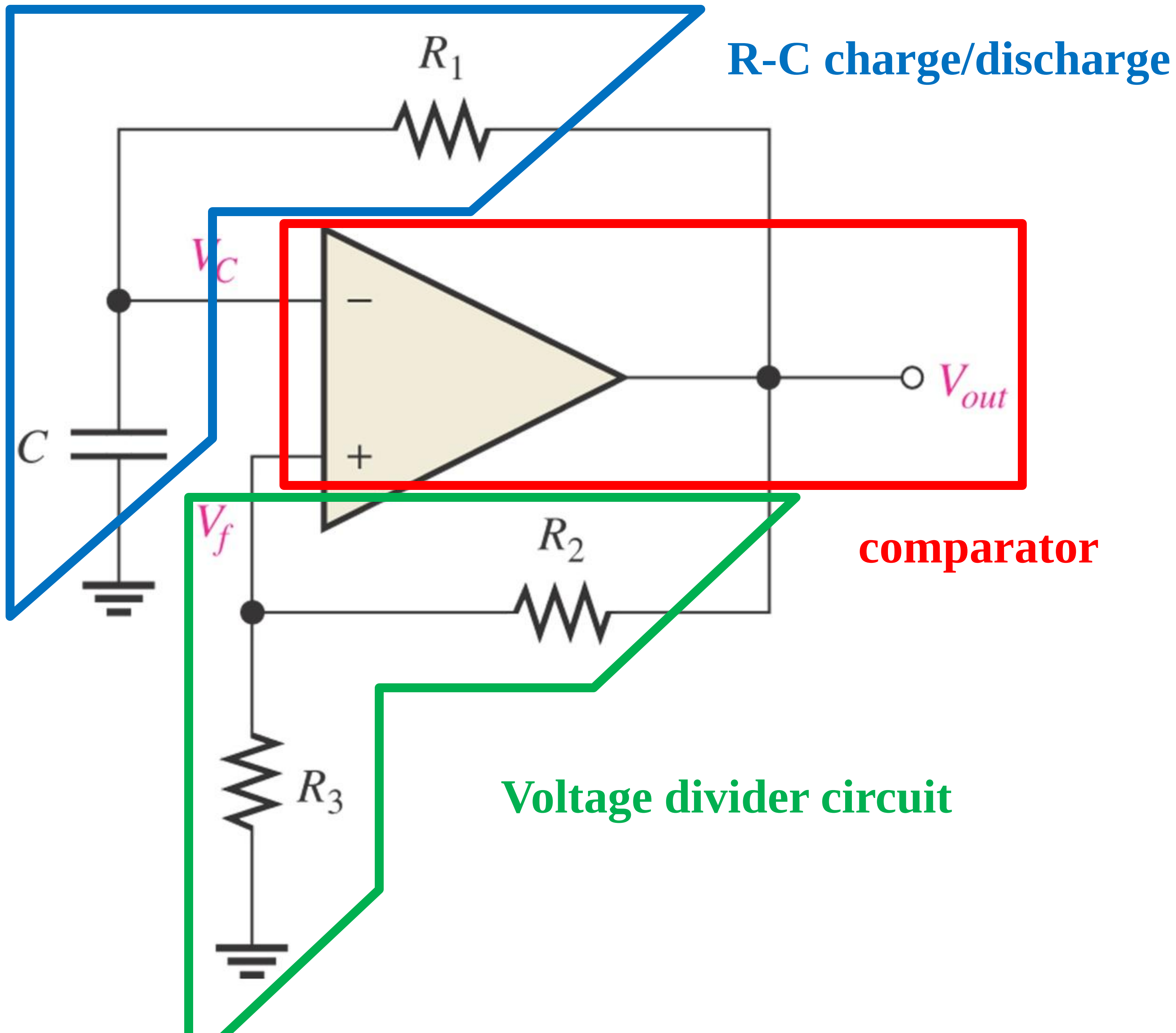
Review Discharging a Capacitor

capacitor voltage in an *RC* circuit



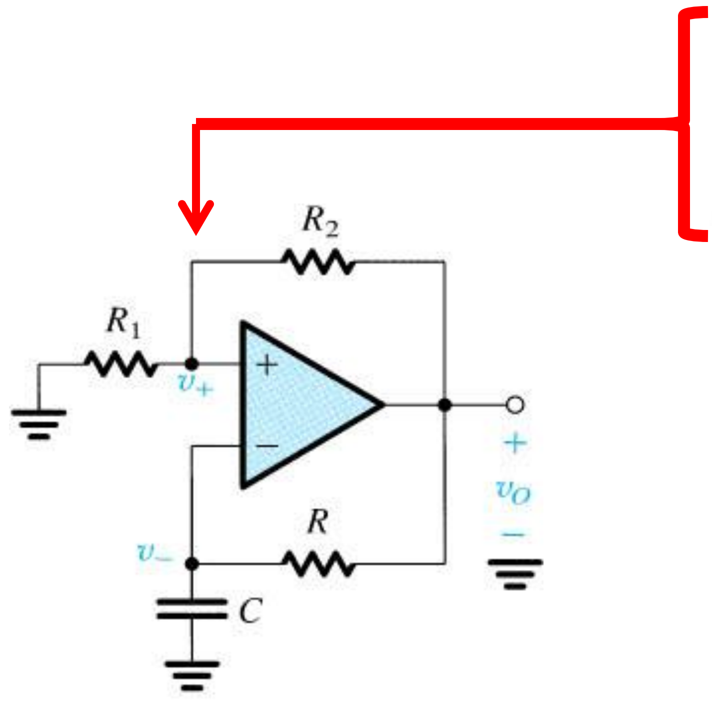
(b) Discharging curve with percentages of initial voltage



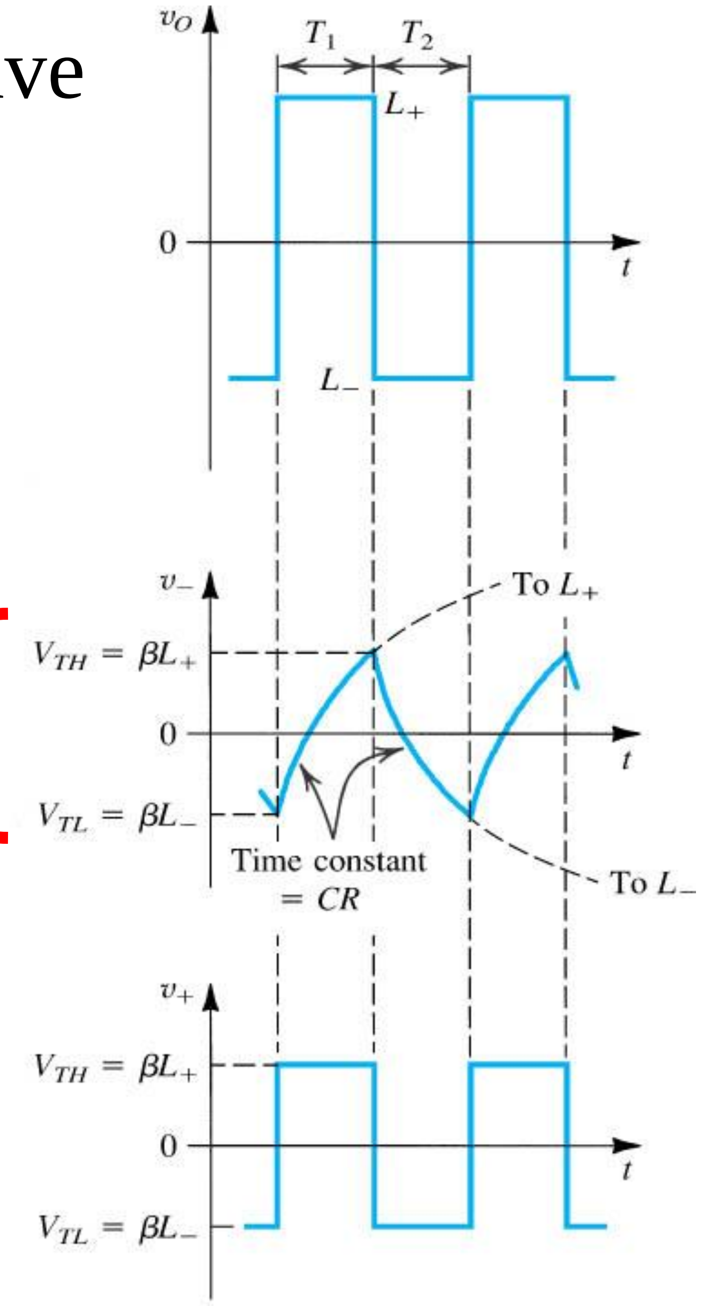


R-C charge/discharge
R_1
V_C
C
V_{out}
comparator
V_f
R_2
R_3
Voltage divider circuit

Waveforms for the square-wave relaxation oscillator



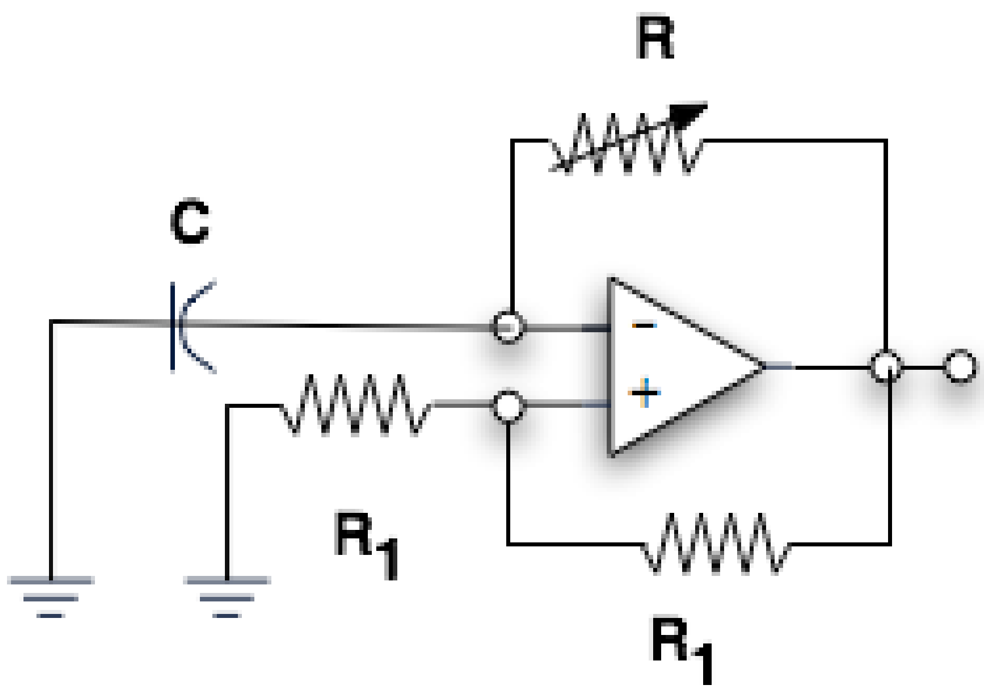
(b)



(c)

R1 = R1 some value between 1k to 1 meg ohms

F = 1 / 2RC , R some value 1k to 1 meg ohms

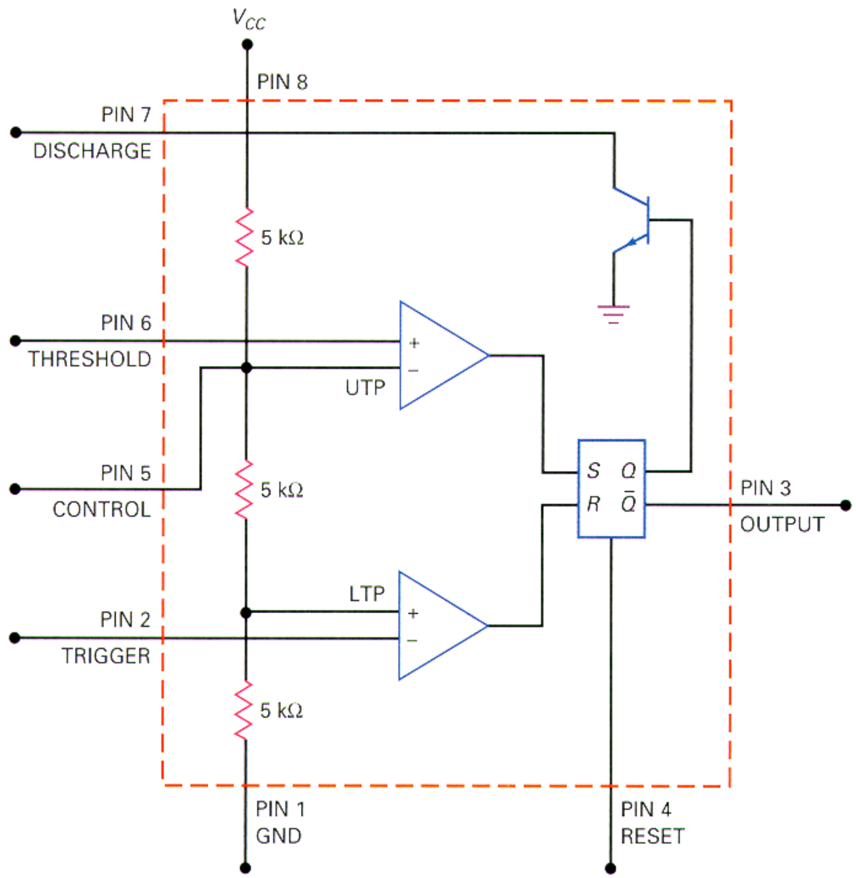


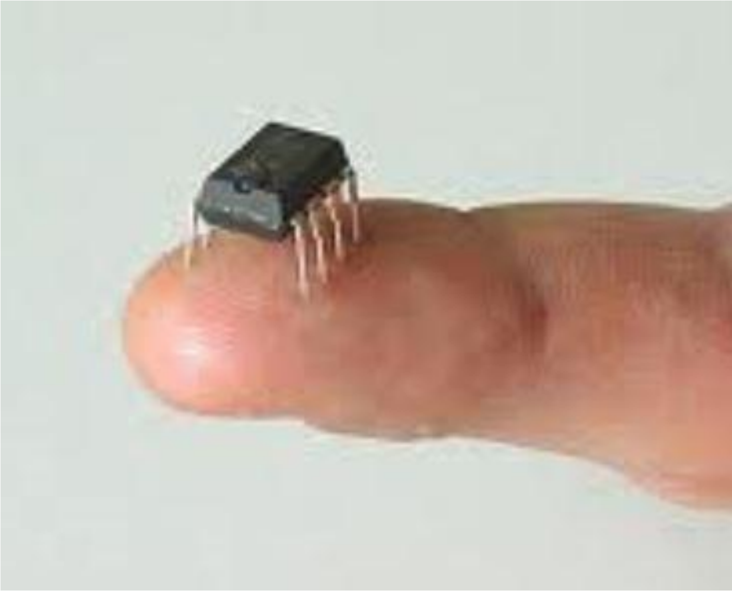
Remember op-amps require power, not shown in this slide.

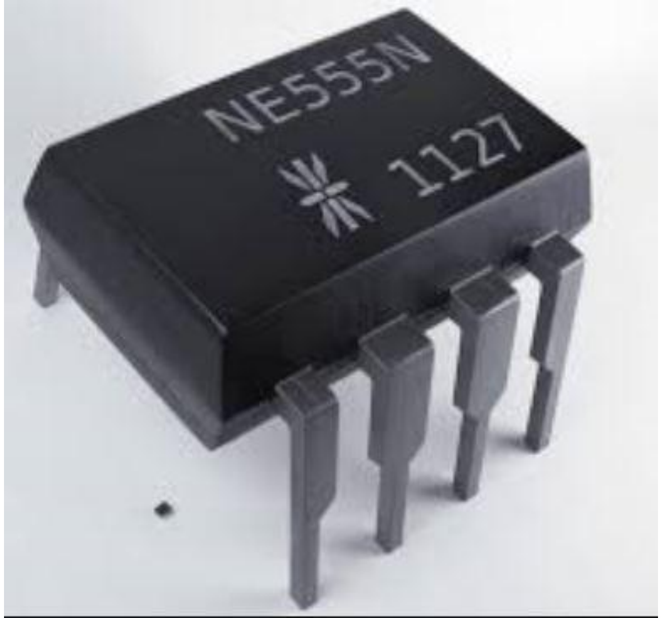
555 Timer

The LM555 is a highly stable device for generating accurate time delays or oscillation. Additional terminals are provided for triggering or resetting if desired.

