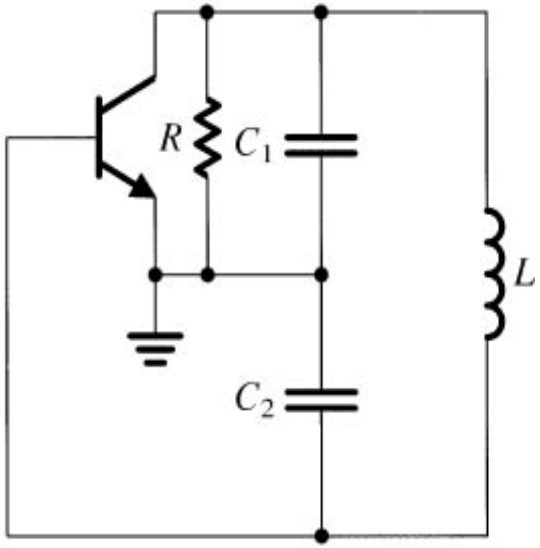
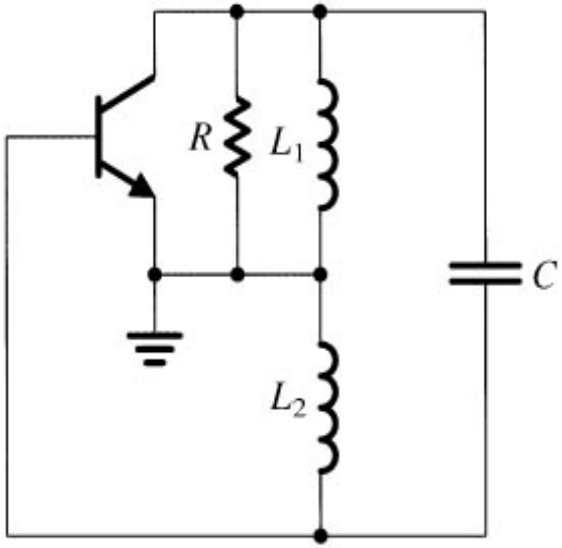
LC and Crystal Oscillators

- (a) Colpitts (b) Hartley



(a)

