电子技术

Introduction to Electronics

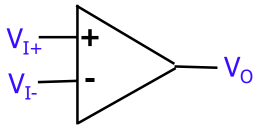
By Bao Qilian

鲍其莲

3 555 Timer

- Basic Operation
- One-shot Operation
- Astable Operation
- Schmitt Trigger Operation

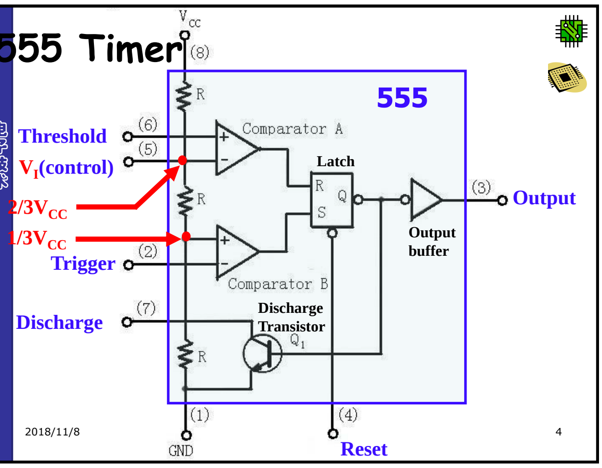
Comparator

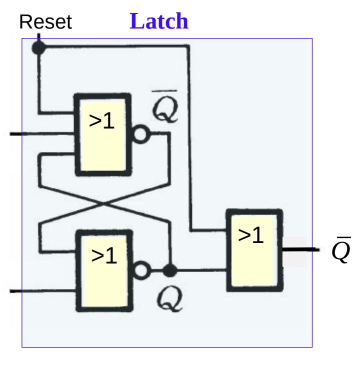


If $V_{I+} > V_{I-}$, then V_O=HIGH

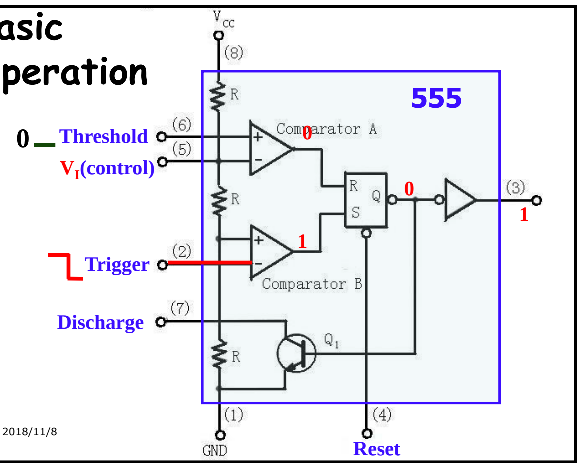
If $V_{I+} < V_{I-}$, then V_O=LOW

555 Timer

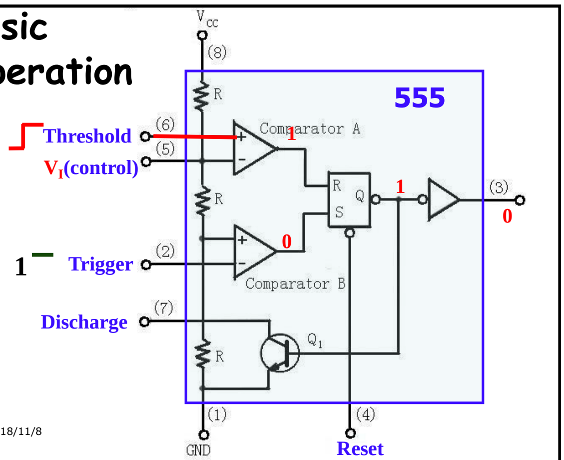


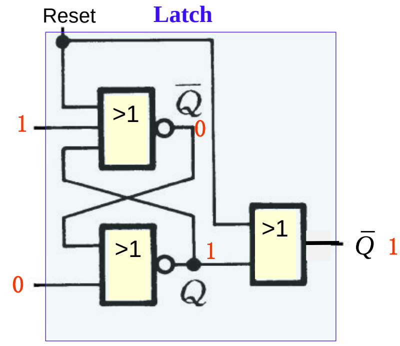


Basic Operation

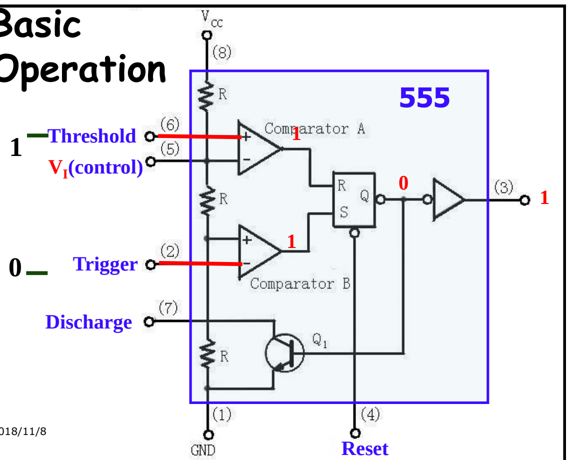


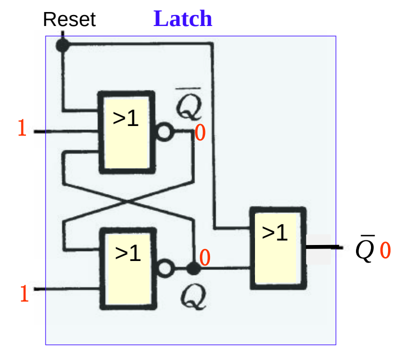
Basic Operation



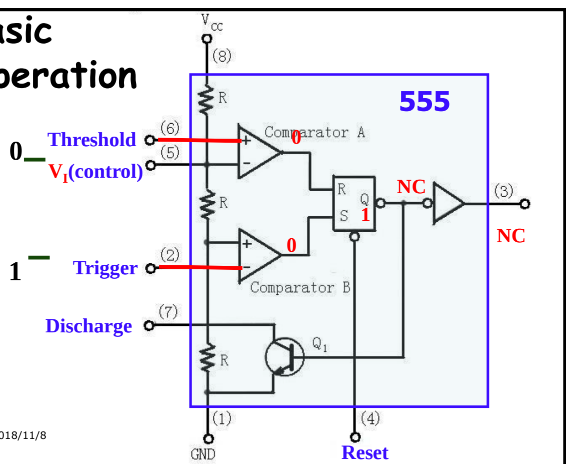


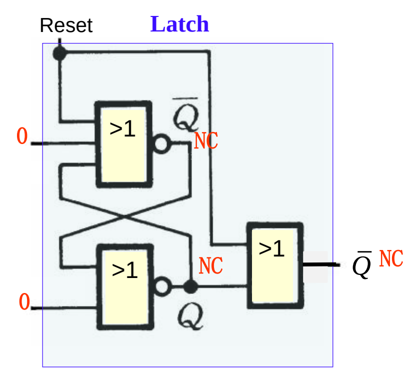
Basic Operation





Basic Operation





Functional Table

Inputs			Outputs	
Reset	V_I	Trigger	Output	Q_1
0	X	X	LOW	HIGH