555 Timer


V_{CC}
PIN 8
PIN 7
DISCHARGE
5 kΩ
PIN 6
THRESHOLD
UTP
PIN 5
CONTROL
5 kΩ
LTP
PIN 2
TRIGGER
5 kΩ
S
Q
R
$\bar{Q}$
PIN 3
OUTPUT
PIN 1
GND
PIN 4
RESET

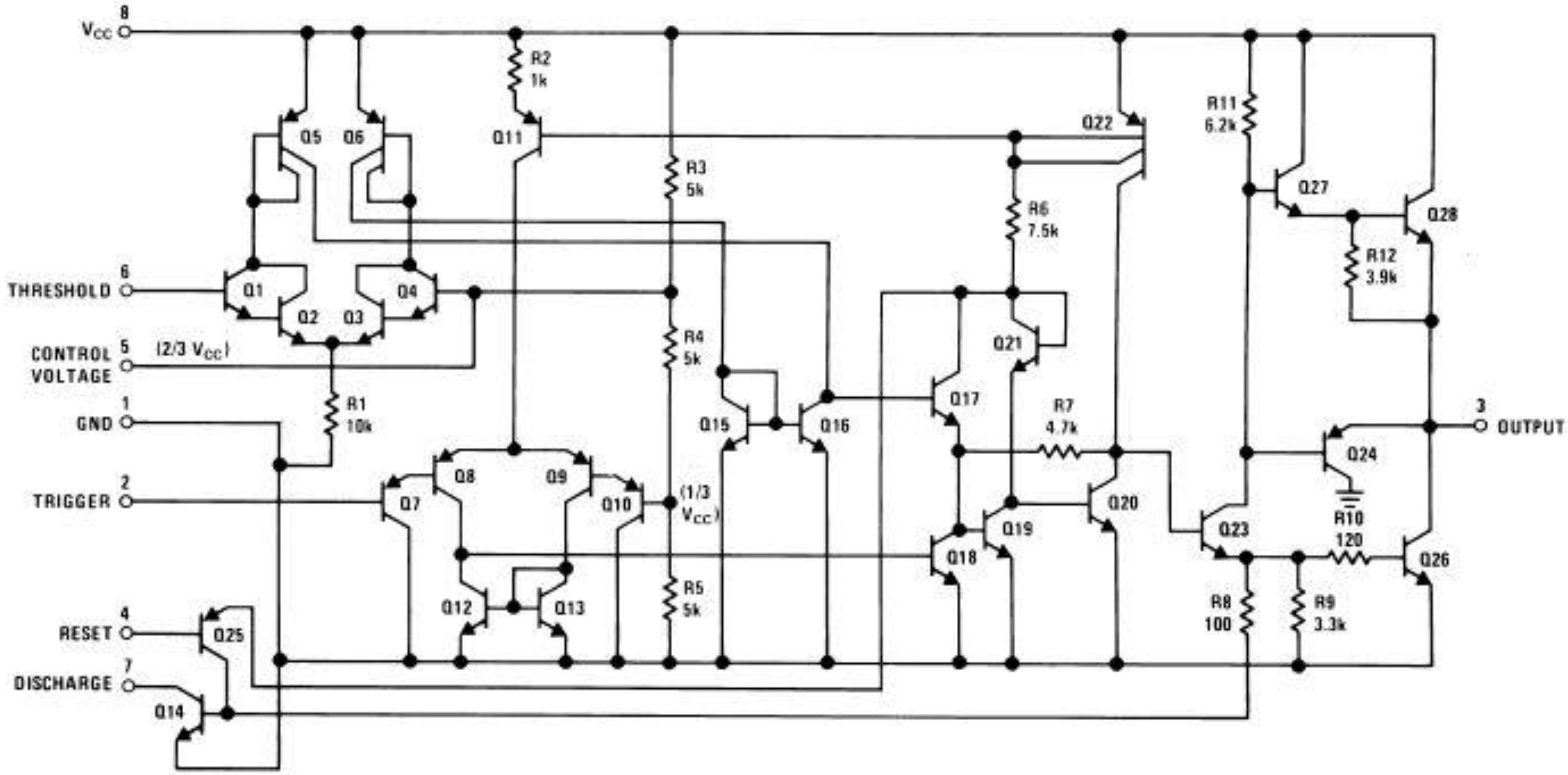



NE555N
1127

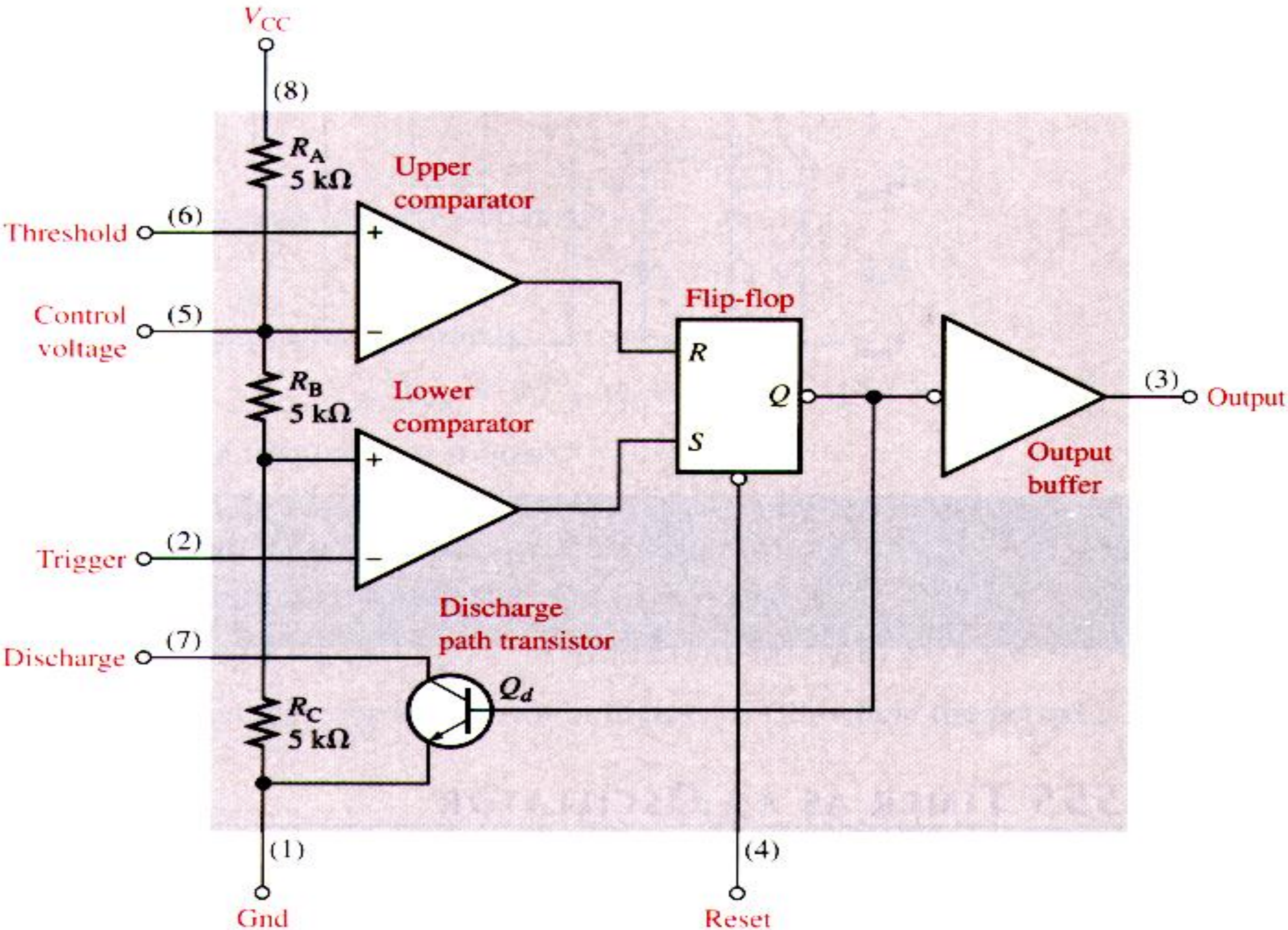
LM 555 timer data sheet

- **http://www.ti.com/lit/ds/symlink/lm555.pdf**

Schematic Diagram



555 Timer



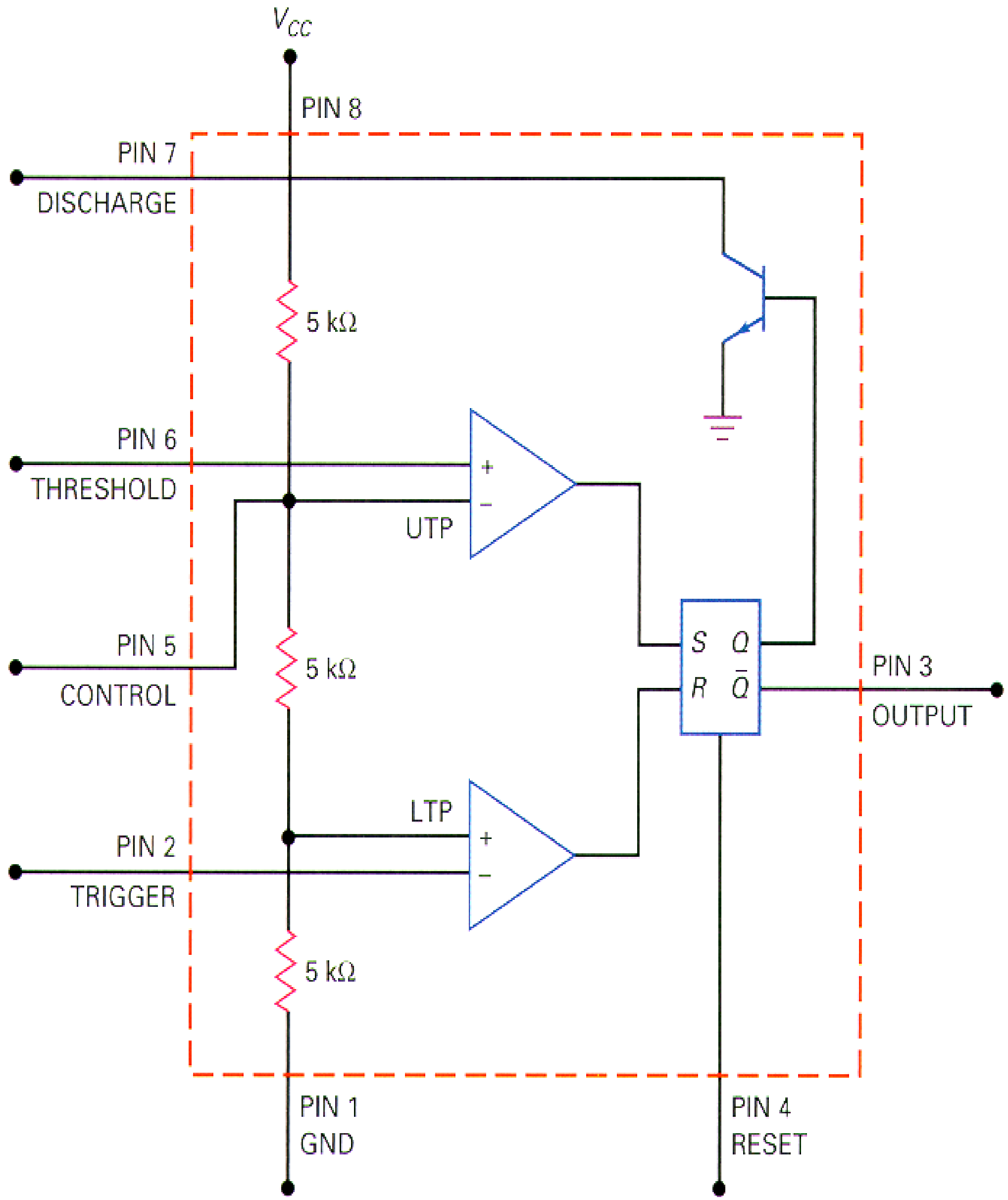
V_{CC}
(8)
R_A
5 kΩ
Upper
comparator
Threshold
(6)
+
Control
voltage
(5)
−
Flip-flop
R
Q
S
R_B
5 kΩ
Lower
comparator
+
(3)
Output
Output
buffer
Trigger
(2)
−
Discharge
path transistor
Discharge
(7)
Q_d
R_C
5 kΩ
(1)
Gnd
(4)
Reset

LM555 block diagram

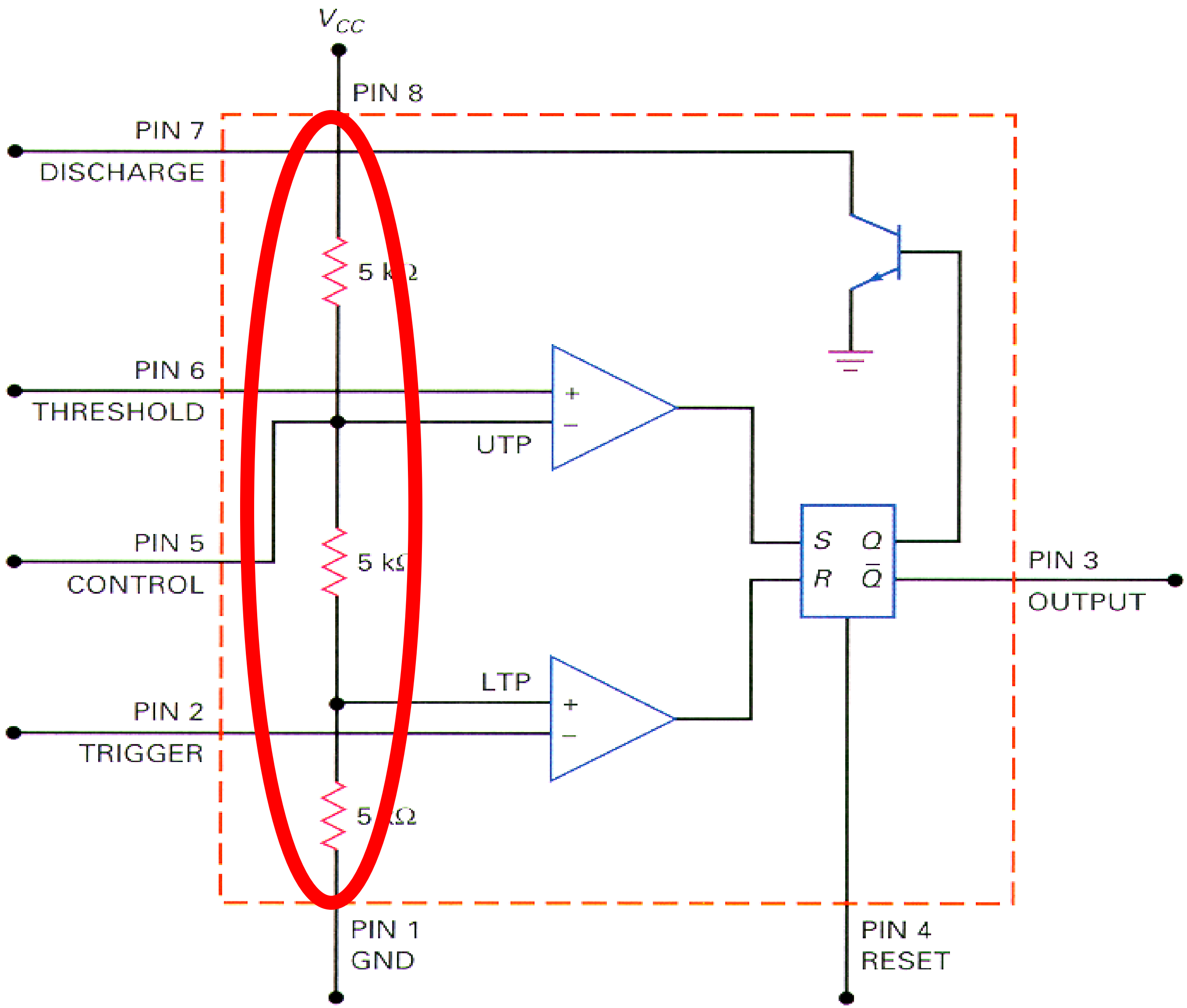
Upper threshold trip point

Lower threshold trip point

R-S Flip-Flop (reset - set)

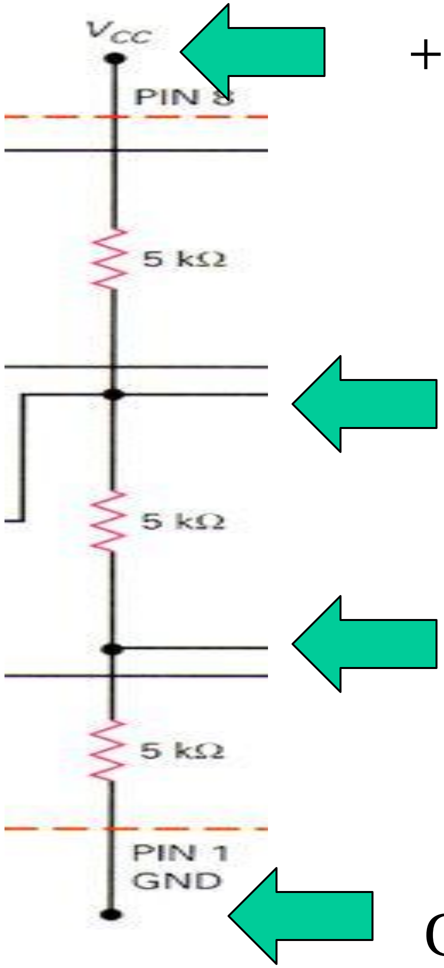


555 Timer



V_{CC}
PIN 8
PIN 7
DISCHARGE
PIN 6
THRESHOLD
UTP
PIN 5
CONTROL
LTP
PIN 2
TRIGGER
PIN 1
GND
PIN 4
RESET
PIN 3
OUTPUT
S
Q
R
$\bar{Q}$
+
–