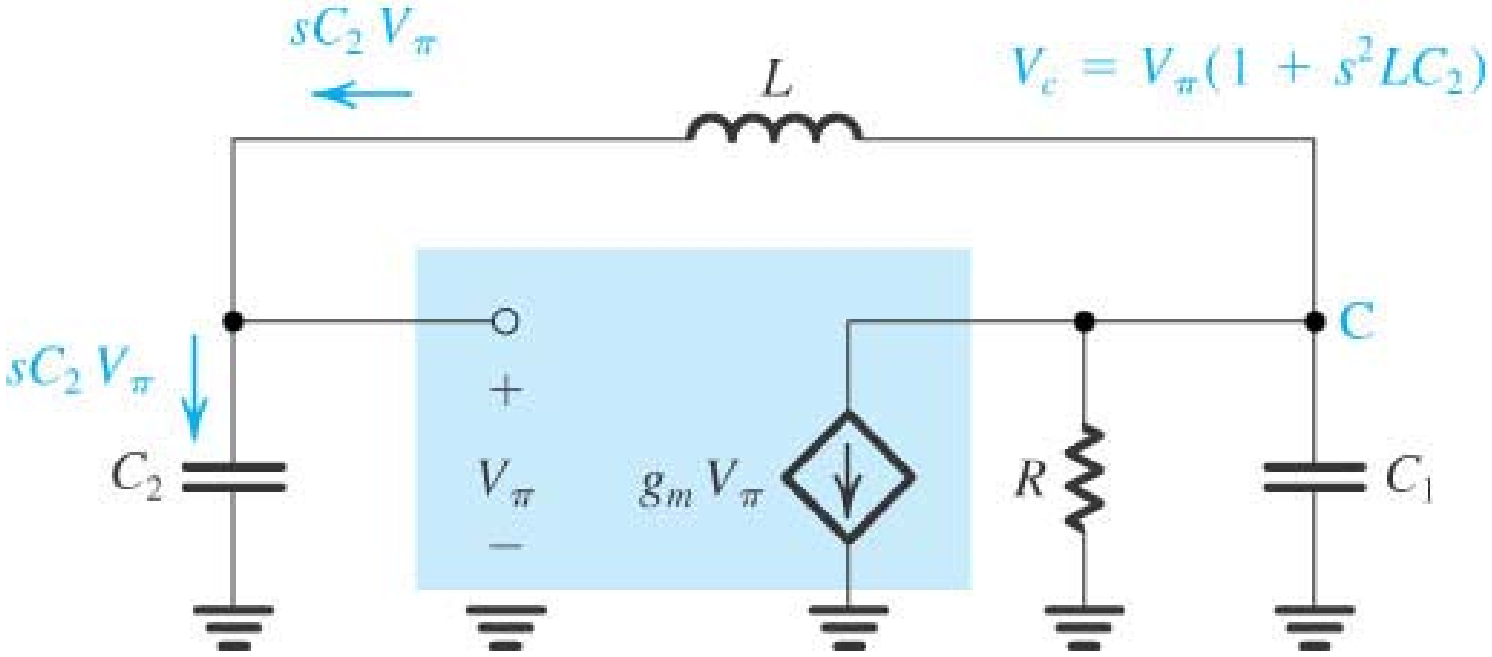


(b)

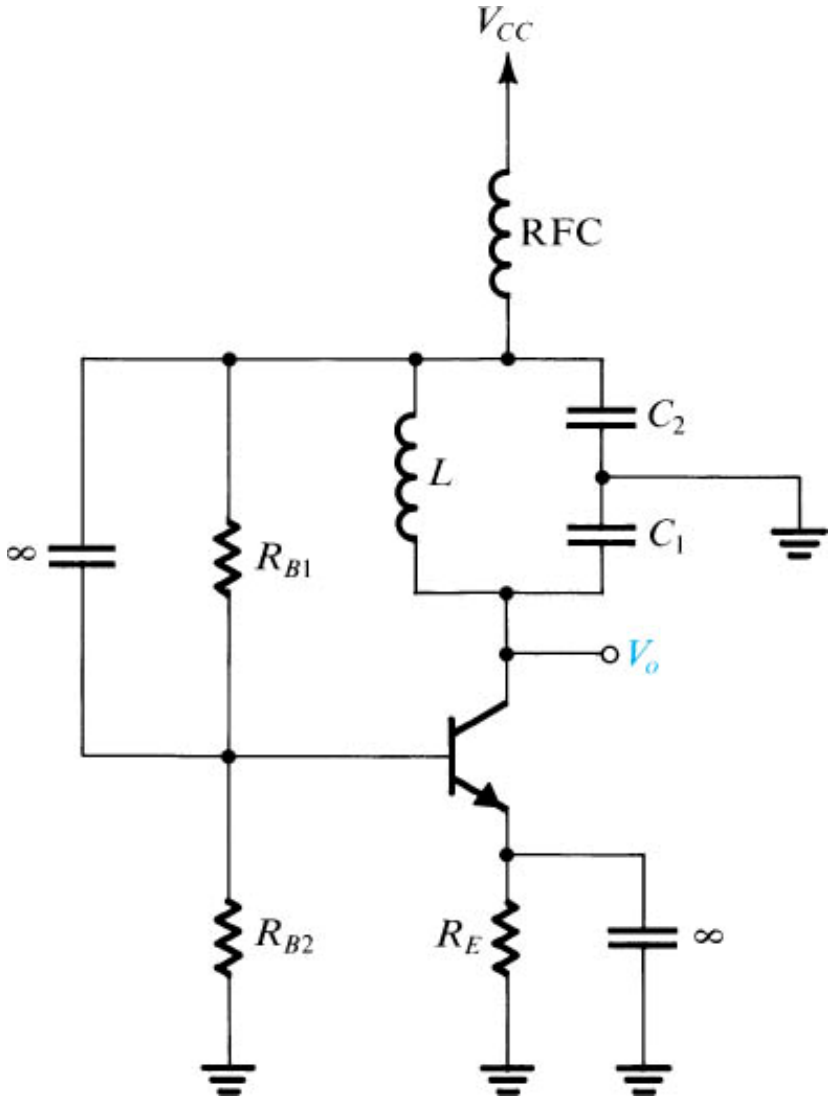
$$\omega_o = \frac{1}{\sqrt{L\left(\frac{C_1 C_2}{C_1 + C_2}\right)}}$$