1	$>2/3V_{CC}$	$>1/3V_{CC}$	LOW	HIGH
1	$<2/3V_{CC}$	$>1/3V_{CC}$	NC	NC
1	$>2/3V_{CC}$	$<1/3V_{CC}$	HIGH	LOW
1	$<2/3V_{CC}$	$<1/3V_{CC}$	HIGH	LOW

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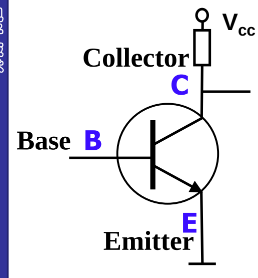

If $V_{BE}>V_{bias}$, V_c=LOW

If $V_{BE}<V_{bias}$, V_c=HIGH

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Functional Table

Inputs			Outputs		
Reset	V_I	Trigger	Output	Q_1	Transistor
0	X	X	LOW	HIGH	On
1	$>2/3V_{CC}$	$>1/3V_{CC}$	LOW	HIGH	On
1	$<2/3V_{CC}$	$>1/3V_{CC}$	NC	NC	NC
1	$>2/3V_{CC}$	$<1/3V_{CC}$	HIGH	LOW	Off
1	$<2/3V_{CC}$	$<1/3V_{CC}$	HIGH	LOW	Off

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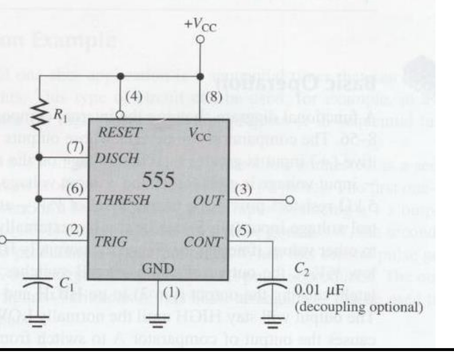
One-shot Operation



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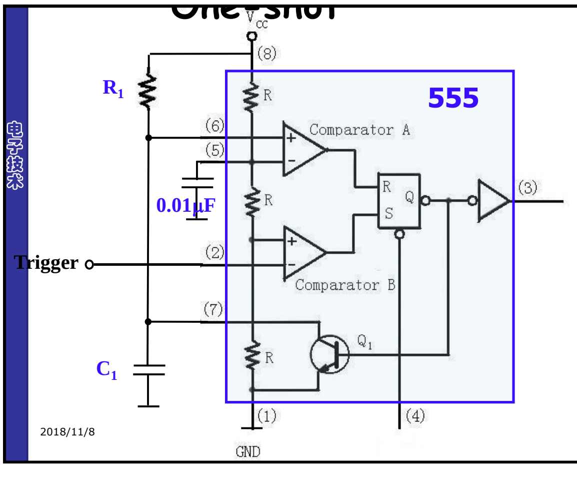
One-shot