Voltage divider



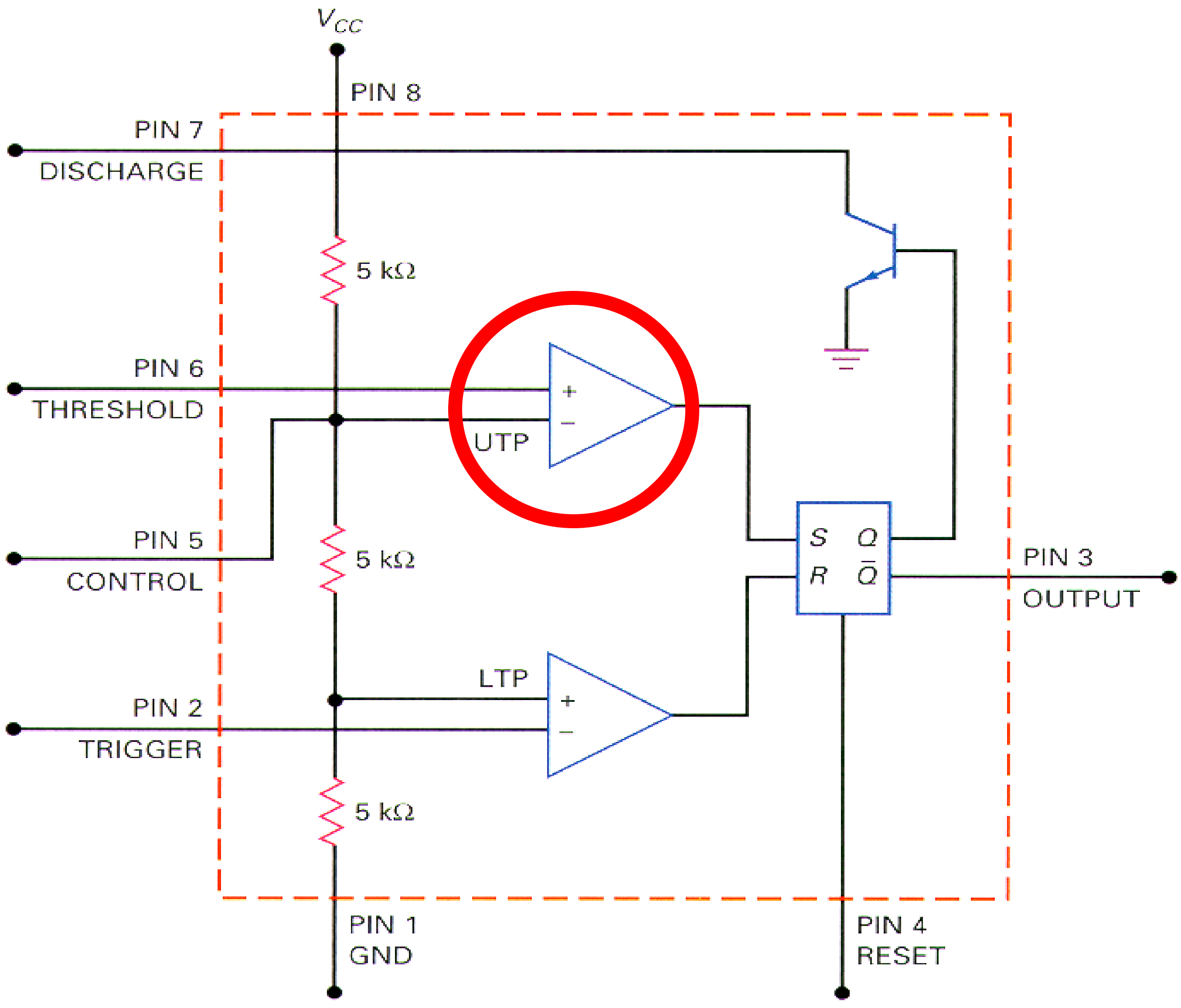
+ 10 volts

+ 6.66 volts

+ 3.33 volts

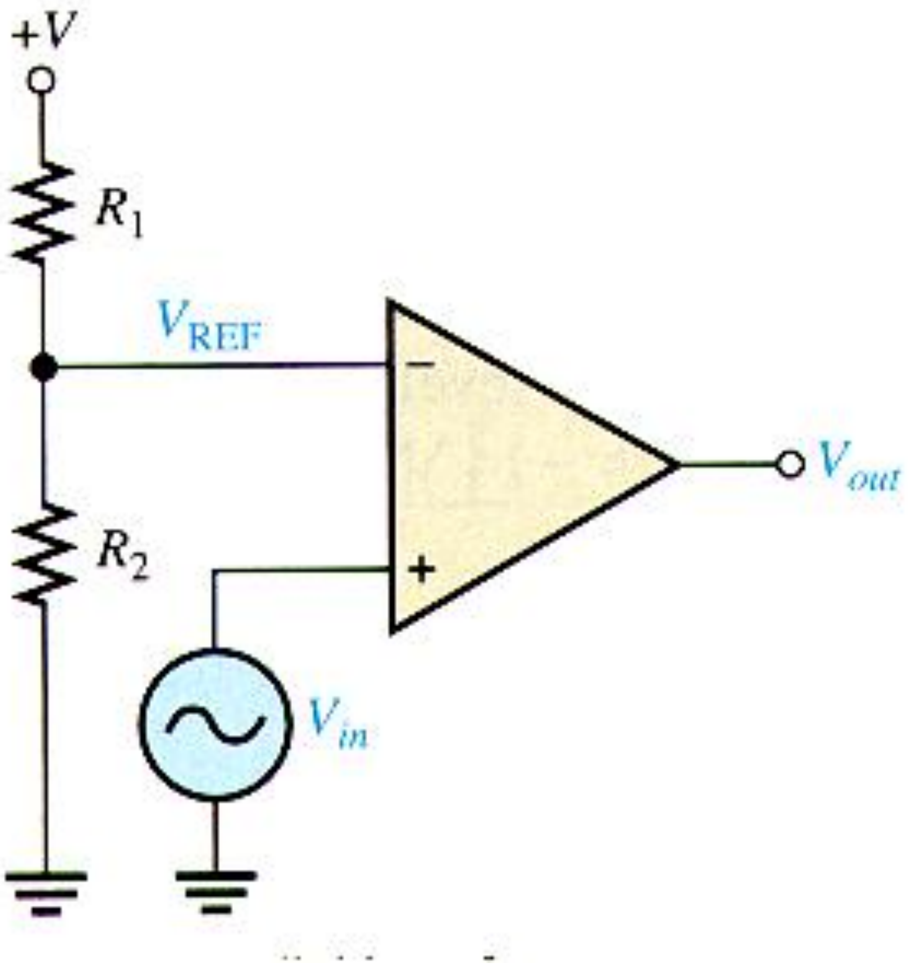
Gnd. = 0 volts

555 Timer

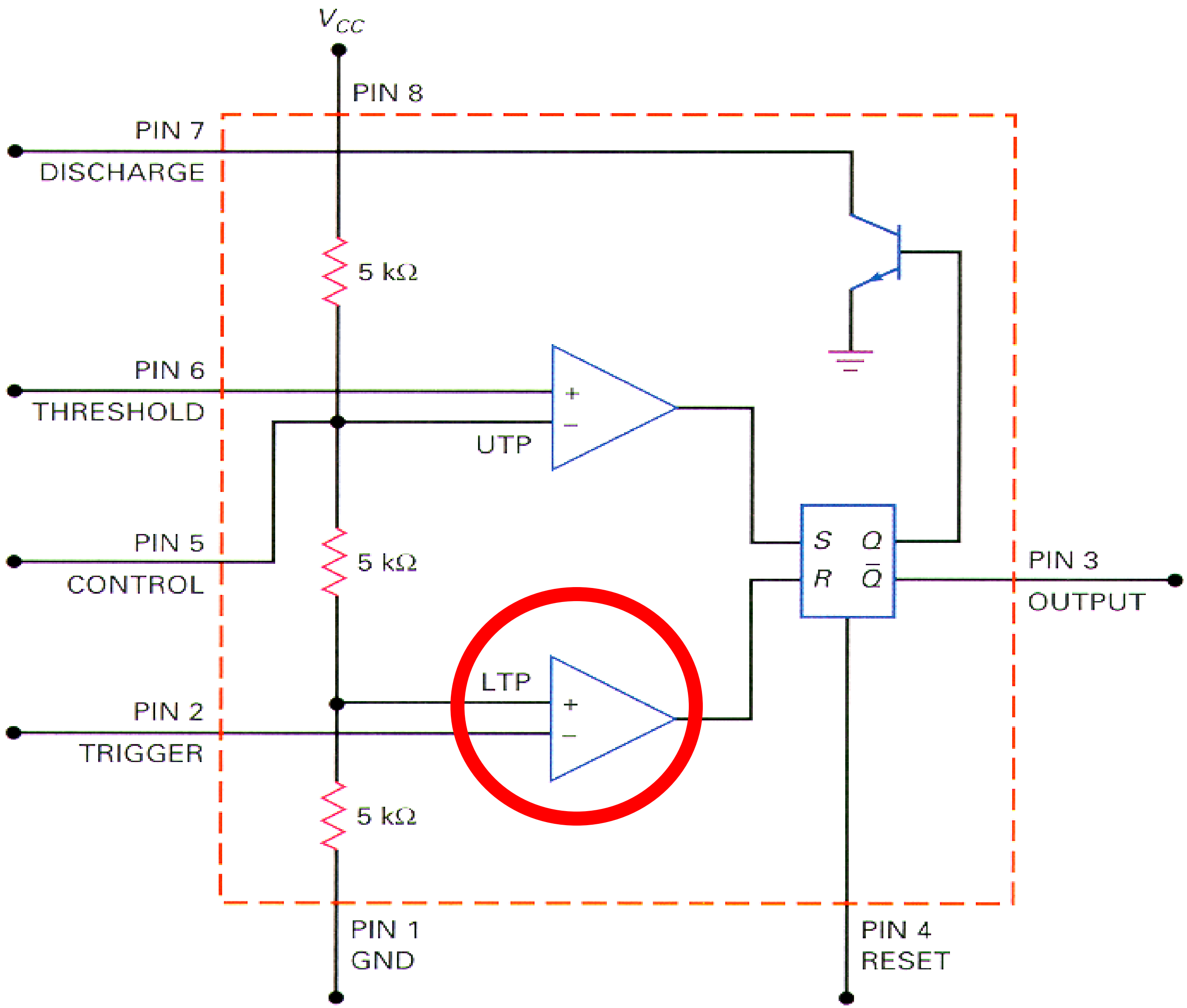


V_{CC}
PIN 8
PIN 7
DISCHARGE
5 kΩ
PIN 6
THRESHOLD
+
−
UTP
PIN 5
CONTROL
5 kΩ
S
Q
R
$\bar{Q}$
PIN 3
OUTPUT
LTP
+
−
PIN 2
TRIGGER
5 kΩ
PIN 1
GND
PIN 4
RESET

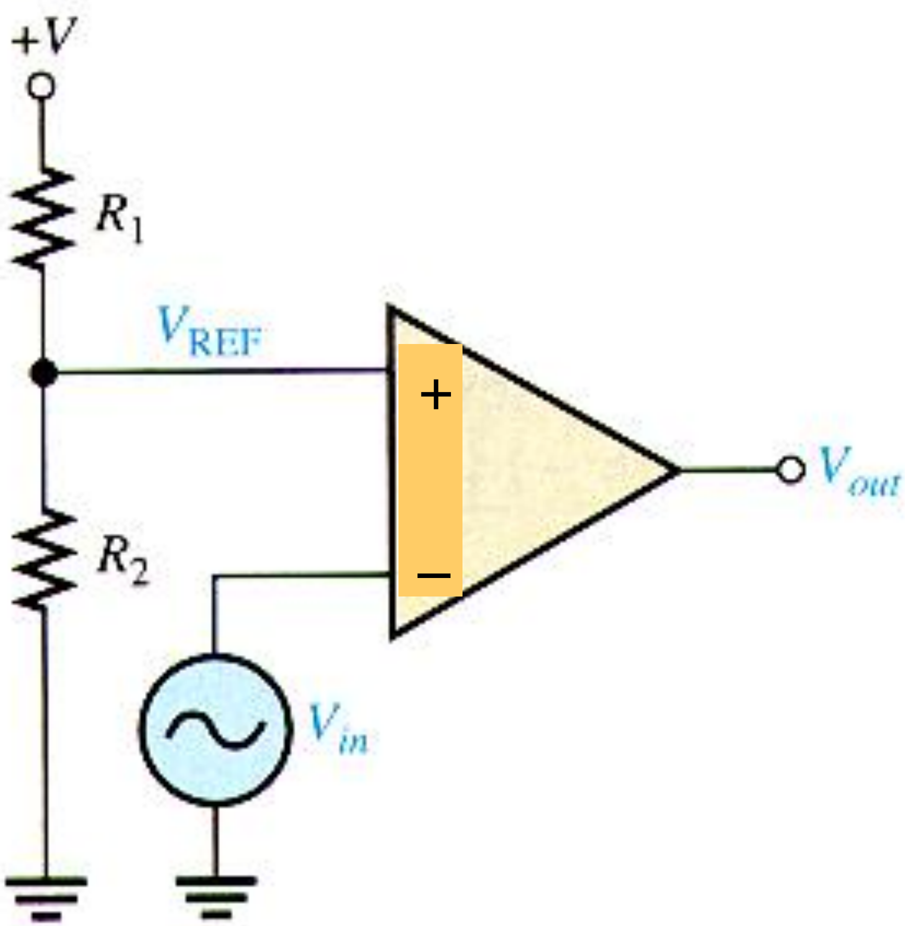
Comparator circuit
Upper **T**hreshold **P**oint



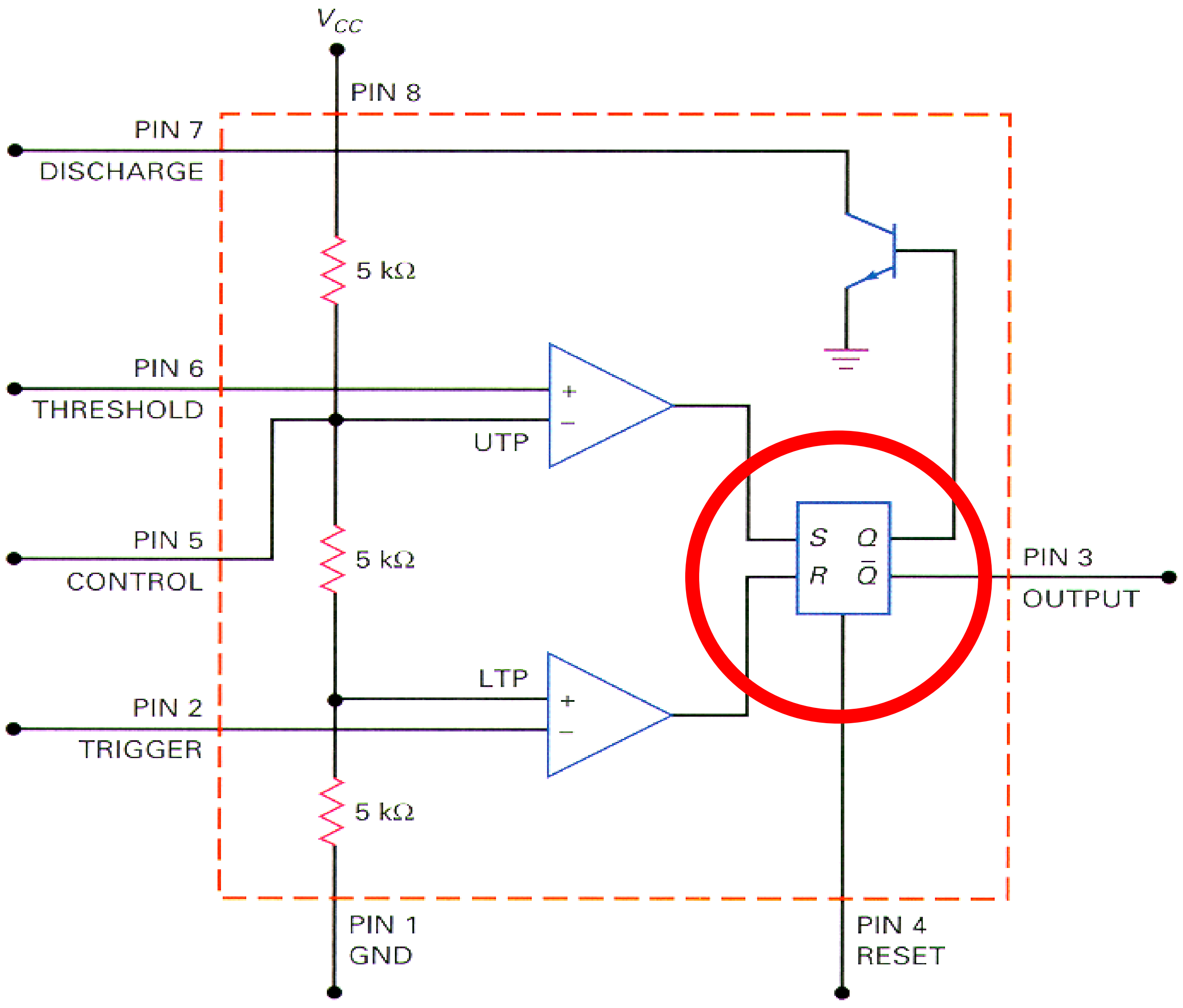
555 Timer


V_{CC}
PIN 8
PIN 7
DISCHARGE
5 kΩ
PIN 6
THRESHOLD
UTP
PIN 5
CONTROL
5 kΩ
S
Q
R
$\bar{Q}$
PIN 3
OUTPUT
LTP
PIN 2
TRIGGER
5 kΩ
PIN 1
GND
PIN 4
RESET

Comparator circuit
Lower Threshold Point

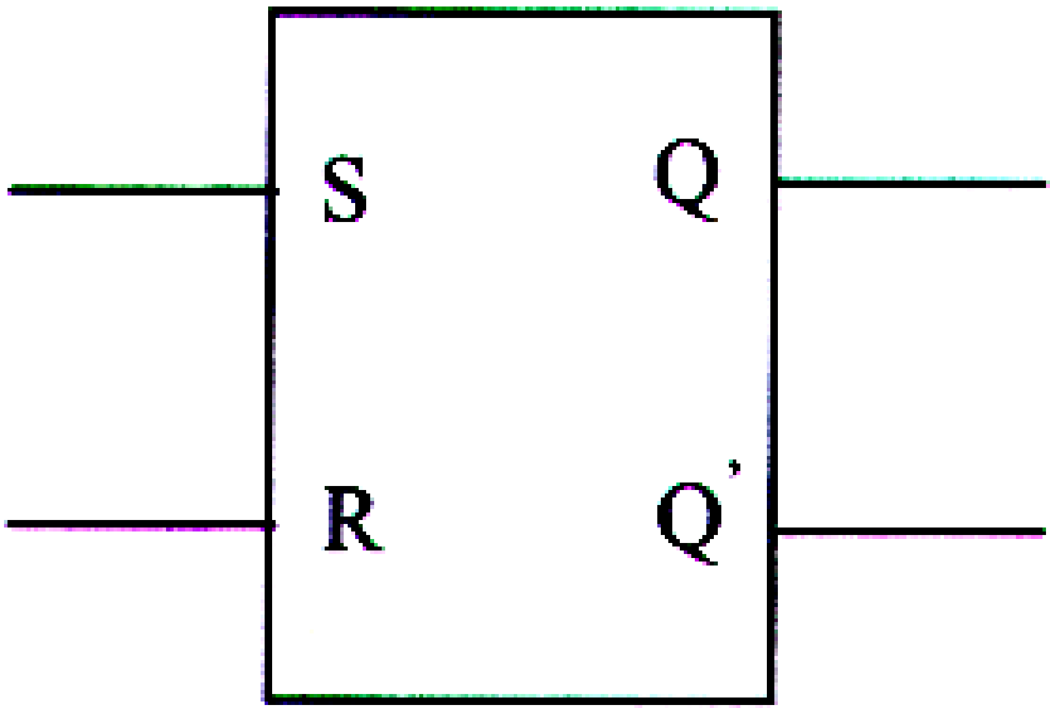


555 Timer



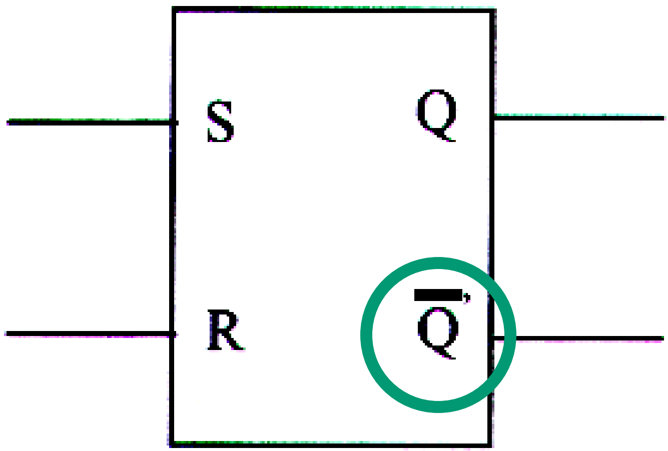
V_{CC}
PIN 8
PIN 7
DISCHARGE
5 kΩ
PIN 6
THRESHOLD
+
−
UTP
PIN 5
CONTROL
5 kΩ
S
Q
R
$\overline{Q}$
PIN 3
OUTPUT
LTP
+
−
PIN 2
TRIGGER
5 kΩ
PIN 1
GND
PIN 4
RESET