$$\omega_o = \frac{1}{\sqrt{(L_1 + L_2)C}}$$

Equivalent Circuit of Colpitts Oscillator

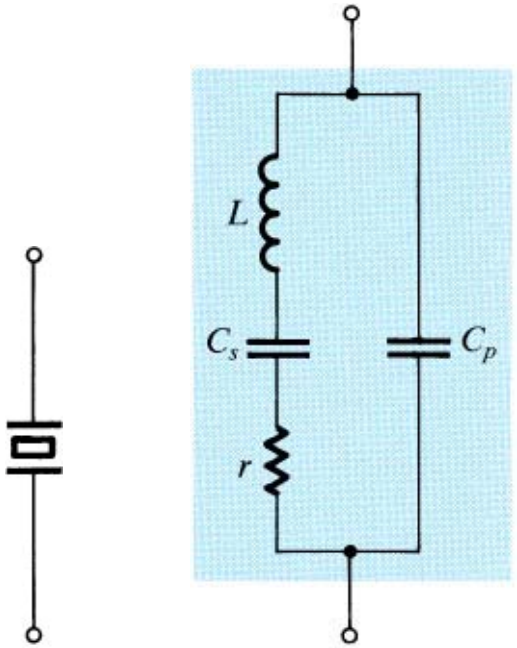


Complete circuit for a Colpitts Oscillator