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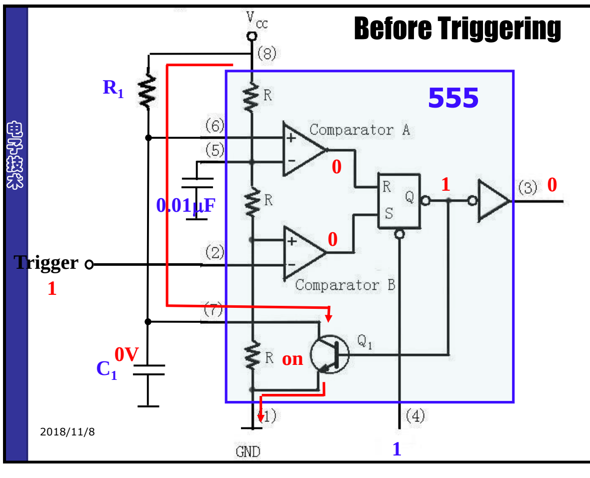
Before Triggering



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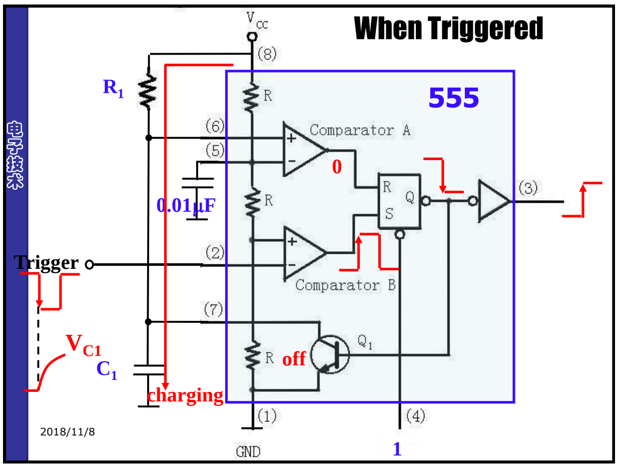
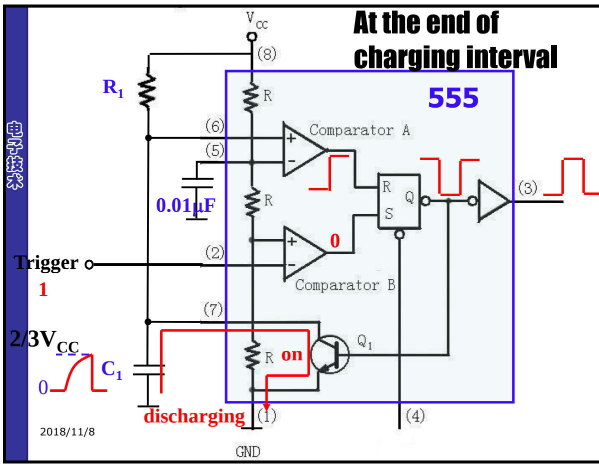
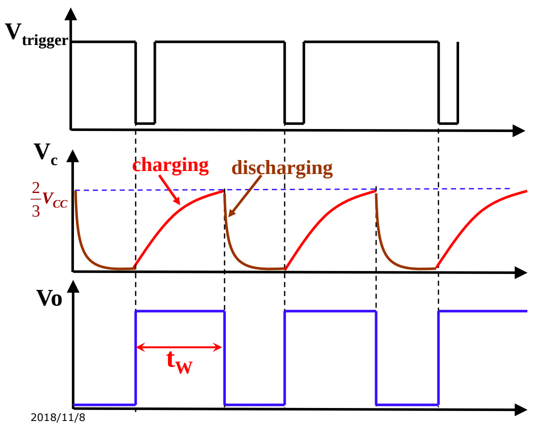
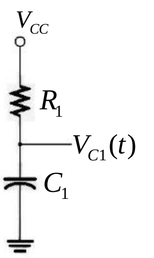






Determine the Pulse Width



$$t_0 = 0$$

$$t_W = t_1 - t_0 = t_1$$

$$R_1 C_1 \frac{dV_{C1}(t)}{dt} + V_{C1}(t) = V_{CC}$$

$$V_{C1}(t) = V_{C1}(\infty) + [V_{C1}(0) - V_{C1}(\infty)]e^{-t/R_1C_1}$$

$$e^{-t/R_1C_1} = \frac{V_{C1}(\infty) - V_{C1}(t)}{V_{C1}(\infty) - V_{C1}(0)}$$

$$t = R_1 C_1 \ln \frac{V_{C1}(\infty) - V_{C1}(0)}{V_{C1}(\infty) - V_{C1}(t)}$$

$$t_W = t_1 = R_1 C_1 \ln \frac{v(\infty) - v(0)}{v(\infty) - v(t_1)} = R_1 C_1 \ln \frac{V_{CC} - 0}{V_{CC} - \frac{2}{3}V_{CC}} = R_1 C_1 \ln 3 \approx 1.1 R_1 C_1$$

$$\boldsymbol{t_W} = \boldsymbol{R_1 C_1} \ln \frac{\boldsymbol{V_{CC}} - 0}{\boldsymbol{V_{CC}} - \frac{2}{3}\boldsymbol{V_{CC}}}$$