Set **R**eset Latch



Set / **R**eset Latch

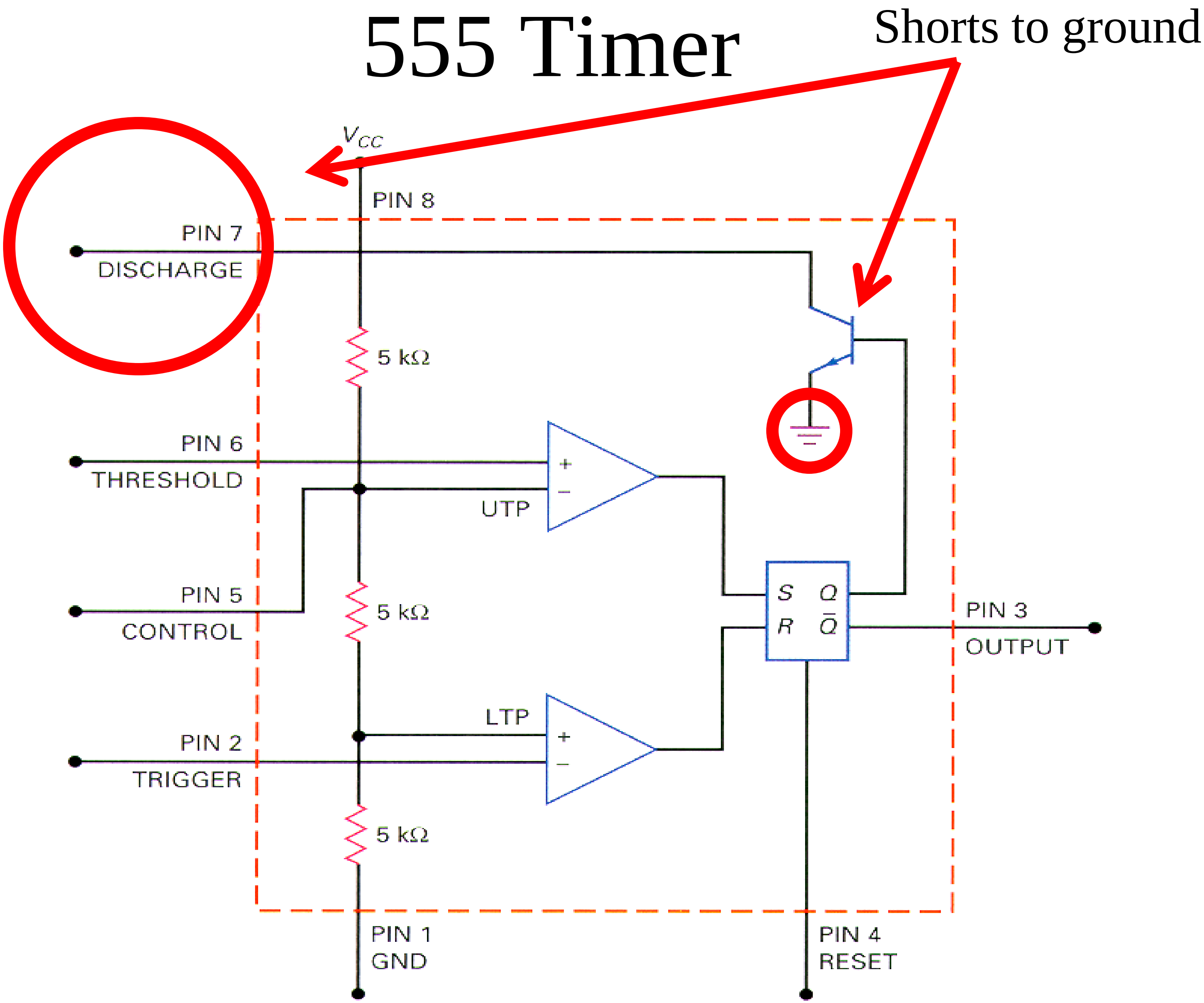
$\overline{Q}$ characteristic table & output pin 3



Clear is same as **Reset**

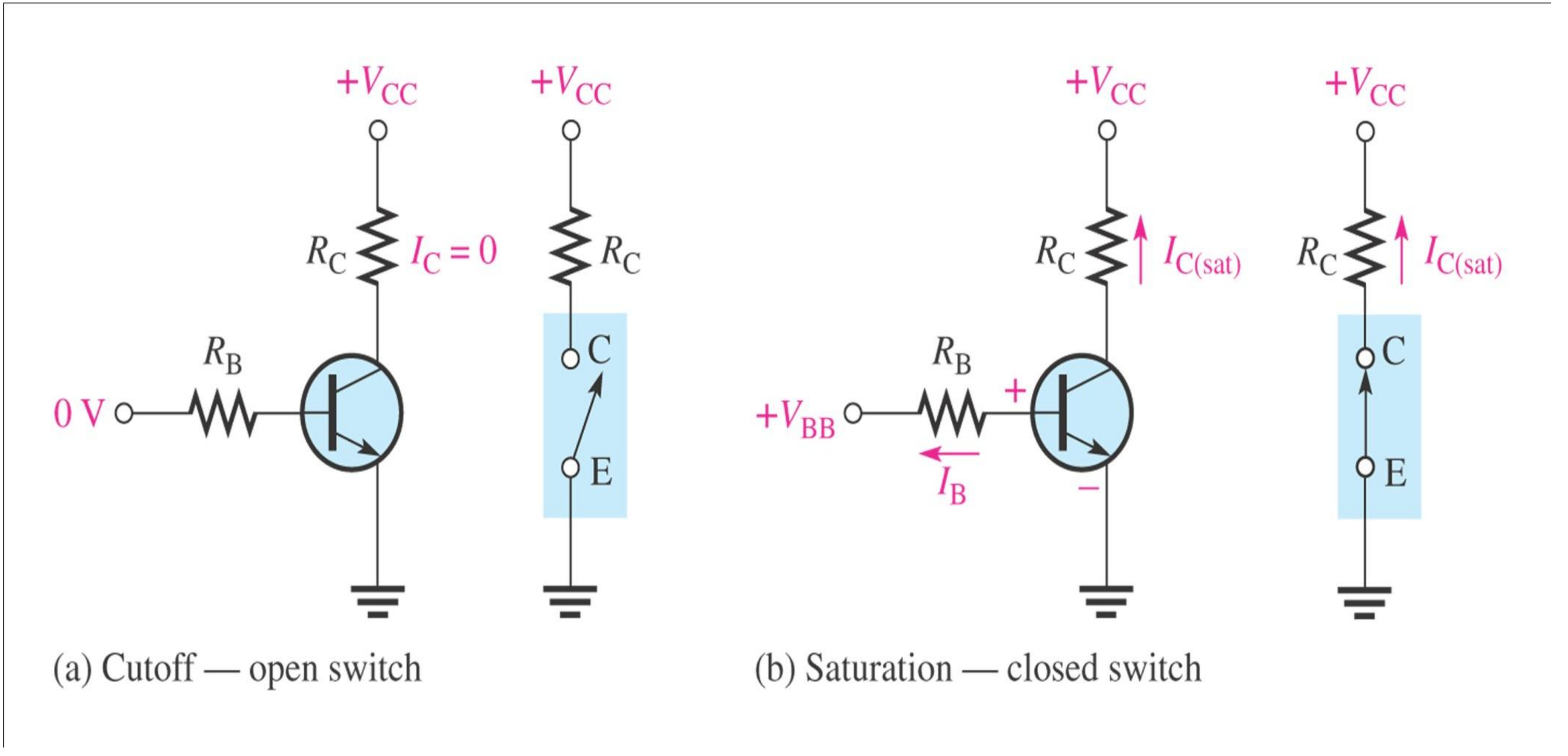
Set	Clear	Output
1	1	No change
0	1	Q = 1
1	0	Q = 0
0	0	Invalid*

555 Timer

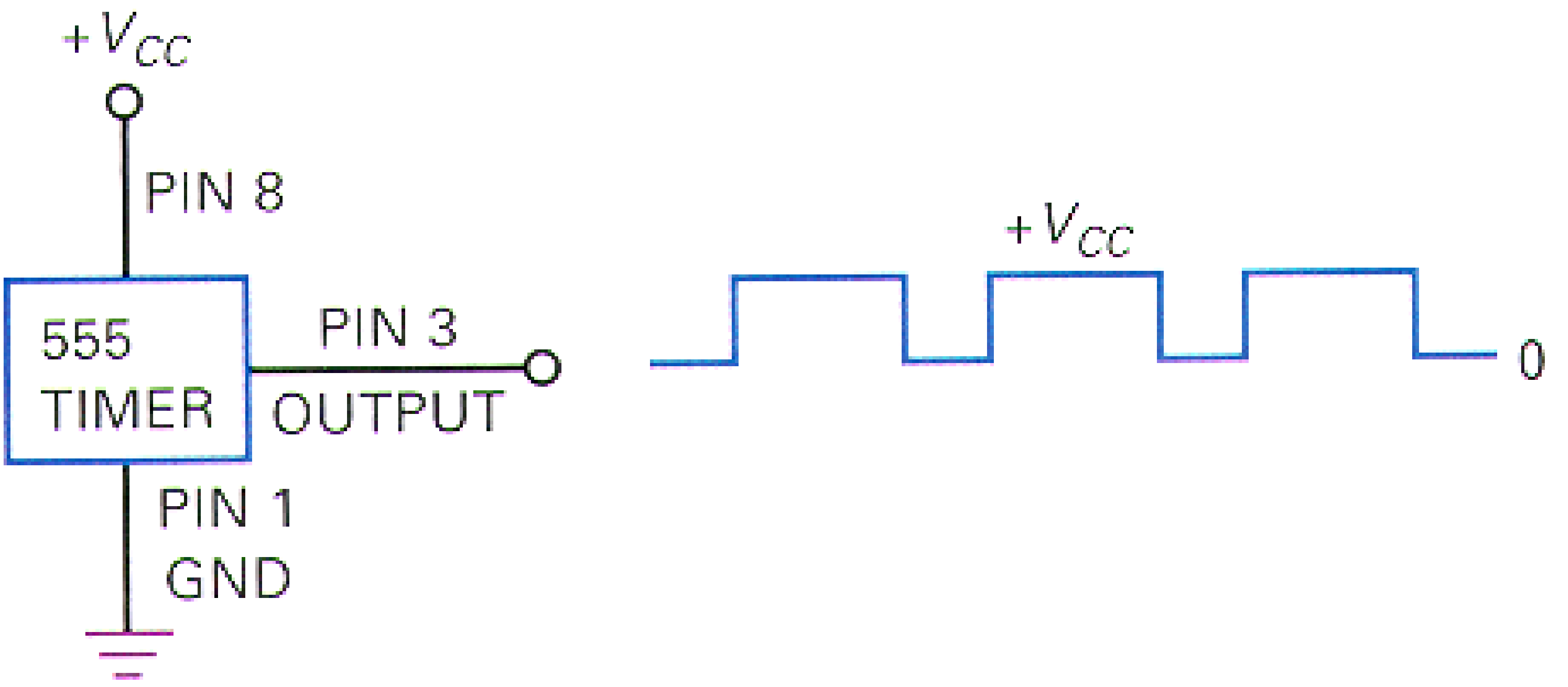

Shorts to ground
V_{CC}
PIN 8
PIN 7
DISCHARGE
5 kΩ
PIN 6
THRESHOLD
UTP
+
−
PIN 5
CONTROL
5 kΩ
S
Q
R
$\bar{Q}$
PIN 3
OUTPUT
LTP
+
−
PIN 2
TRIGGER
5 kΩ
PIN 1
GND
PIN 4
RESET

Lamp Driver Circuit

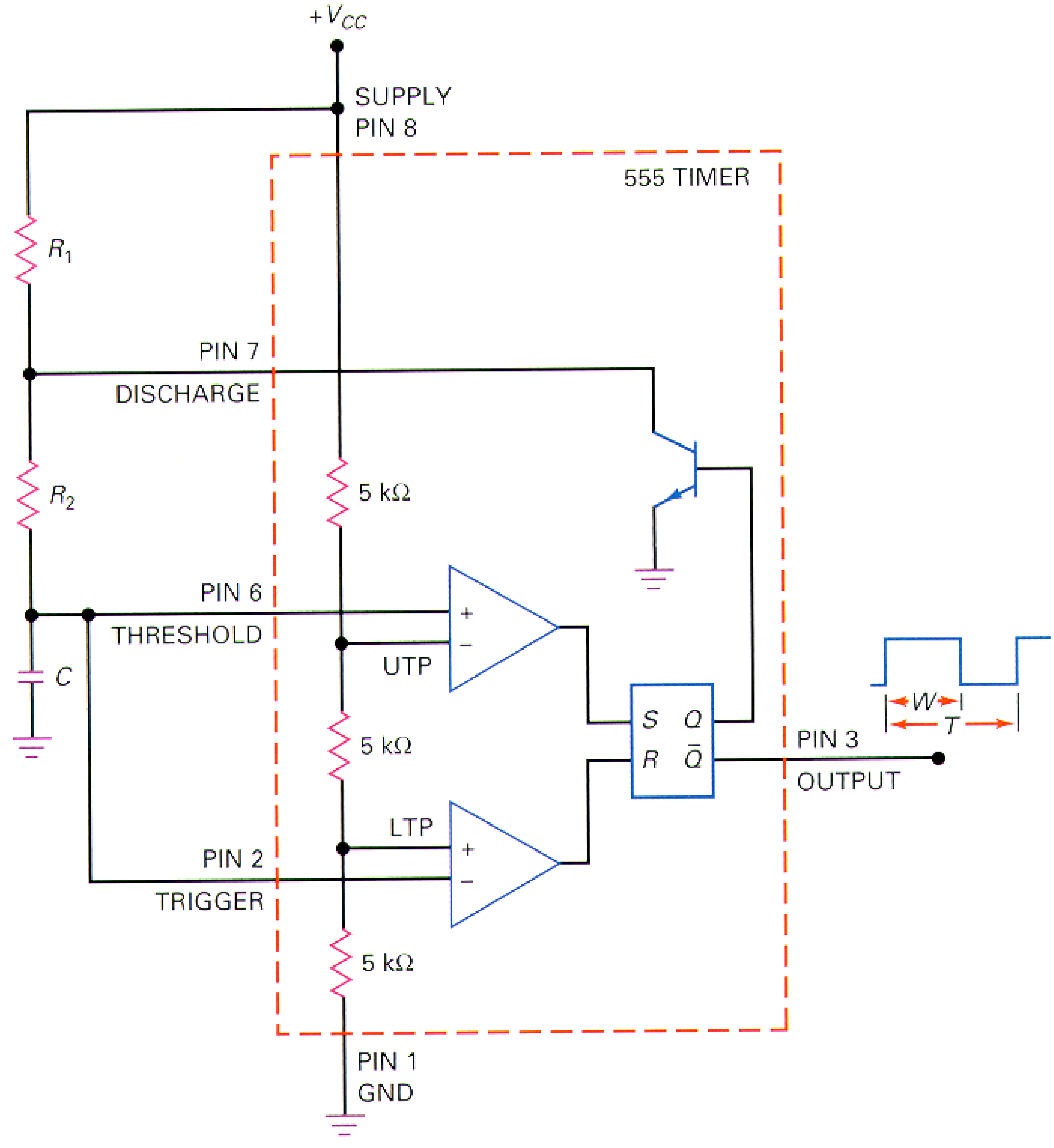
(transistor as a switch to ground)



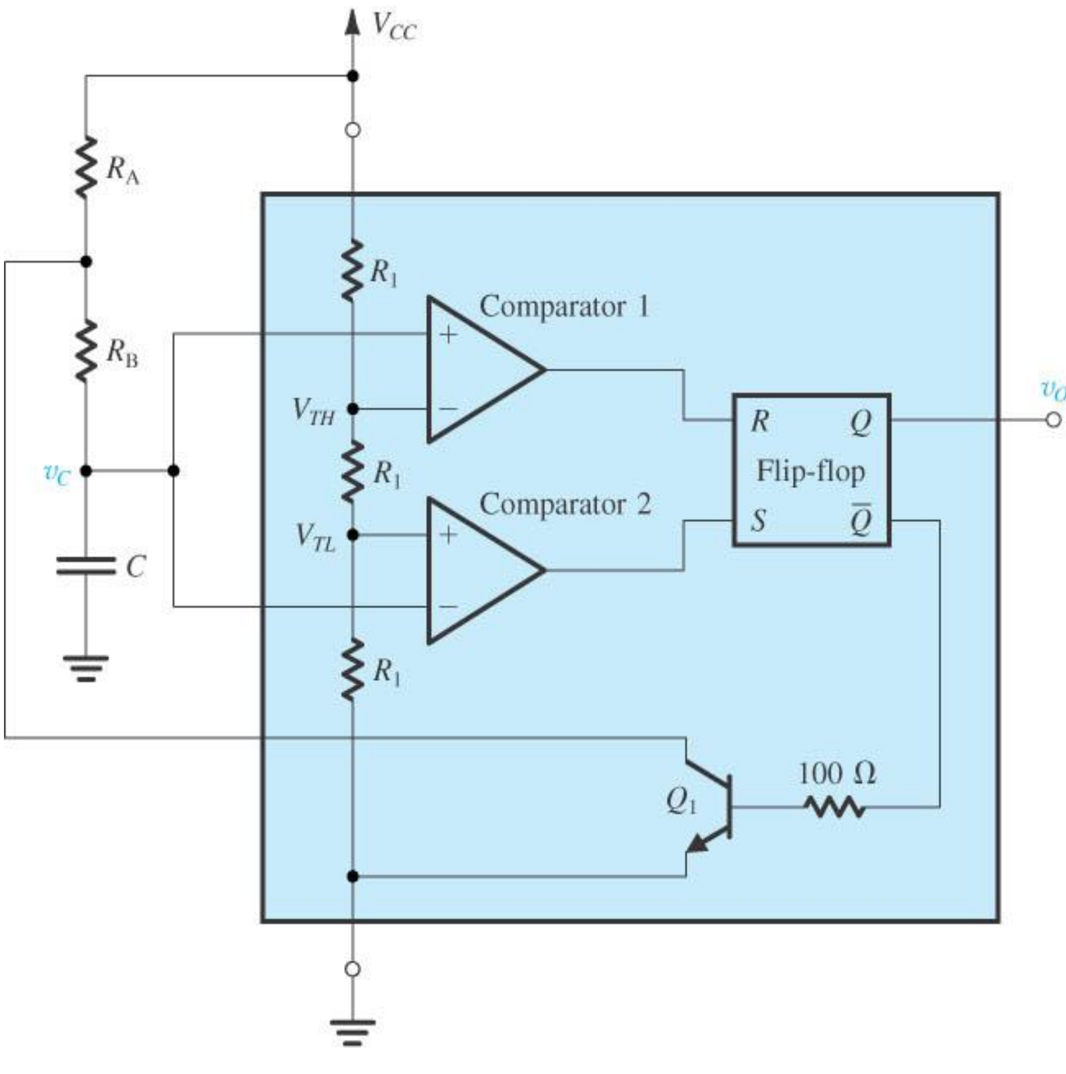
555 Timer Modes
Astable (free-running)