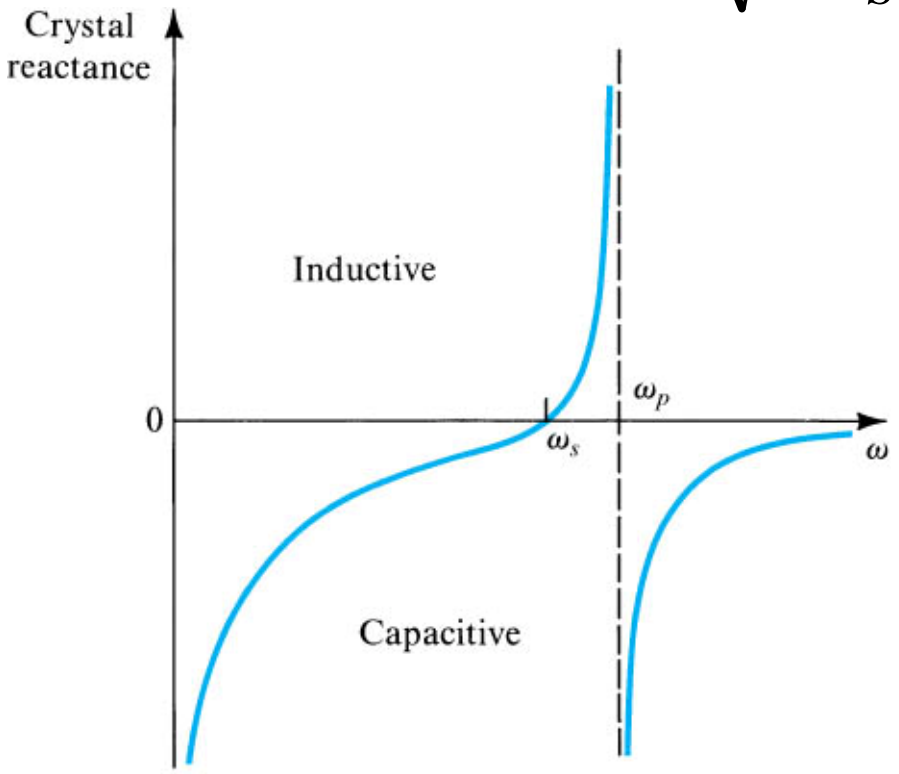


Crystal Oscillator

$$\omega_o = \frac{1}{\sqrt{LC_s}}$$

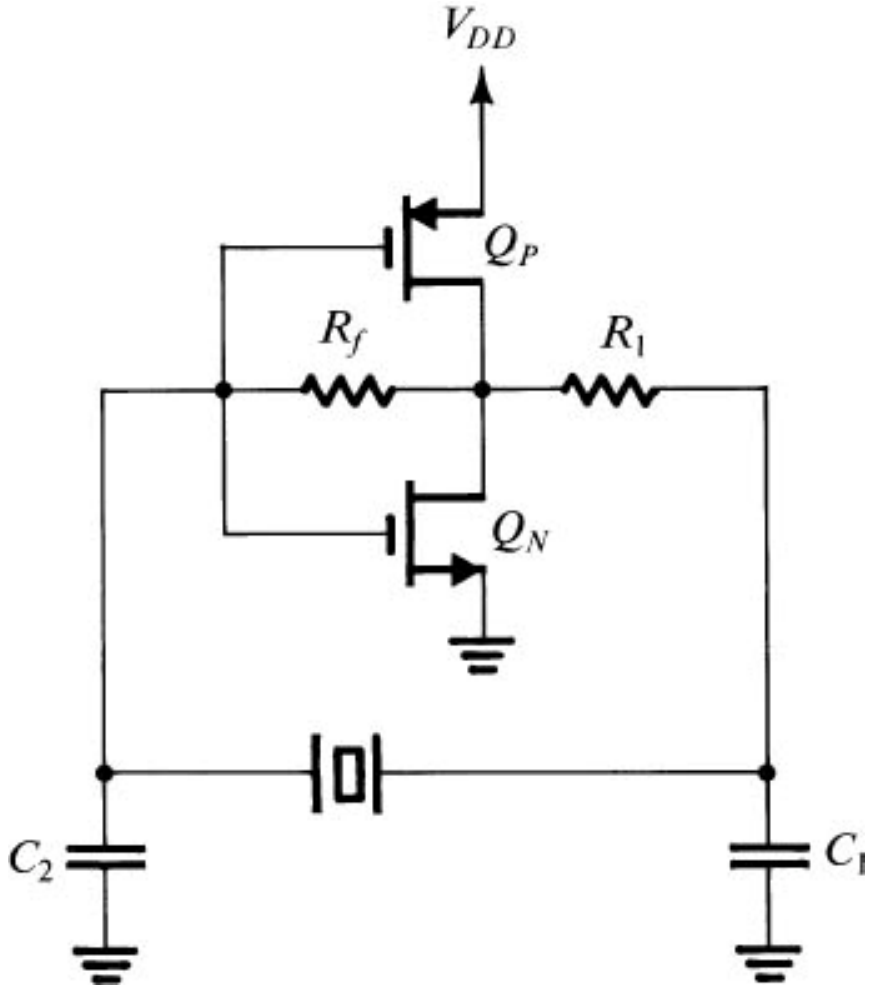


(a) (b)



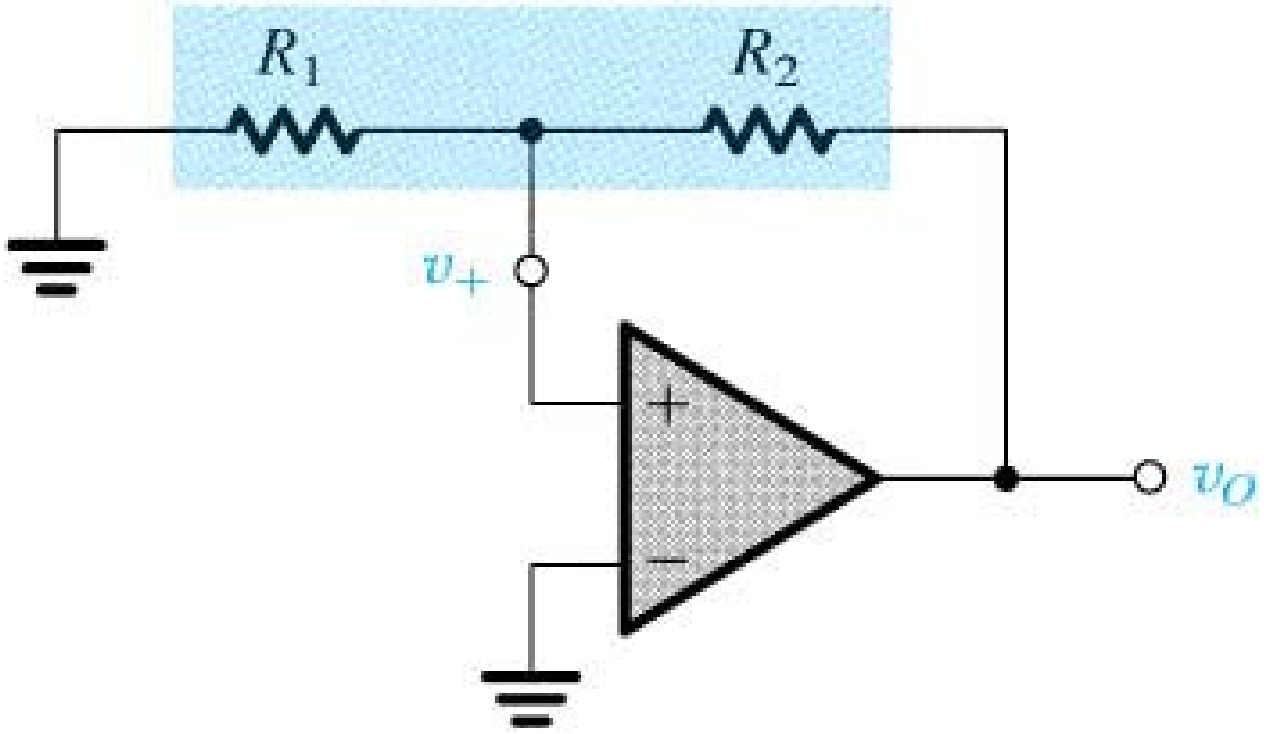
(c)