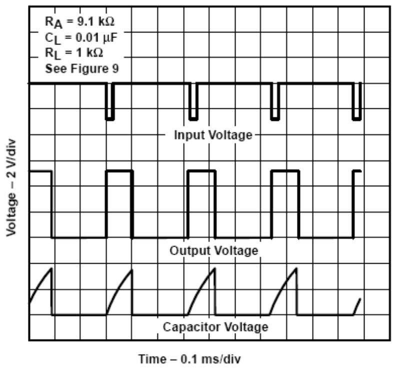
$$= \boldsymbol{R_1 C_1} \ln 3 \approx 1.1 \boldsymbol{R_1 C_1}$$

Example

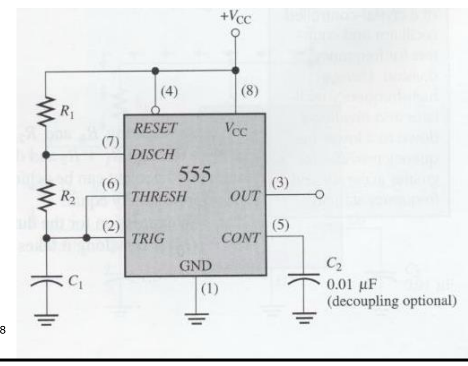
For C_1=0.01μF, determine the value of R_1 for a pulse width of 1ms.

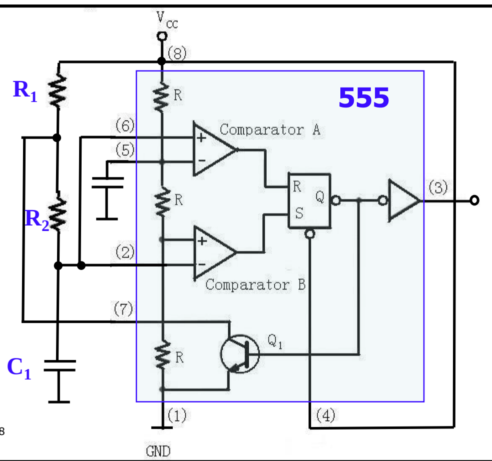
$$R_1 = \frac{t_W}{1.1C_1} = \frac{1\times10^{-3}}{1.1\times0.01\times10^{-6}} \approx 91K\Omega$$

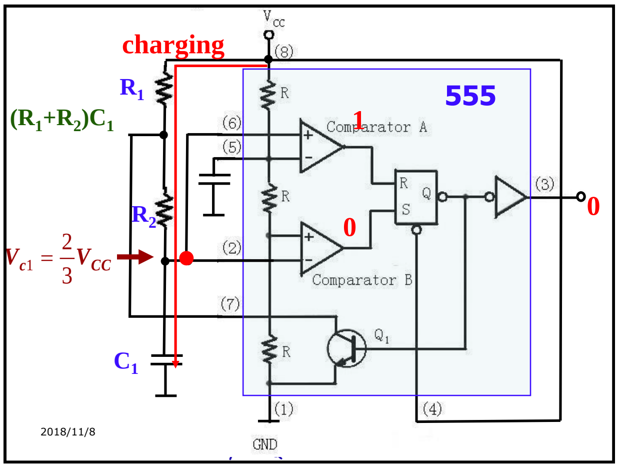
Typical Waveform for Monostable Operation