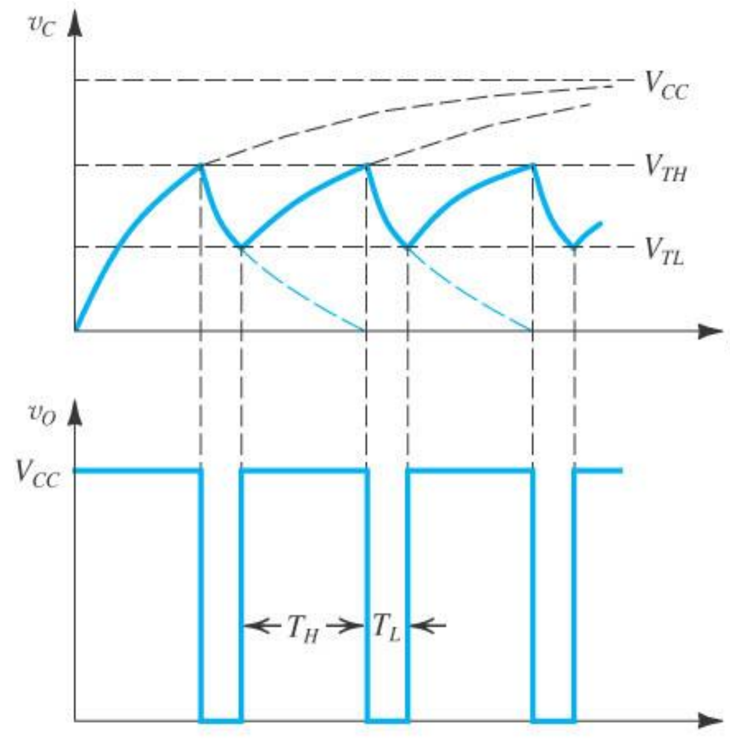
Astable Operation (free-run)



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

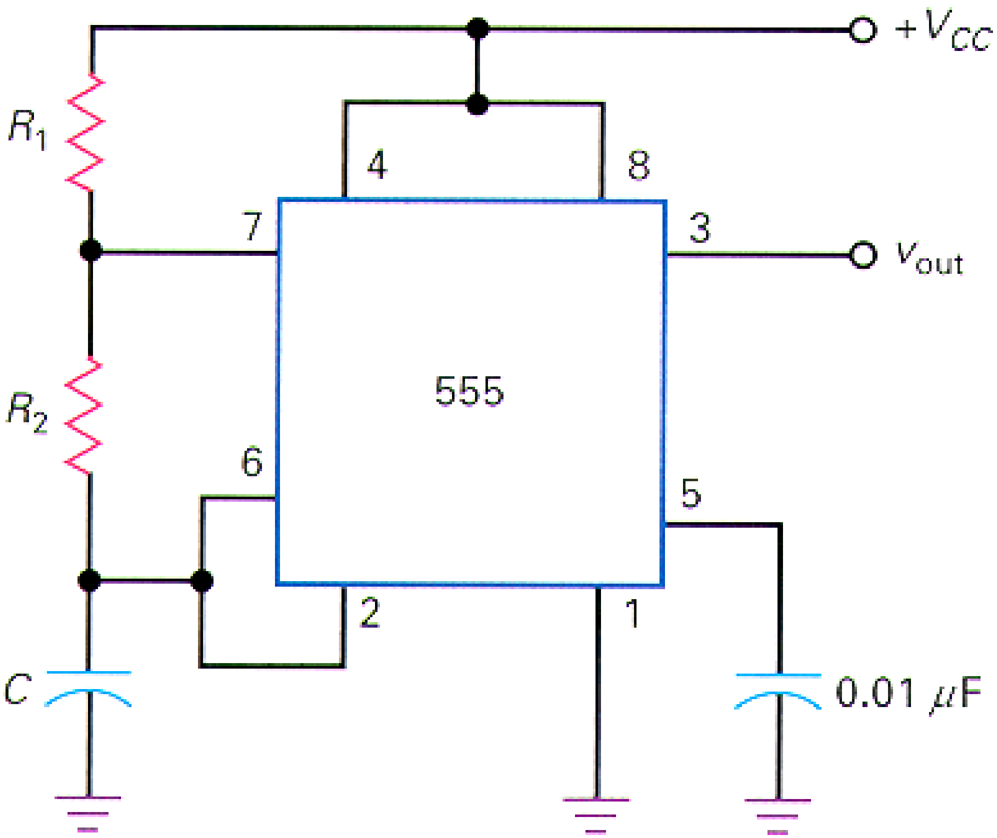


(a)



(b)

Astable Operation (free-run)



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

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

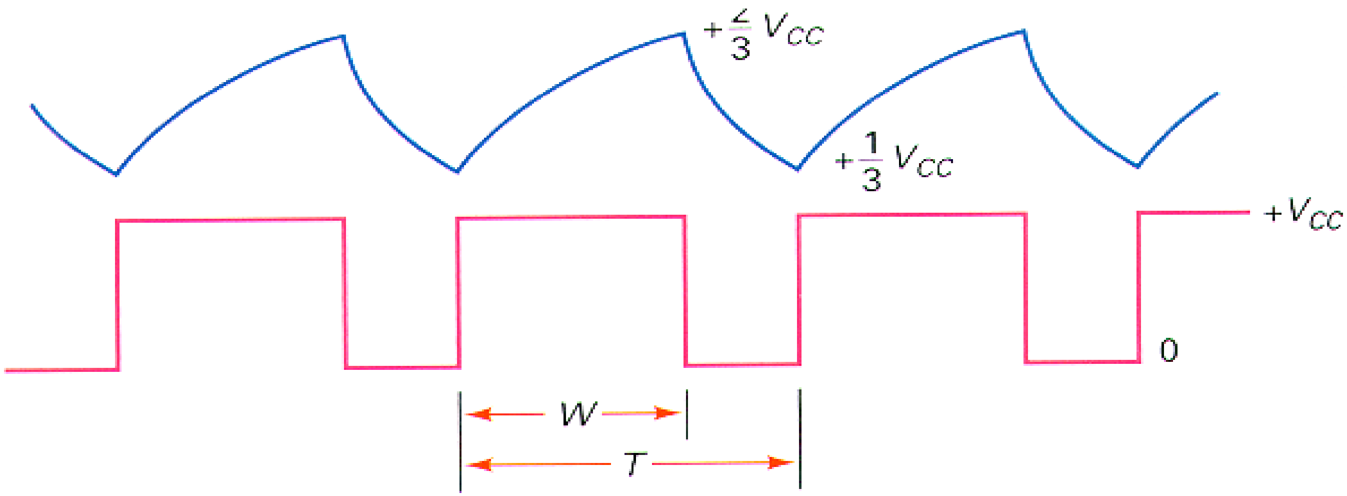
$$f = \frac{1.44}{(R_1 + 2R_2)C}$$

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

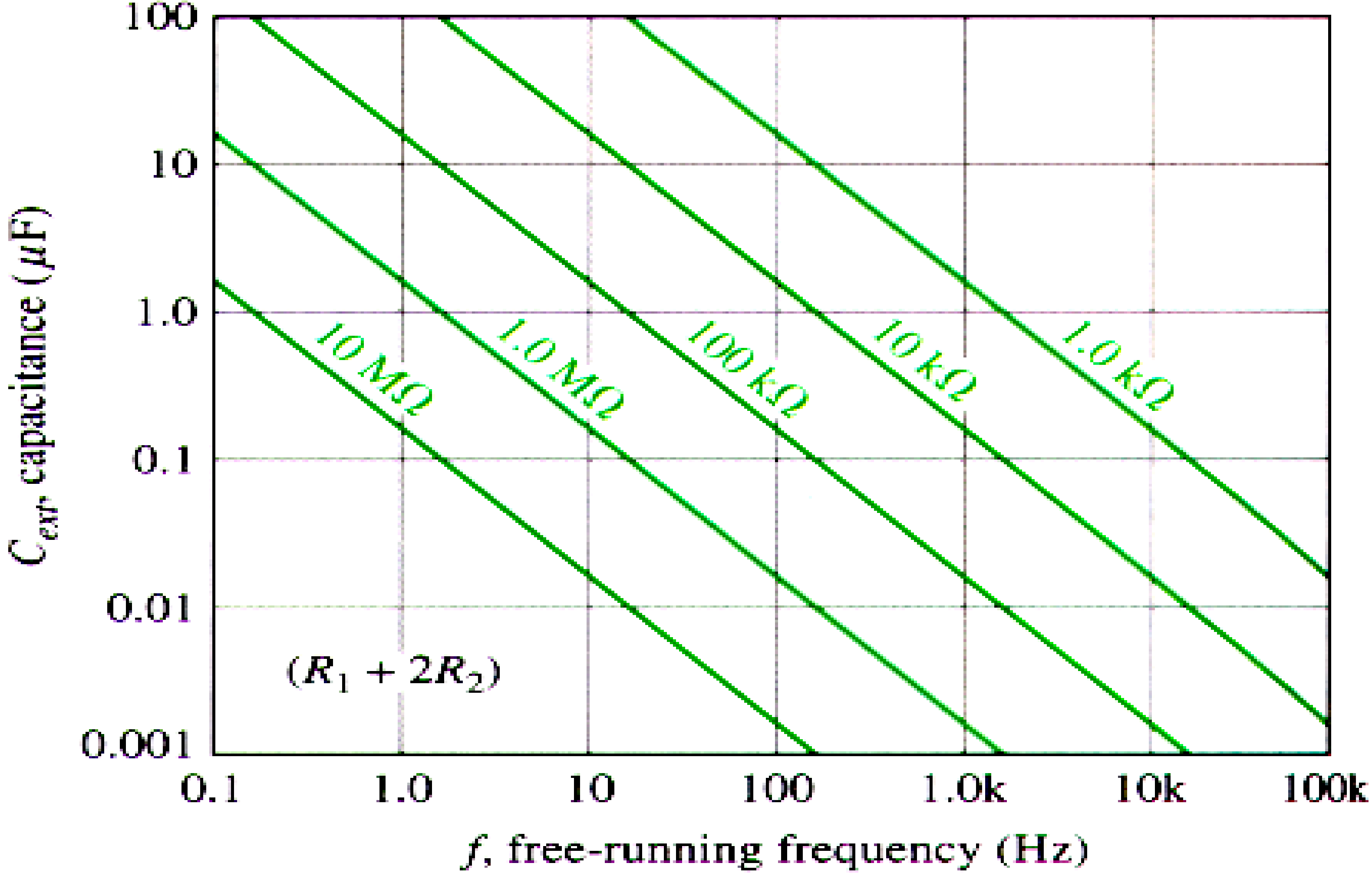
Astable Operation (free-run)

Dividing the pulse width by the period gives the duty cycle:

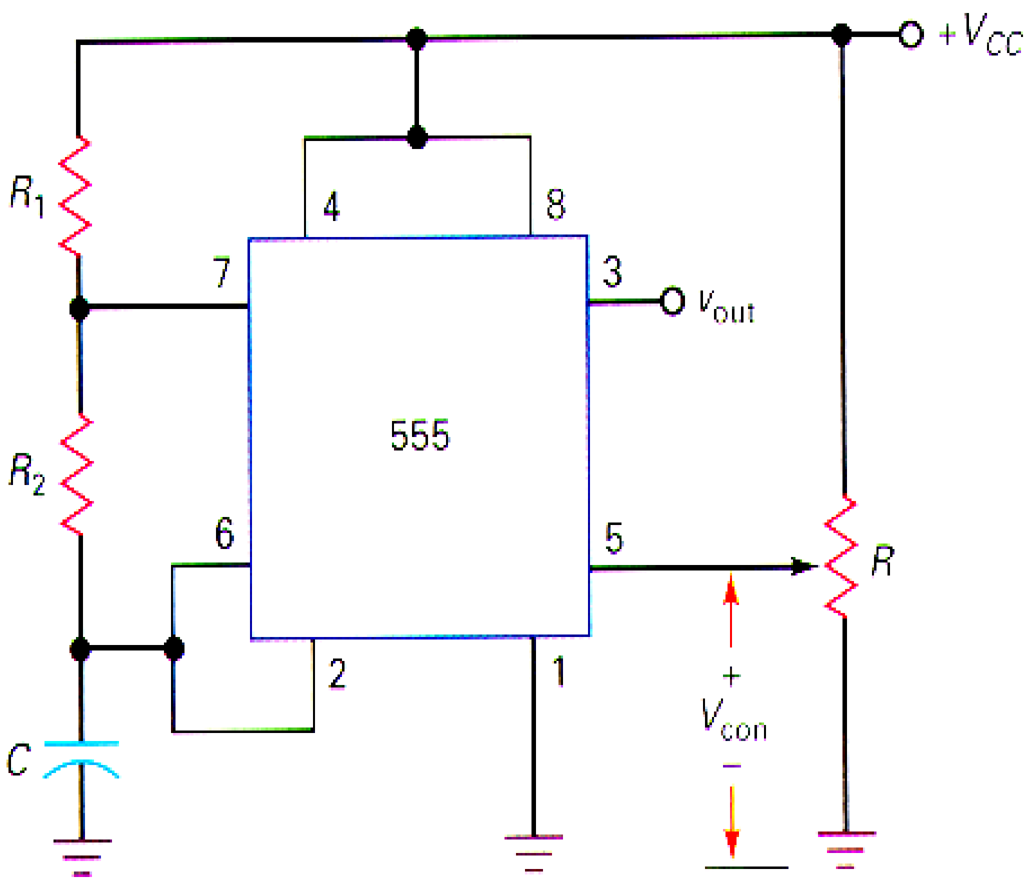
$$D = \frac{R_1 + R_2}{R_1 + 2R_2}$$



Frequency vs. R & C



Voltage controller Oscillator Mode



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

$$T = W + 0.693R_2C$$

$$f = \frac{1}{W + 0.693R_2C}$$

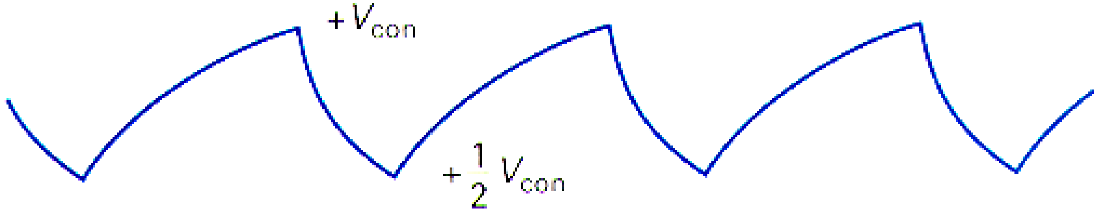
Voltage controller Oscillator Mode

period is given by:

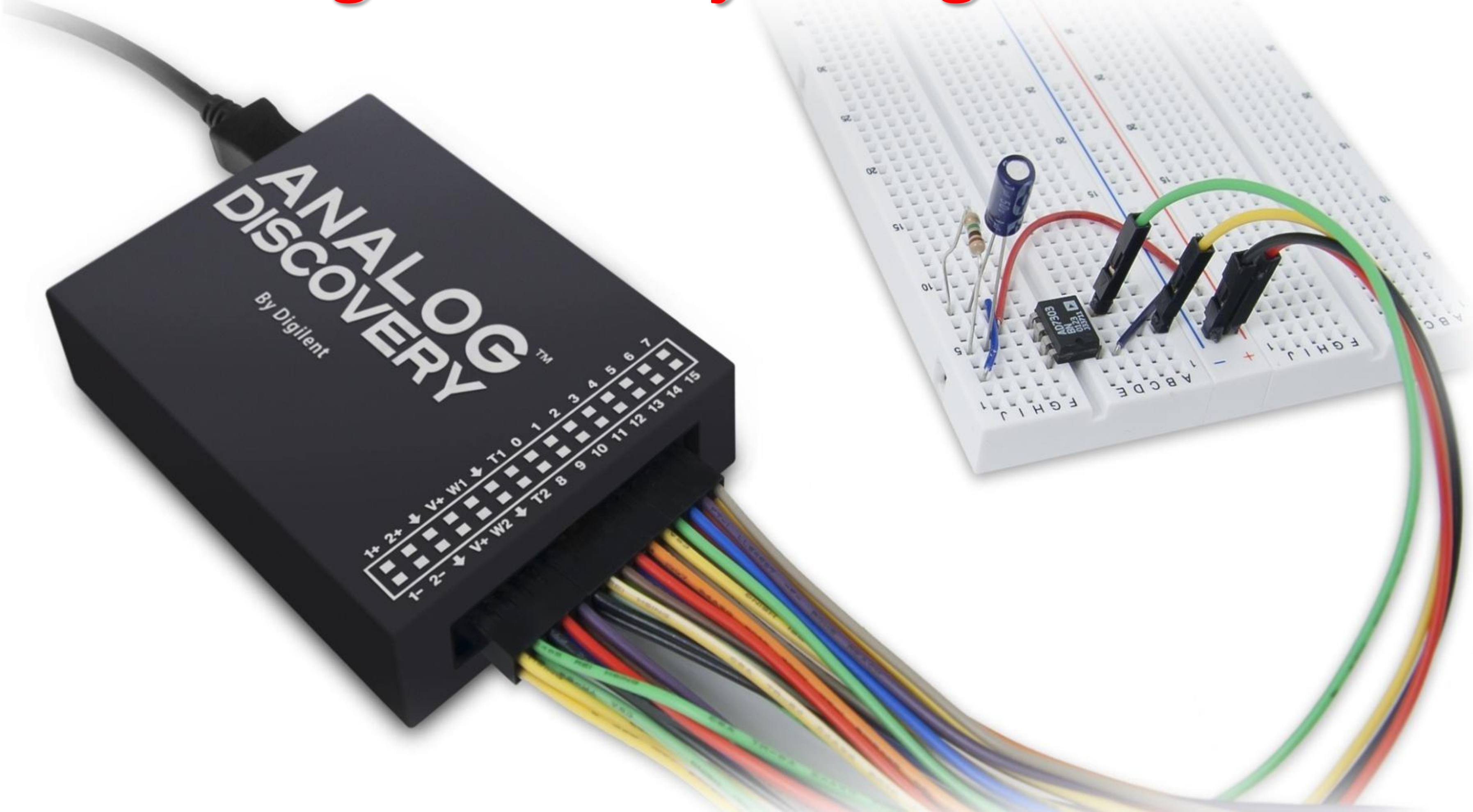
$$T = W + 0.693 R_2 C$$

The frequency is given by:

$$f = \frac{1}{W + 0.693 R_2 C}$$



Analog Discovery Design Kit

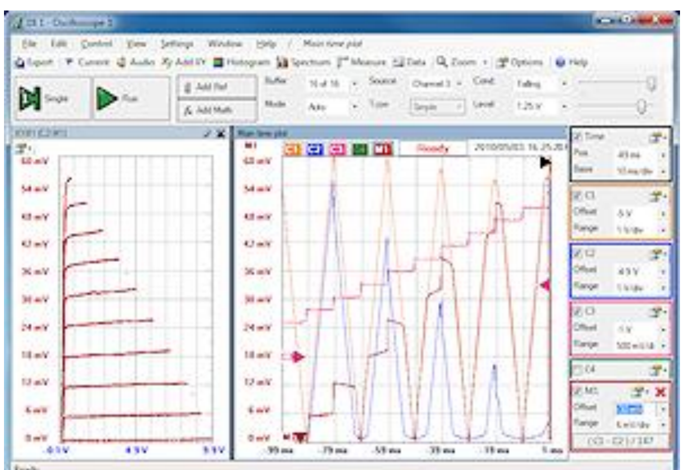


learning by doing

U-Mass, Alan Rux

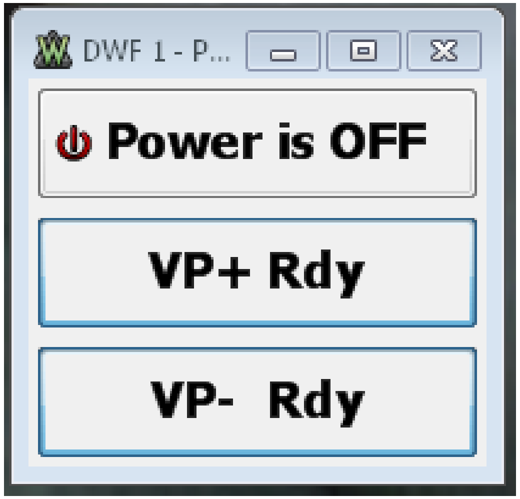
Analog Discovery Design Kit

- Dual Channel Oscilloscope
  - Two channels differential input, 1 Meg ohm, 24pfd
  - +/- 20 volts input max
  - 250 mv. to 5 Volts / division with variable gain settings
  - 100 MSPS, 5 MHz bandwidth, 16K points/channel memory
  - FFT function



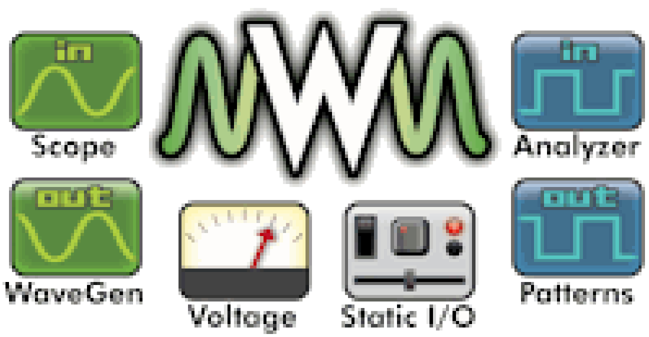
Analog Discovery Design Kit

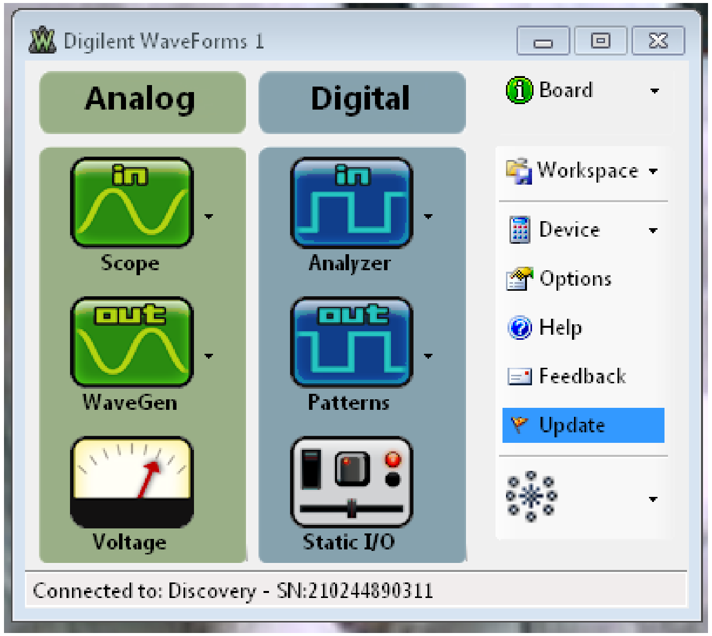
- Power Supply
  - Two fixed voltages +5 volts / -5 volts, 50 ma. Each
  - Switchable ON / OFF comands
  - **Unit powered by USB computer port**, (cable



Analog Discovery Design Kit

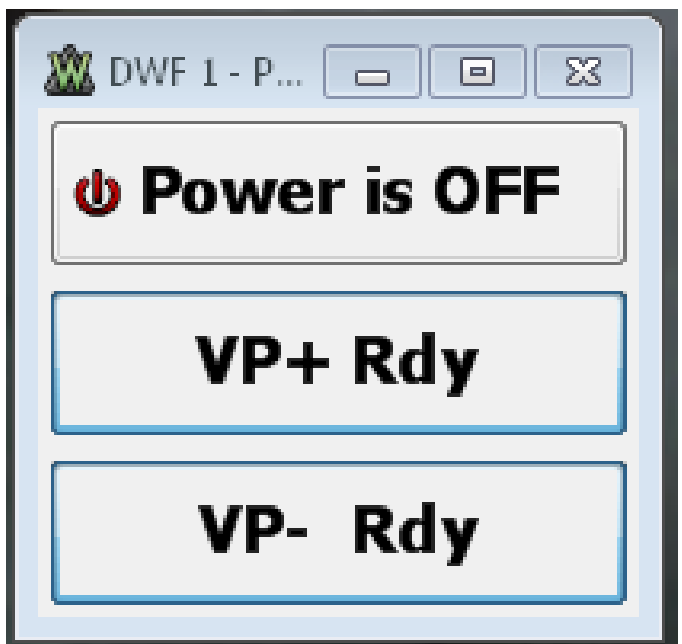
- WaveForms Software
  - Windows XP or newer
  - full –featured GUI for all instruments



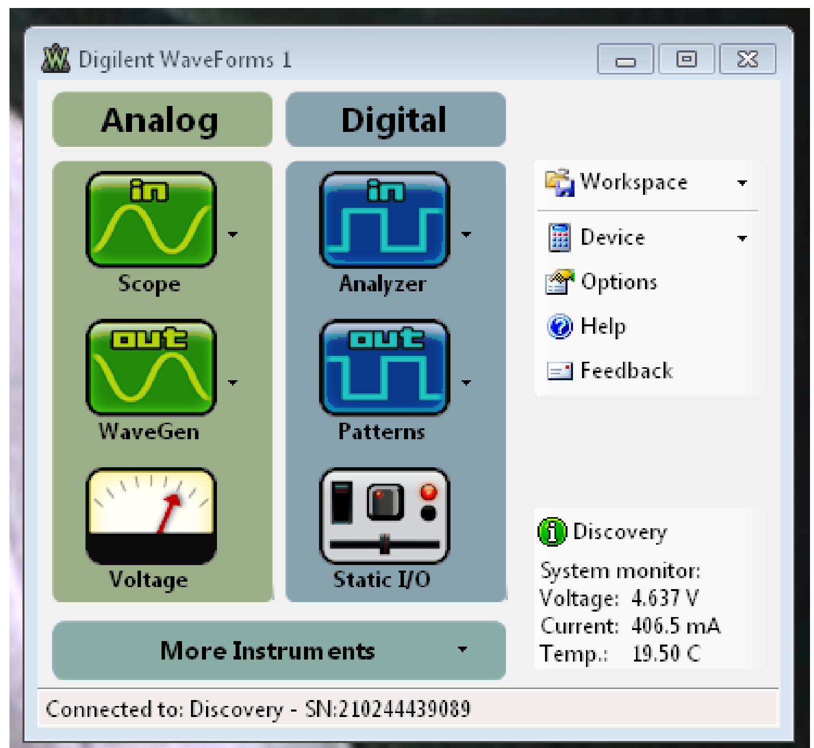


Analog Discovery Design Kit

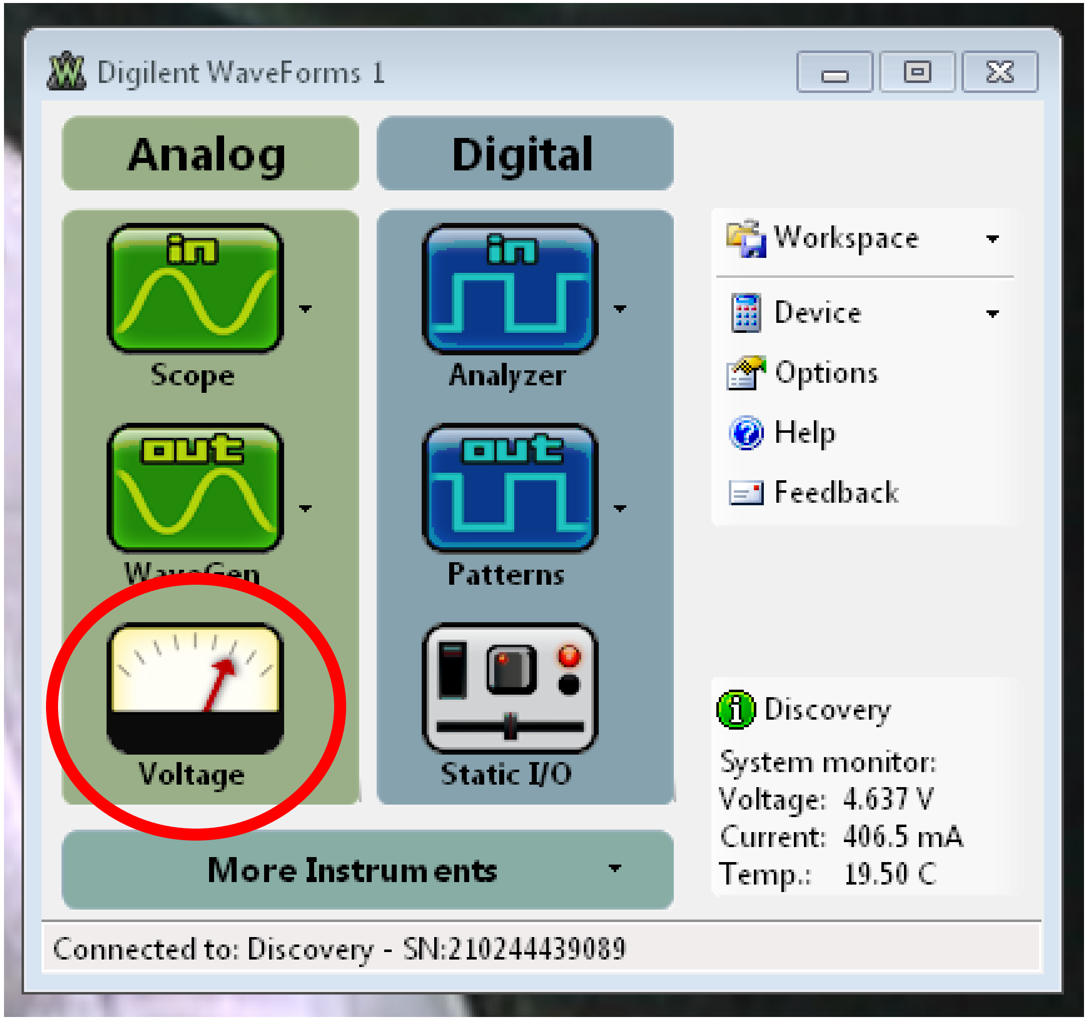
- Power Supply
  - Two fixed voltages +5 volts / -5 volts, **50 ma**. **MAX**
  - Switchable ON / OFF commands
  - **Unit powered by USB computer port**, (cable included)



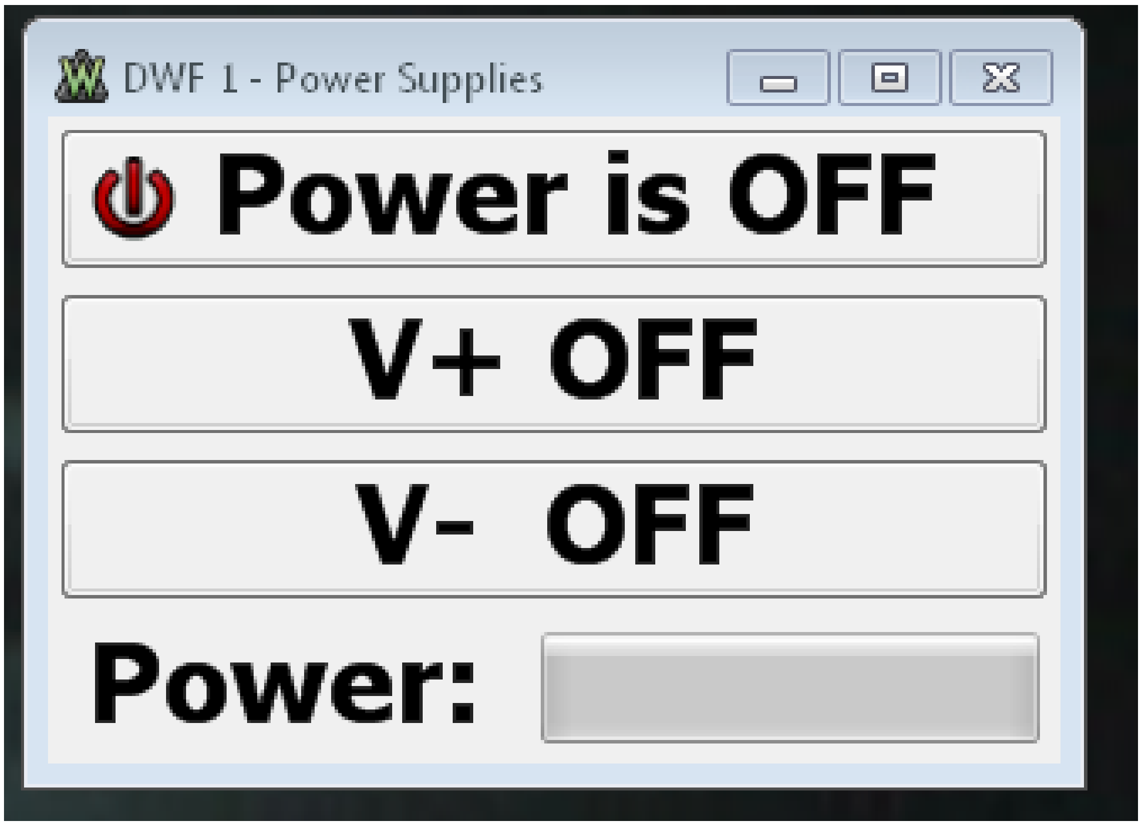
With the ADK plugged into your computer USB port, click on the "W" short-cut logo.
The status bar of the Waveforms Window should appear and a red LED on the ADK near the place the USB cable plugs into should be on