A Pierce crystal oscillator utilizing a CMOS inverter as an amplifier



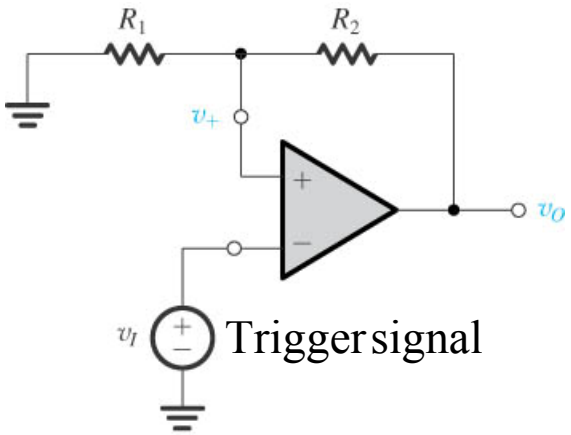
Bistable Multivibrators

Two Stable States. The circuit can remain in either state indefinitely and moves to the other stable state only when triggered.

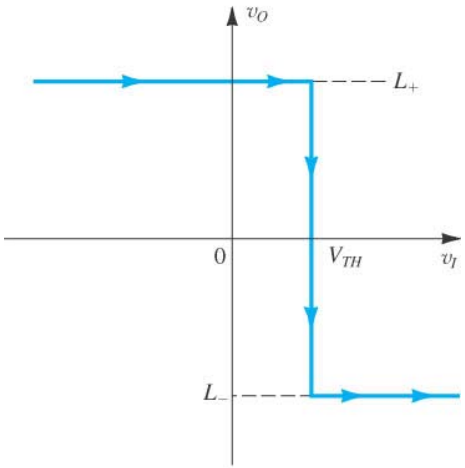


Transfer Characteristics and Triggering the Bistable Circuit

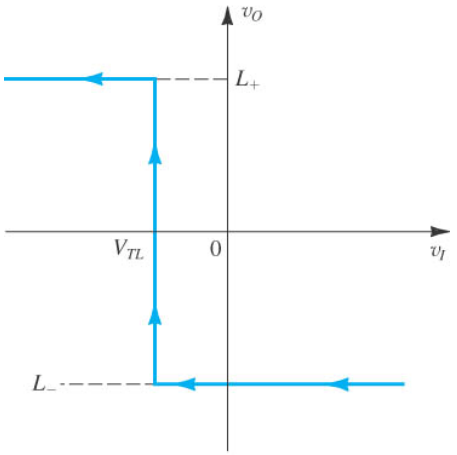
Schmitt Trigger



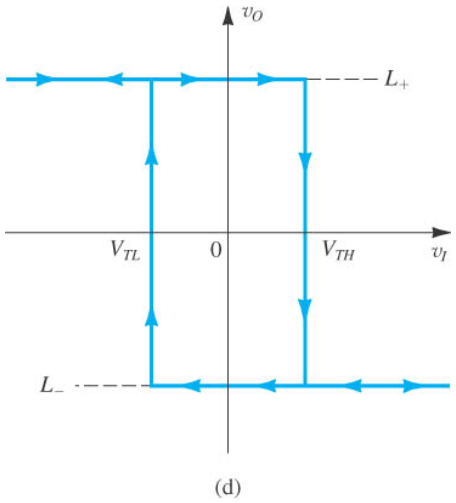
(a)