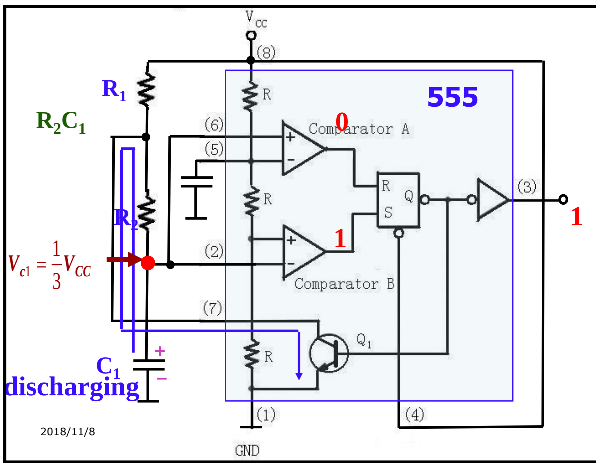


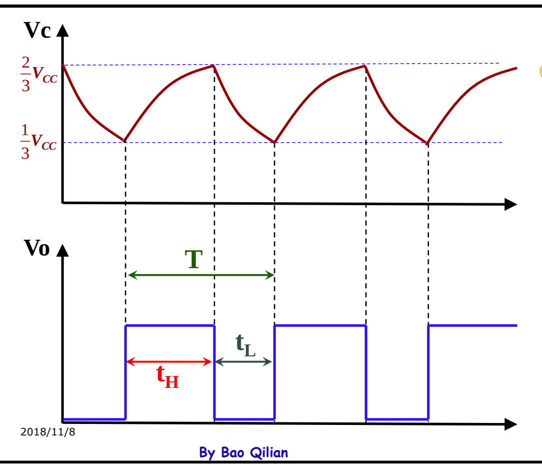
Astable Operation











电子技术

Determine the Frequency of Oscillation

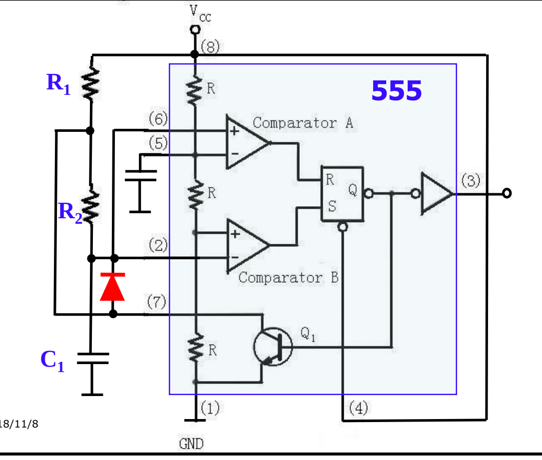
$$t_H = (R_1+R_2)C_1 \ln\frac{V_{CC}-\frac{1}{3}V_{CC}}{V_{CC}-\frac{2}{3}V_{CC}} = (R_1+R_2)C_1\ln 2 \approx 0.7(R_1+R_2)C_1$$

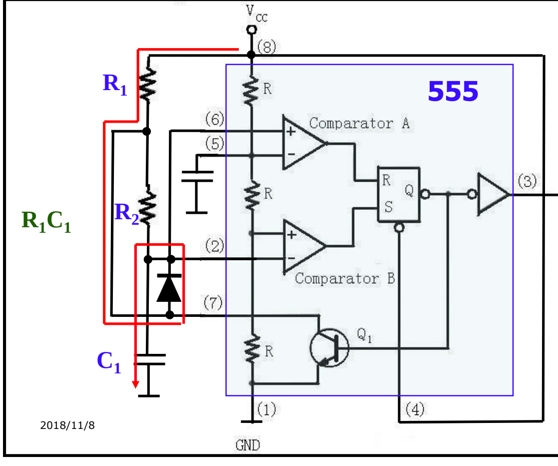
$$t_L = R_2C_1\ln\frac{0-\frac{2}{3}V_{CC}}{0-\frac{1}{3}V_{CC}} = R_2C_1\ln 2 \approx 0.7R_2C_1$$

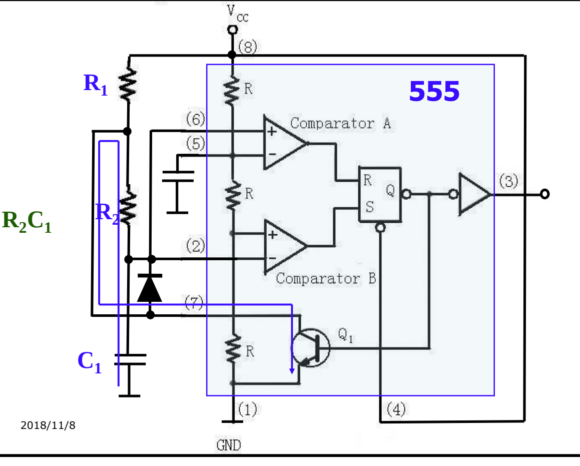
$$T = t_H + t_L = (R_1+2R_2)C_1\ln 2 \approx 0.7(R_1+2R_2)C_1$$

$$f = 1/T \approx \frac{1.44}{(R_1+2R_2)C_1}$$

$$D = t_H/T = \frac{R_1+R_2}{R_1+2R_2}100\% > \frac{R_1+R_2}{2R_1+2R_2}100\% = 50\%$$