To enable the power supplies click on the "Voltage" icon



Power Supply Control Panel



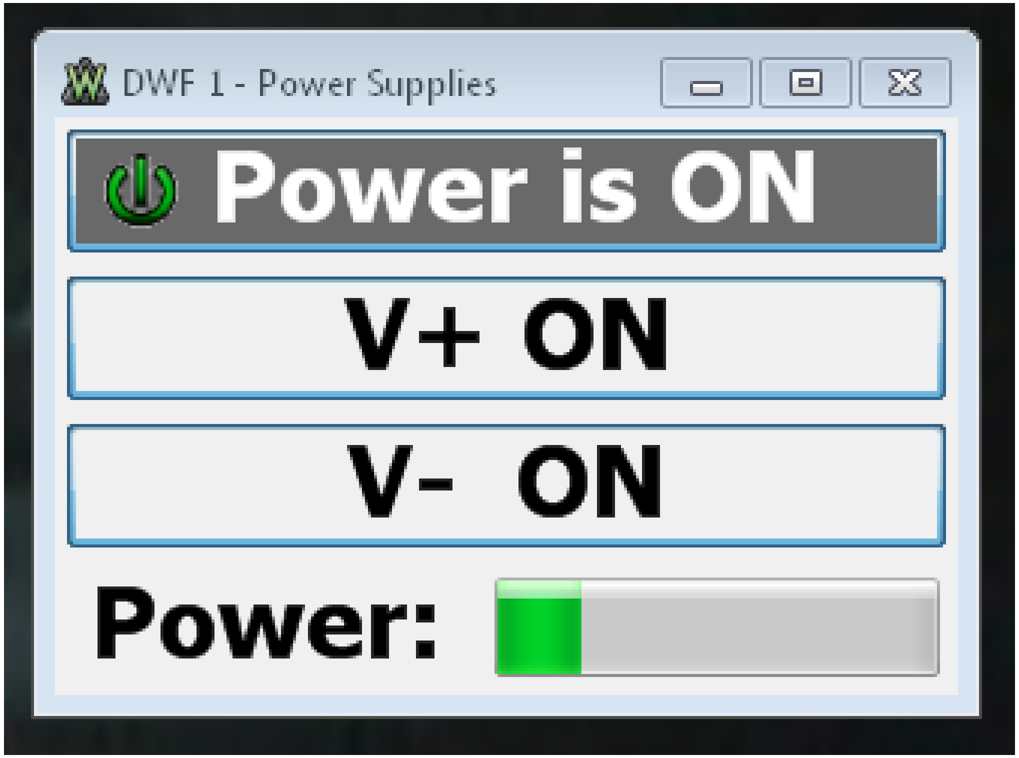
Main power control

+5 volts control

-5 volt control

Power use indicator

Power Supply Control Panel



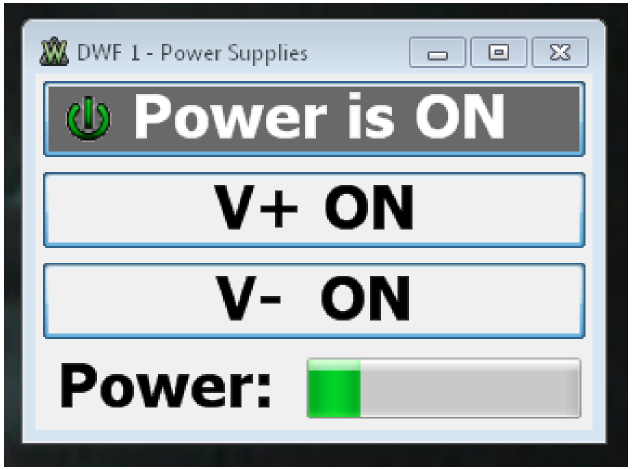
Main power control - on

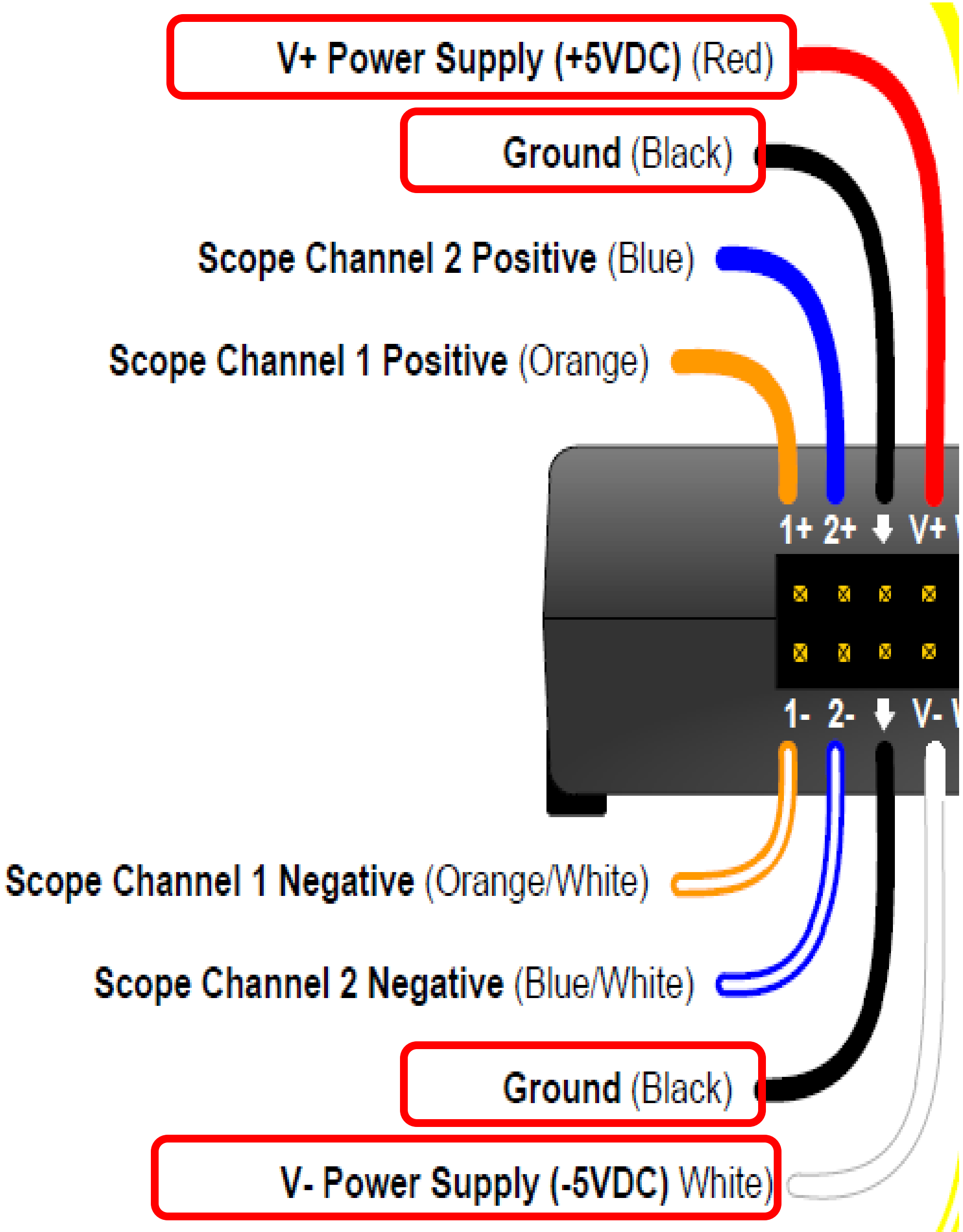
+5 volts - on

-5 volt - on

Power use indicator

Power active

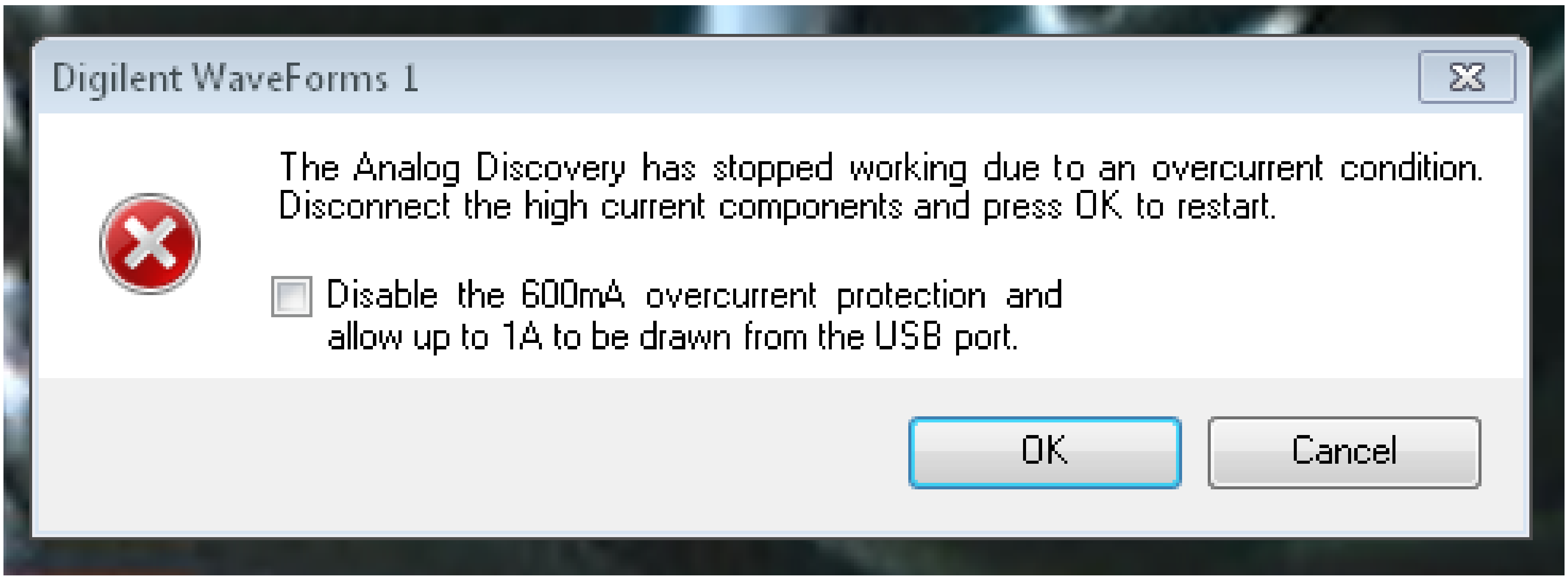




Power Supply Control Panel

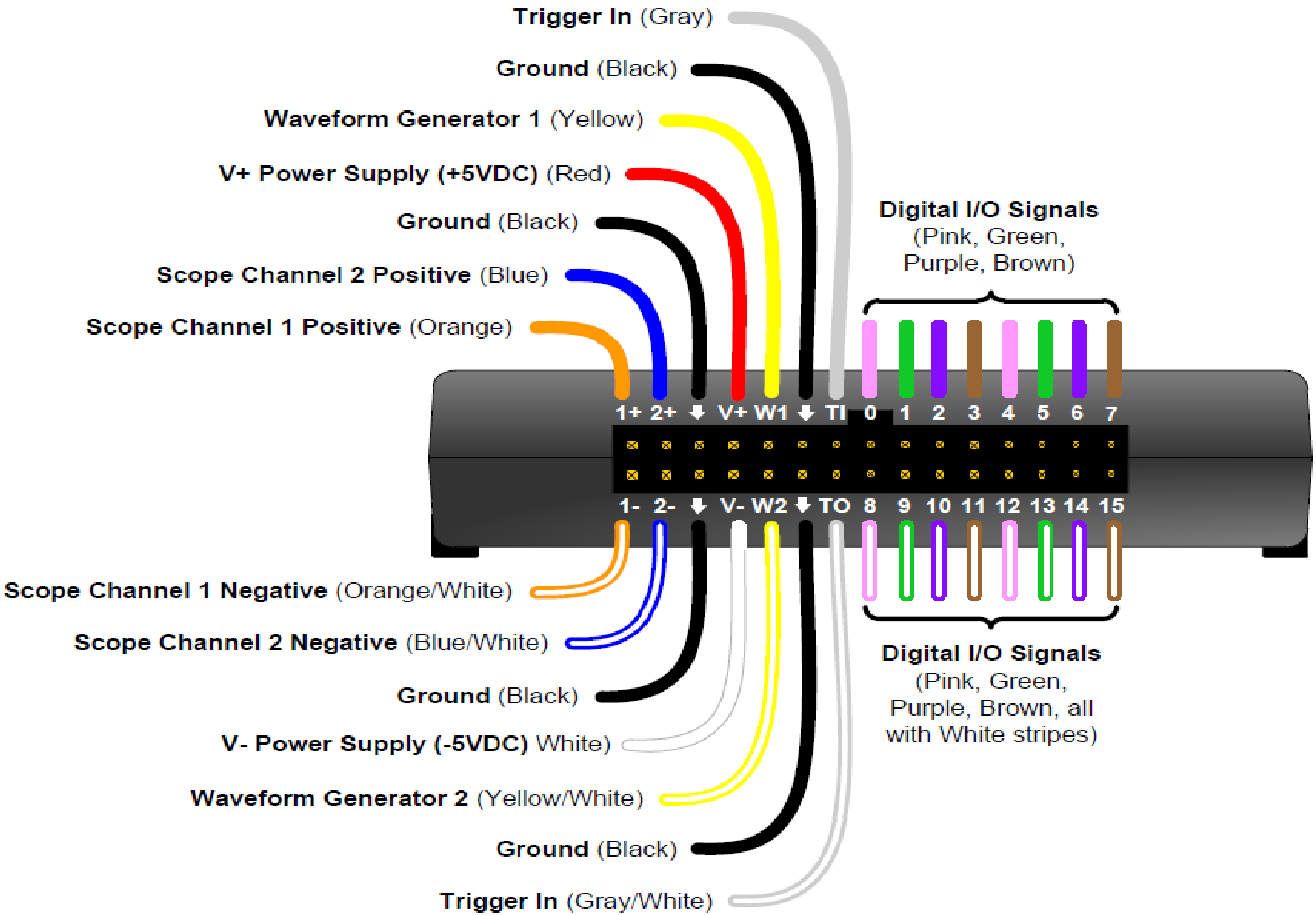
power over the 50 MA limit

Error message

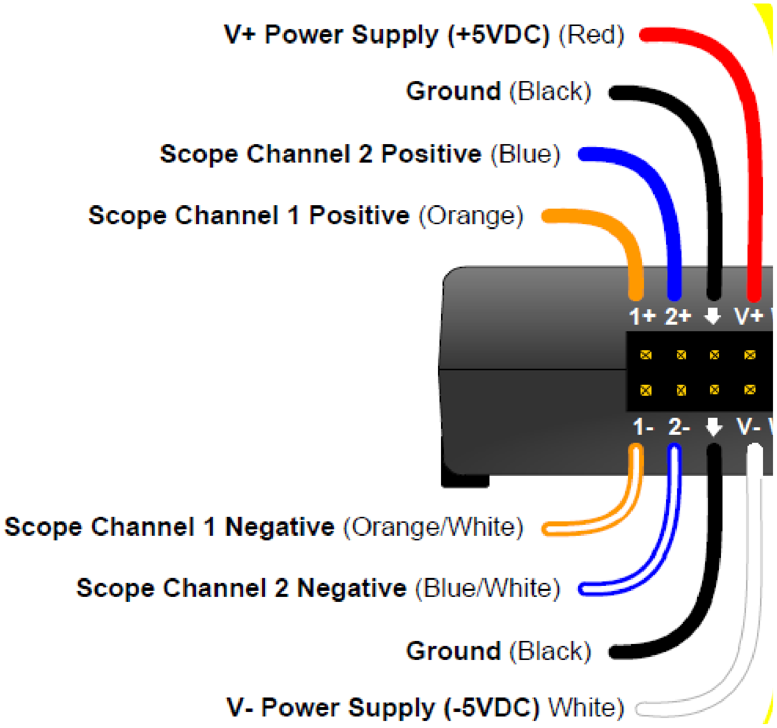


At this time do not allow 1 amp to be drawn

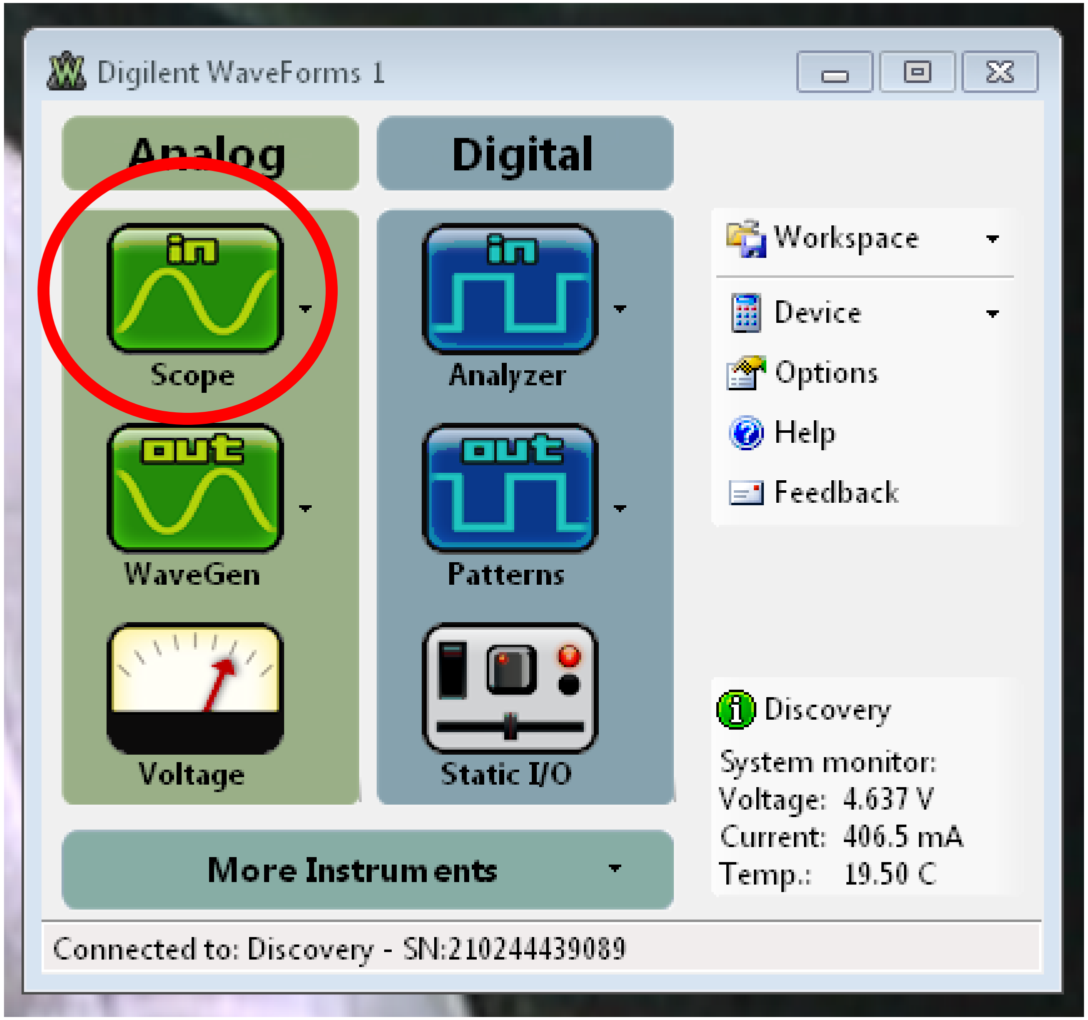
Leads are color coded



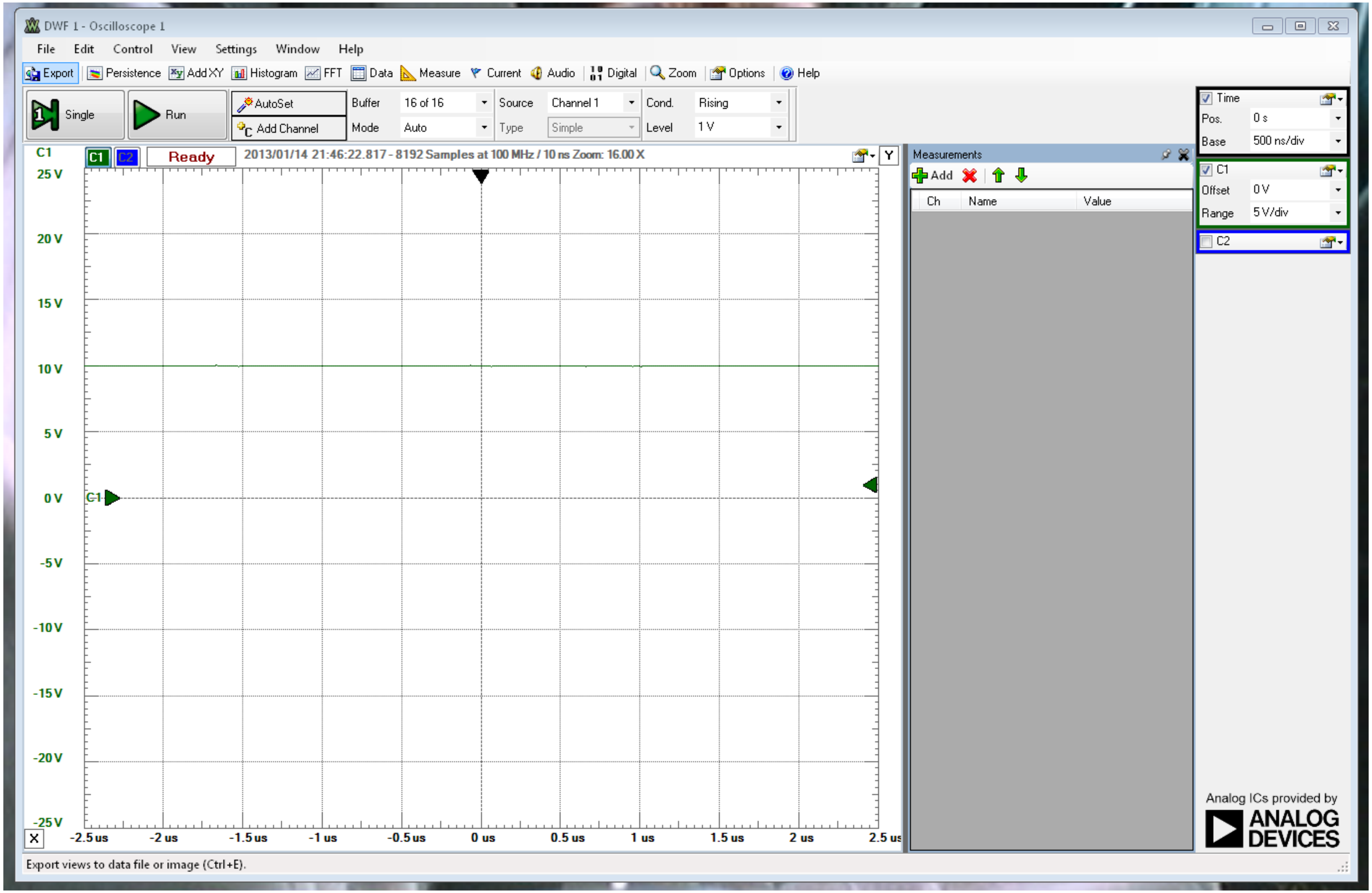
Leads we will be using today



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

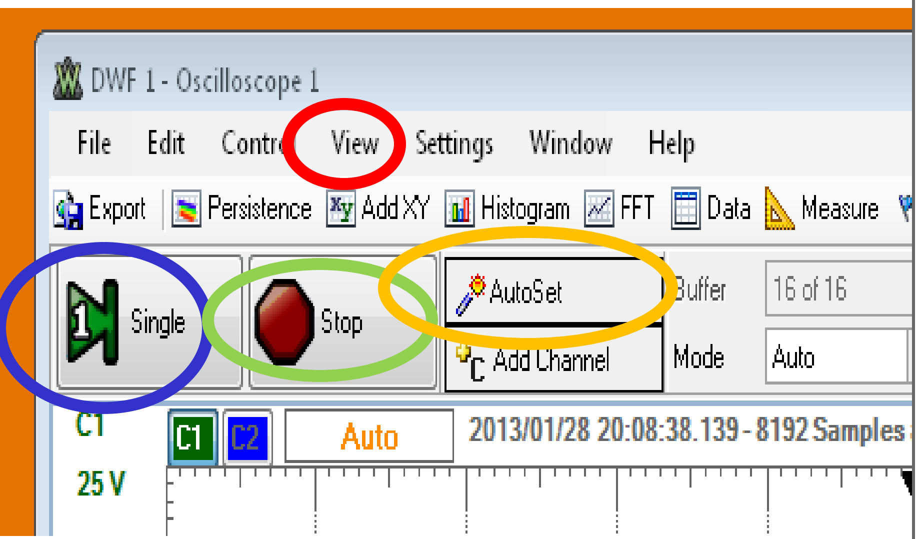


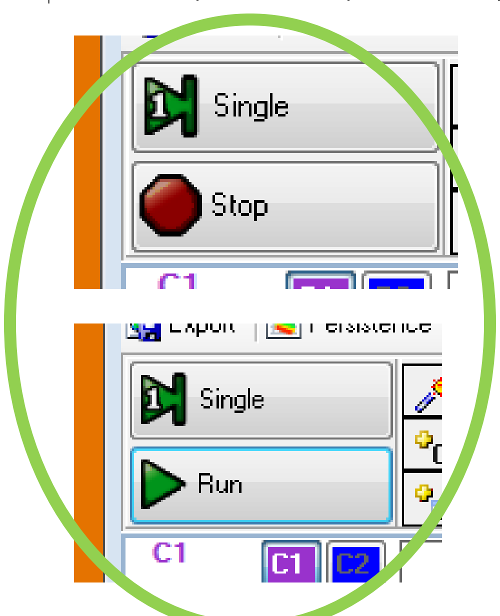
2 Channel Oscilloscope Window