(b)



(c)



(d)

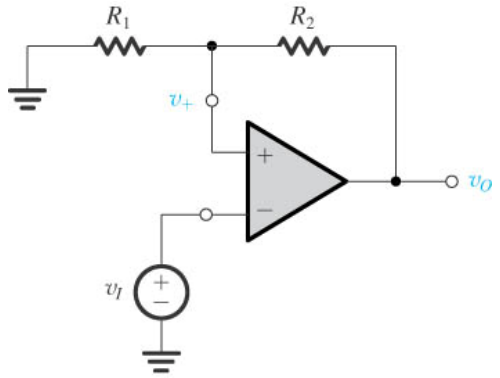
$$v+ = \left(\frac{R_1}{R_1 + R_2}\right) v_o; \; v+ = \left(\frac{R_1}{R_1 + R_2}\right) v_H$$

Crossover occurs at $v_I = v_+$ and is defined as V_{TH}

$$V_{TH} = \left(\frac{R_1}{R_1 + R_2}\right) v_H \text{; When } v_I \rangle V_{TH}$$

$$v+ = \left(\frac{R_1}{R_1 + R_2}\right) v_L \text{; As } v_I \text{ decreases } V_{TL} = \left(\frac{R_1}{R_1 + R_2}\right) v_L$$

Determine the hysterisis width of a Schmitt trigger circuit with R_1 = 10 kΩ and R_2 = 90 kΩ. Let V_H = 10 V and V_L = -10 V.



(a)

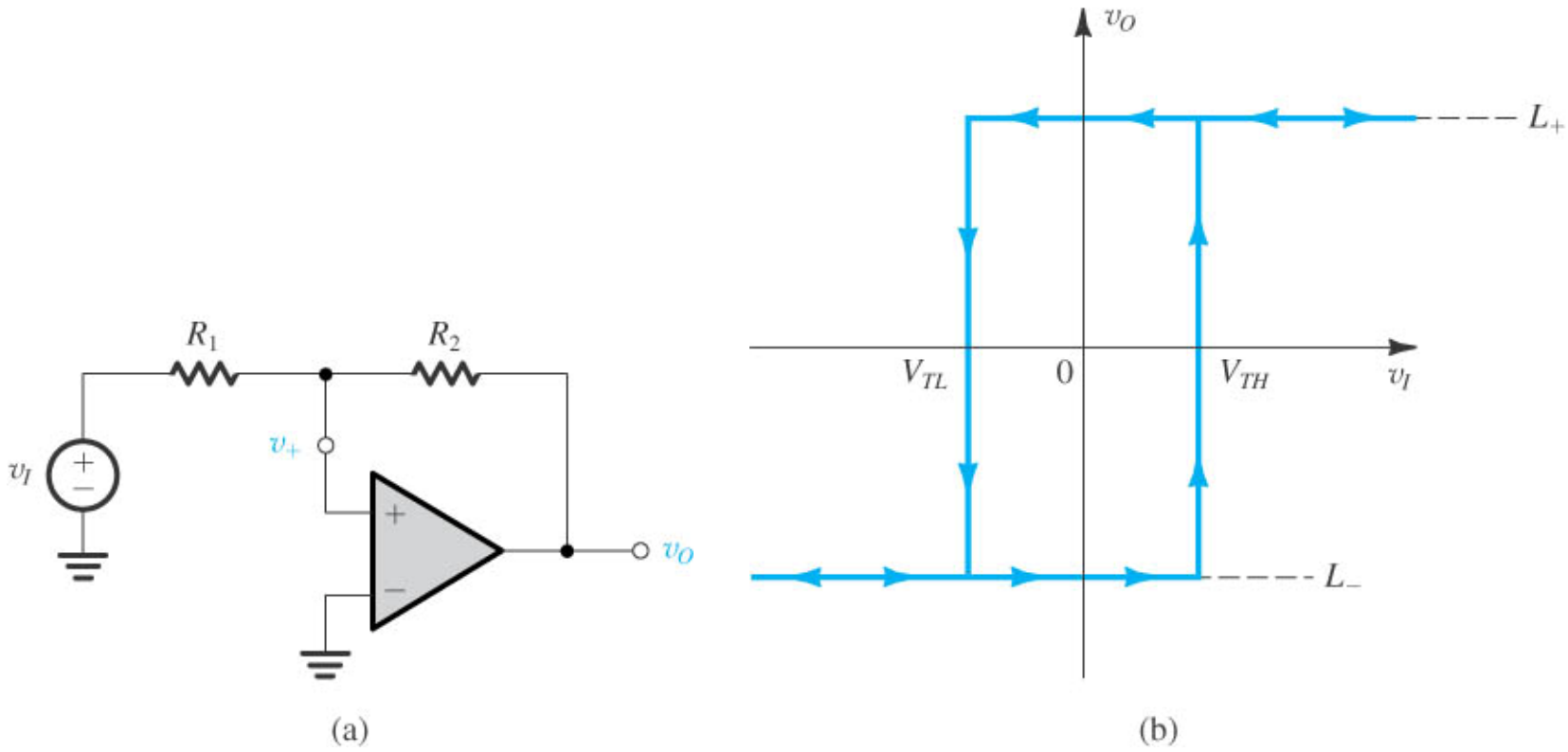
$$V_{TH} = \left(\frac{R_1}{R_1 + R_2}\right)V_H = \left(\frac{10}{10+90}\right)(10) = 1\text{V}$$