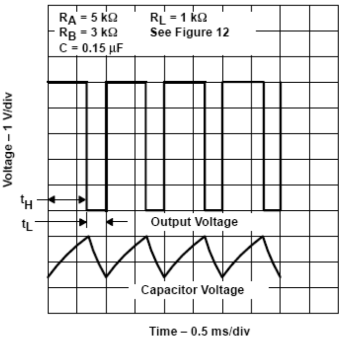






电子技术

Typical Astable Waveform



电子技术

Determine the Frequency of Oscillation

$$t_H = R_1C_1\ln\frac{V_{CC}-\frac{1}{3}V_{CC}}{V_{CC}-\frac{2}{3}V_{CC}} = R_1C_1\ln 2 \approx 0.7R_1C_1$$

$$t_L = R_2C_1\ln\frac{0-\frac{2}{3}V_{CC}}{0-\frac{1}{3}V_{CC}} = R_2C_1\ln 2 \approx 0.7R_2C_1$$

$$T = t_H + t_L = (R_1+R_2)C_1\ln 2 \approx 0.7(R_1+R_2)C_1$$

$$f = 1/T \approx \frac{1.44}{(R_1+R_2)C_1}$$

$$D = t_H/T = \frac{R_1}{R_1+R_2}100\%$$

Exercise

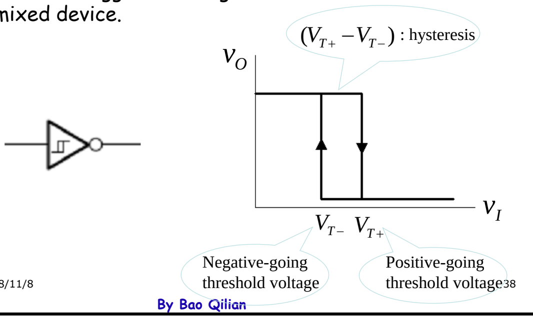
A circuit need a signal with a duty cycle of 2/3. R_1=40kΩ, Determine the value of R_2. C1=1uF

(1)Using the first connection of 555 timer.

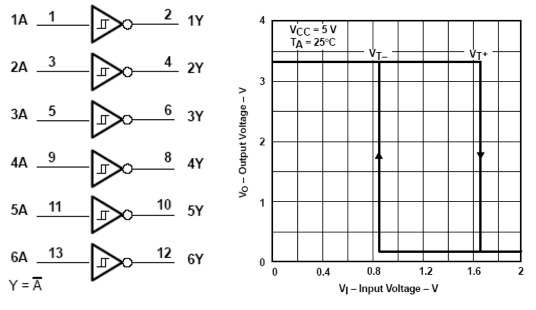
(2)Using the second connection of 555 timer.

Schmitt Trigger

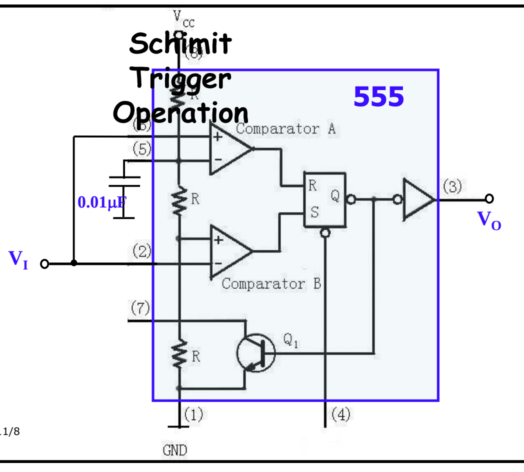
•Schmitt trigger is a special threshold circuit that produces hysteresis. Some times, the input to a Schmitt trigger is analog so it can be considered as mixed device.