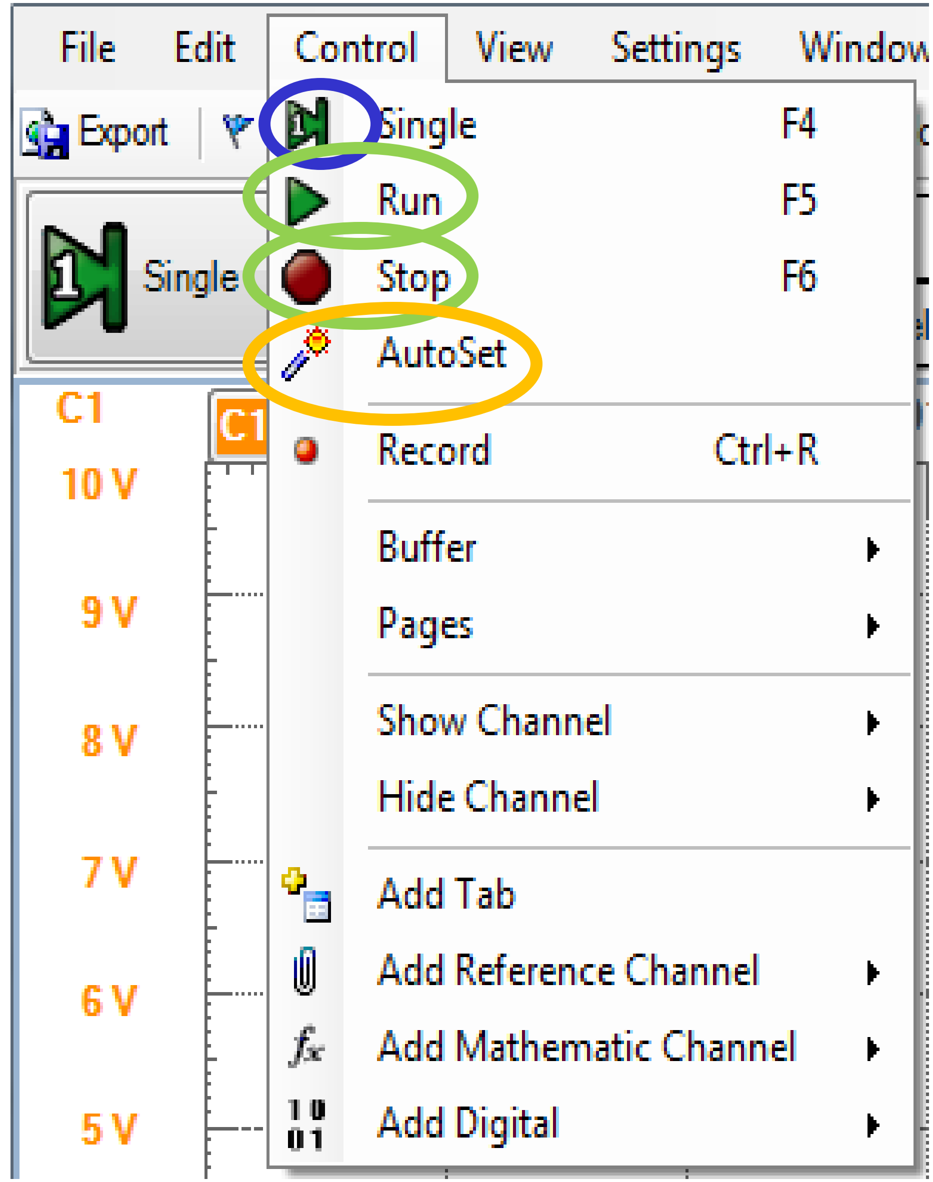


2 Channel Oscilloscope

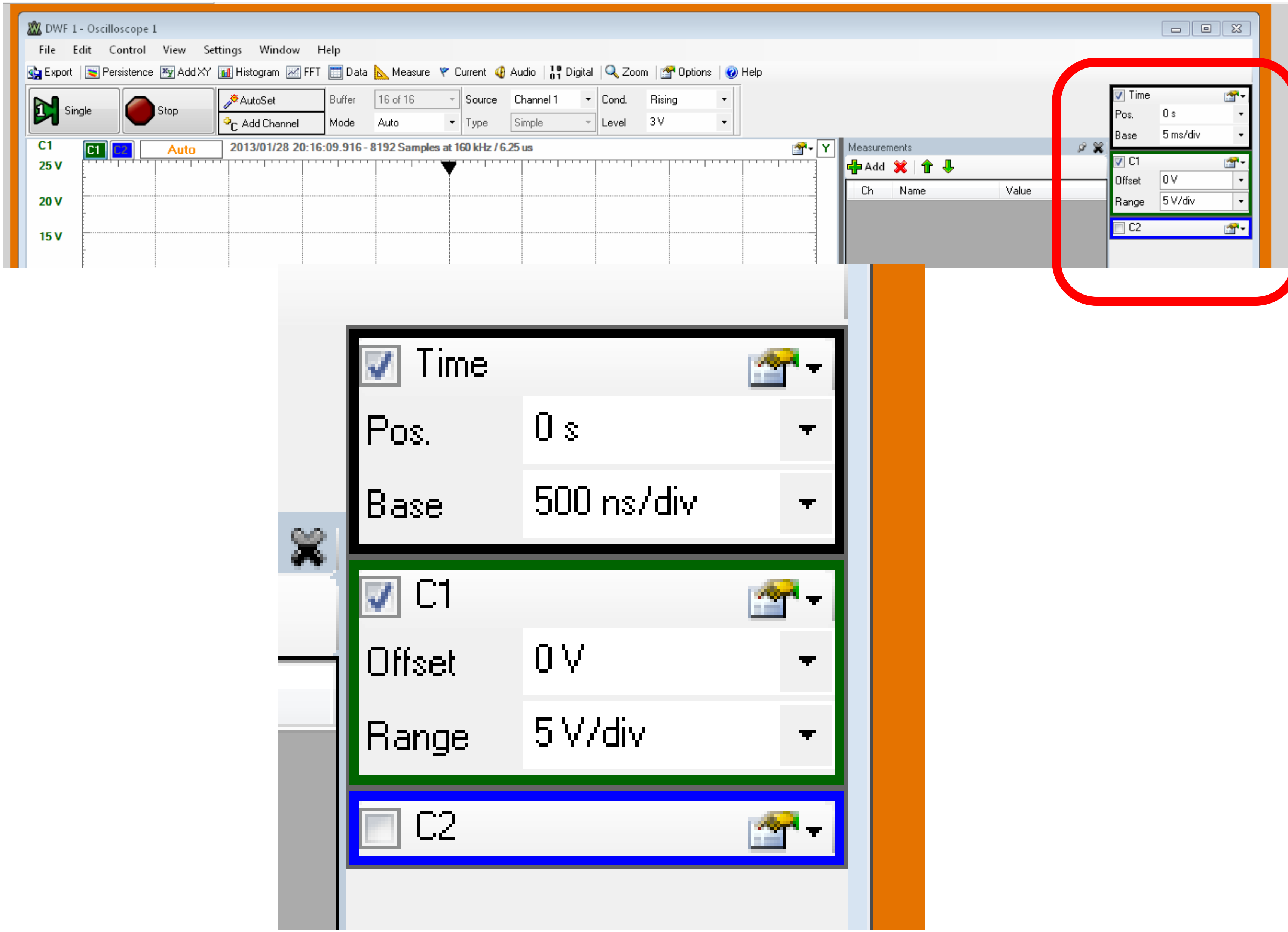
Main Toolbar & Menu-Strip



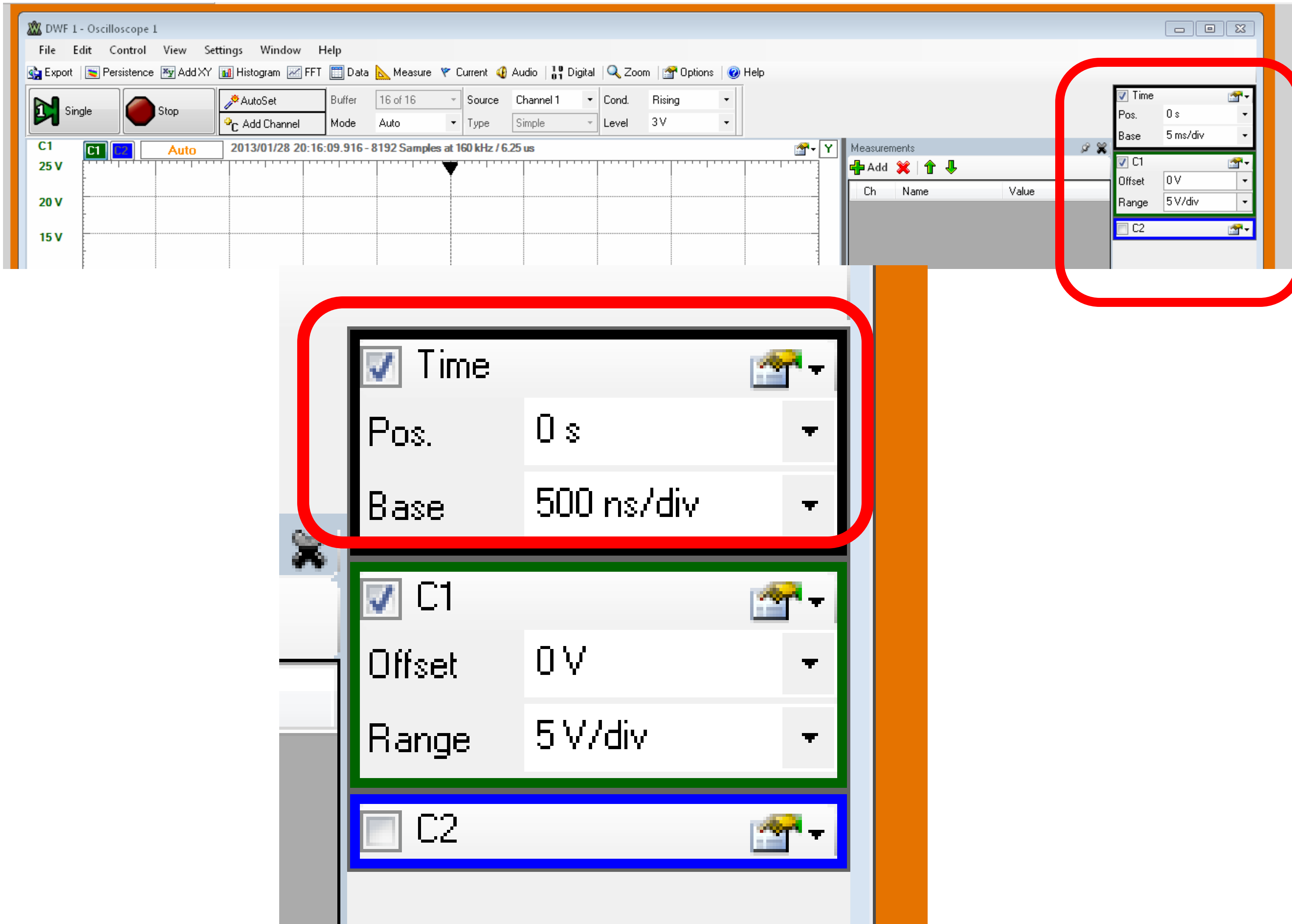




Channel Toolbar   Channel 1 & 2 Configuration
(Vertical Gain, volts/cm)



Channel Toolbar Channel 1 & 2 Configuration (Horizontal Sweep, time/cm)



Channel Toolbar Channel 1 & 2 Configuration (Trigger Configuration)

Look at 555 Data sheet and application notes

- http://www.ti.com/lit/ds/symlink/lm555.pdf

TEXAS INSTRUMENTS

LM555

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.

ADK - Oscillator / Timer - Lab.

- **Square Wave Oscillators**

✓ use ADK to observe R-C operation at inverting input pin
✓ use ADK to observe Output Waveform at op-amp output
✓ use ADK to determine frequency

- **555 Astable Mode Operation**

✓ use ADK to observe R-C operation at pin 6
✓ use ADK to observe Output Pulses at pin 3
✓ use ADK to determine frequency

Questions?