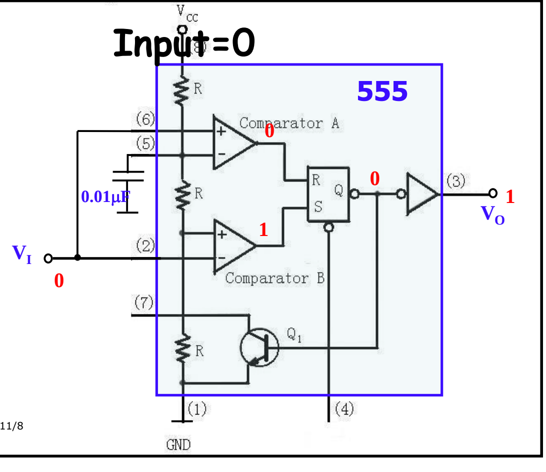
7414: Hex Schmitt-Trigger Inverters



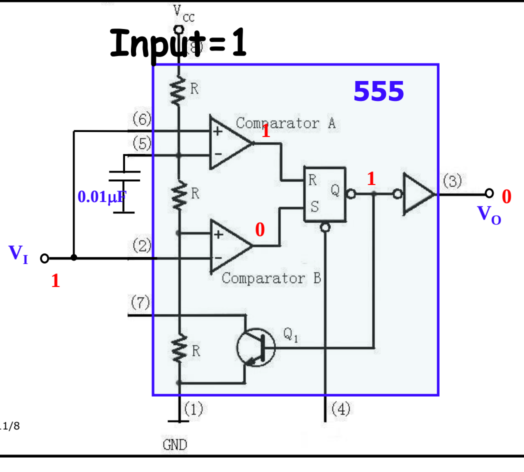
Schmitt Trigger Operation

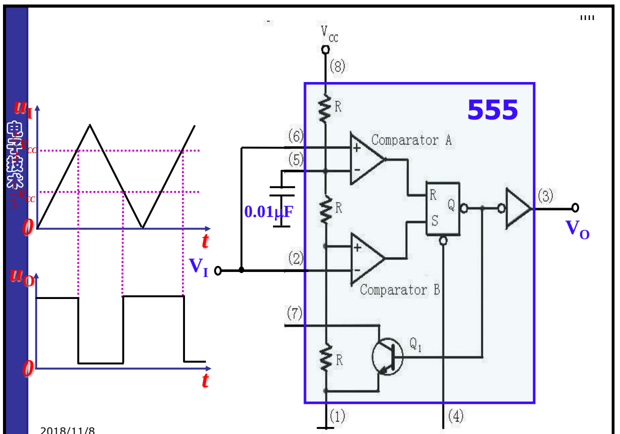


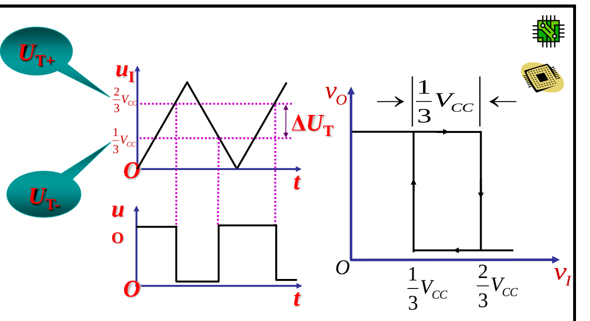
Input=0



Input=1



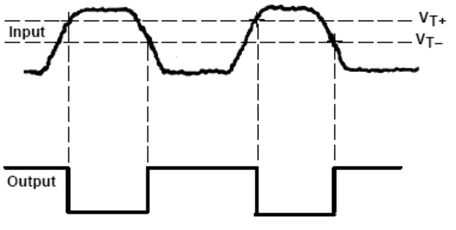




Note: if control voltage V_{CO} (PIN 5) is given, then

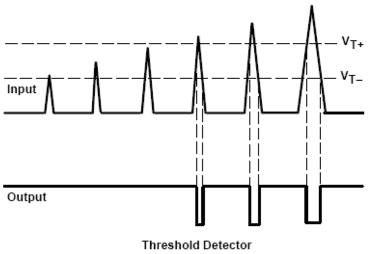
$U_{T+} = V_{CO}$ $U_{T-} = 1/2V_{CO}$ $\Delta U_{T-} = 1/2V_{CO}$

Typical Application: Pulse Shaper



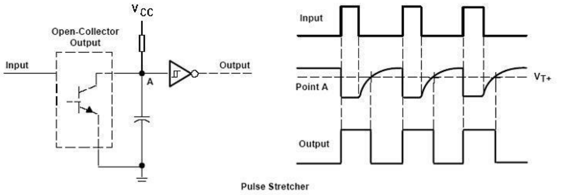
Pulse Shaper

Typical Application: Amplitude Discriminator



Threshold Detector

Typical Application: Stretch Circuit



Pulse Stretcher

Summary

- Latches
- Flip-flops
  - S-R FF
  - D FF
  - J-K FF
  - T FF
  - Master-slave FF
- One shot
- Multi-vibrator
- 555 Timer

Chapter7

27.30.31.36

补充题

[题 6.25] 图 P6.25 是用 555 定时器组成的开机延时电路。若给定 $C = 25\mu F$，$R = 91k\Omega$，$V_{CC} = 12V$，试计算常闭开关 S 断开以后经过多长的延迟时间 v_O 才跳变为高电平。

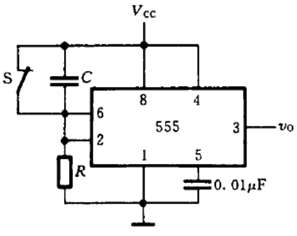


图 P6.25

[题 6.31] 图 P6.31 是用两个 555 定时器接成的延迟报警器。当开关 S 断开后，经过一定的延迟时间后扬声器开始发出声音。如果在延迟时间内 S 重新闭合，扬声器不会发出声音。在图中给定的参数下，试求延迟时间的具体数值和扬声器发出声音的频率。图中的 G_1 是 CMOS 反相器，输出的高、低电平分别为 $V_{OH} \approx 12V$，$V_{OL} \approx 0V$。

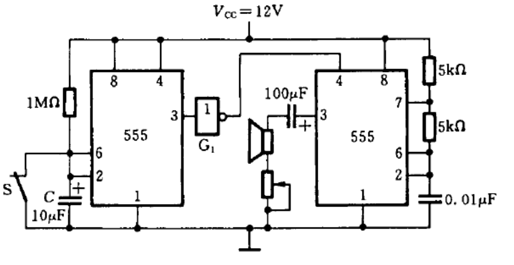
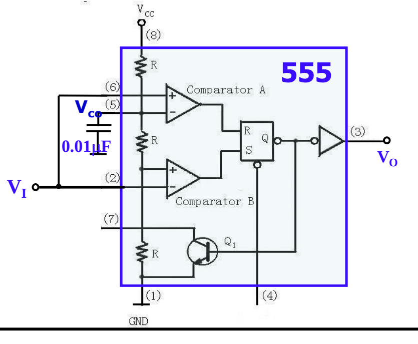


图 P6.31

[题 6.24] 在图 6.5.2 用 555 定时器接成的施密特触发器电路中，试求：

(1) 当 $V_{CC} = 12V$，而且没有外接控制电压时，V_{T+}、V_{T-} 及 ΔV_T 值。

(2) 当 $V_{CC} = 9V$、外接控制电压 $V_{CO} = 5V$ 时，V_{T+}、V_{T-}、ΔV_T 各为多少。



思考题

[题 6.32] 图 P6.32 是救护车扬声器发音电路。在图中给出的电路参数下，试计算扬声器发出声音的高、低音频率以及高、低音的持续时间。当 $V_{CC} = 12V$ 时，555 定时器输出的高、低电平分别为 11V 和 0.2V，输出电阻小于 100Ω。

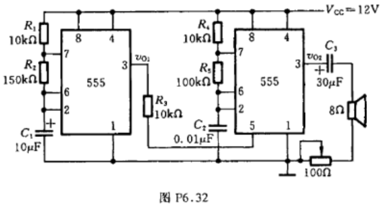


图 P6.32

[题 6.27] 试用 555 定时器设计一个单稳态触发器，要求输出脉冲宽度在 1～10 秒的范围内可手动调节。给定 555 定时器的电源为 15V。触发信号来自 TTL 电路，高低电平分别为 3.4V 和 0.1V。

［题 6.29］ 图 P6.29 是用 555 定时器构成的压控振荡器，试求输入控制电压 v_I 和振荡频率之间的关系式。当 v_I 升高时频率是升高还是降低？

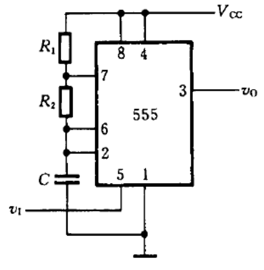


图 P6.29

［题 6.30］ 图 P6.30 是一个简易电子琴电路，当琴键 $S_1 \sim S_n$ 均未按下时，三极管 T 接近饱和导通，v_E 约为 0V，使 555 定时器组成的振荡器停振。当按下不同琴键时，因 $R_1 \sim R_n$ 的阻值不等，扬声器发出不同的声音。

若 $R_B = 20k\Omega$，$R_1 = 10k\Omega$，$R_E = 2k\Omega$，三极管的电流放大系数 $\beta = 150$，$V_{CC} = 12V$，振荡器外接电阻、电容参数如图所示，试计算按下琴键 S_1 时扬声器发出声音的频率。

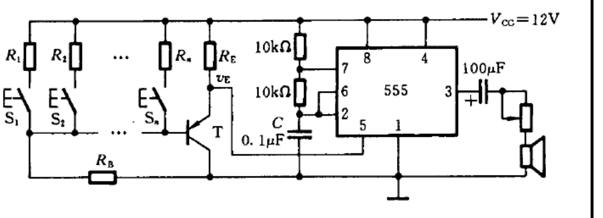
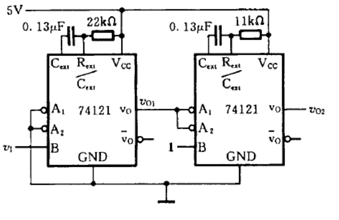
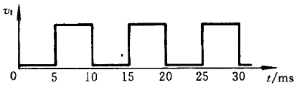


图 P6.30

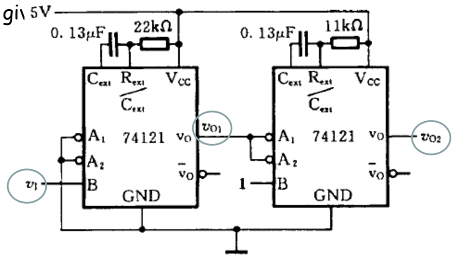
［题 6.12］ 图 P6.12 是用两个集成单稳态触发器 74121 所组成的脉冲变换电路，外接电阻和外接电容的参数如图中所示。试计算在输入触发信号 v_I 作用下 v_{O1}、v_{O2} 输出脉冲的宽度，并画出与 v_I 波形相对应的 v_{O1}、v_{O2} 的电压波形。v_I 的波形如图中所示。

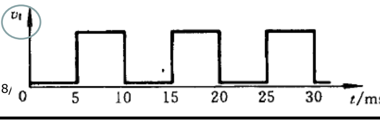




By Bao Qilian

Calculate the pulse width of Vo1 and Vo2 in the following diagram. Draw the waveforms of Vo1 and Vo2 in terms of the gi\





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