$$V_{TL} = \left(\frac{R_1}{R_1 + R_2}\right)V_L = \left(\frac{10}{10+90}\right)(-10) = -1\text{V}$$

$$V_{TL} = V_{TH} - V_{TL} = 2\text{ V}$$

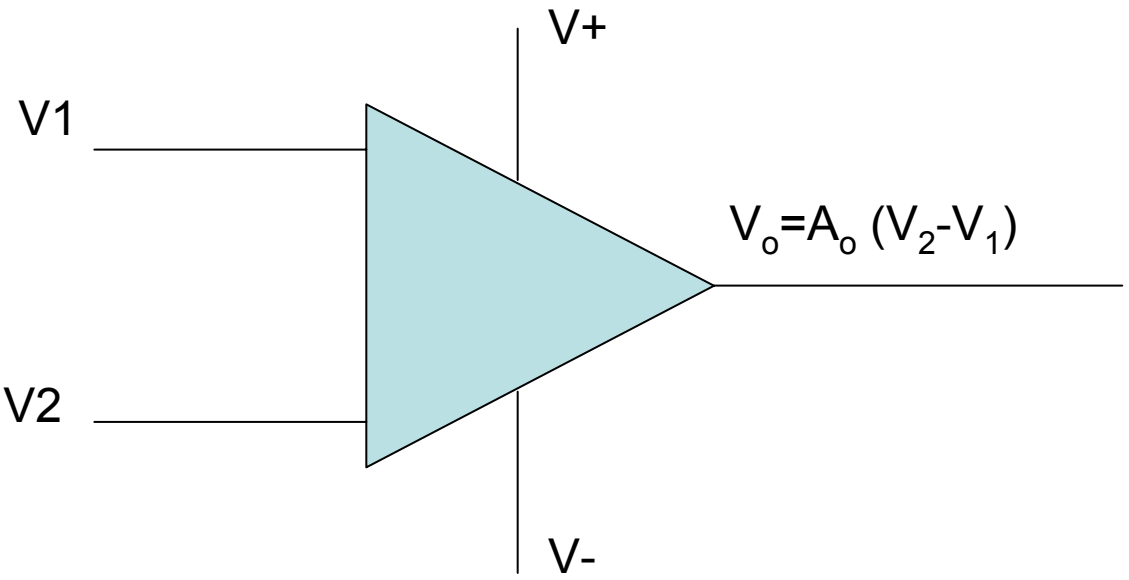
The hysteresis width can be designed to be larger or smaller for specific applications by adjusting voltage divider ratio of R_1 and R_2

A Bistable Circuit with Noninverting Transfer Characteristics



Op-Amp Open Loop Gain

- Practically, the gain is so high that the output will be driven to V+ or V- for any appreciable difference between V_1 and V_2



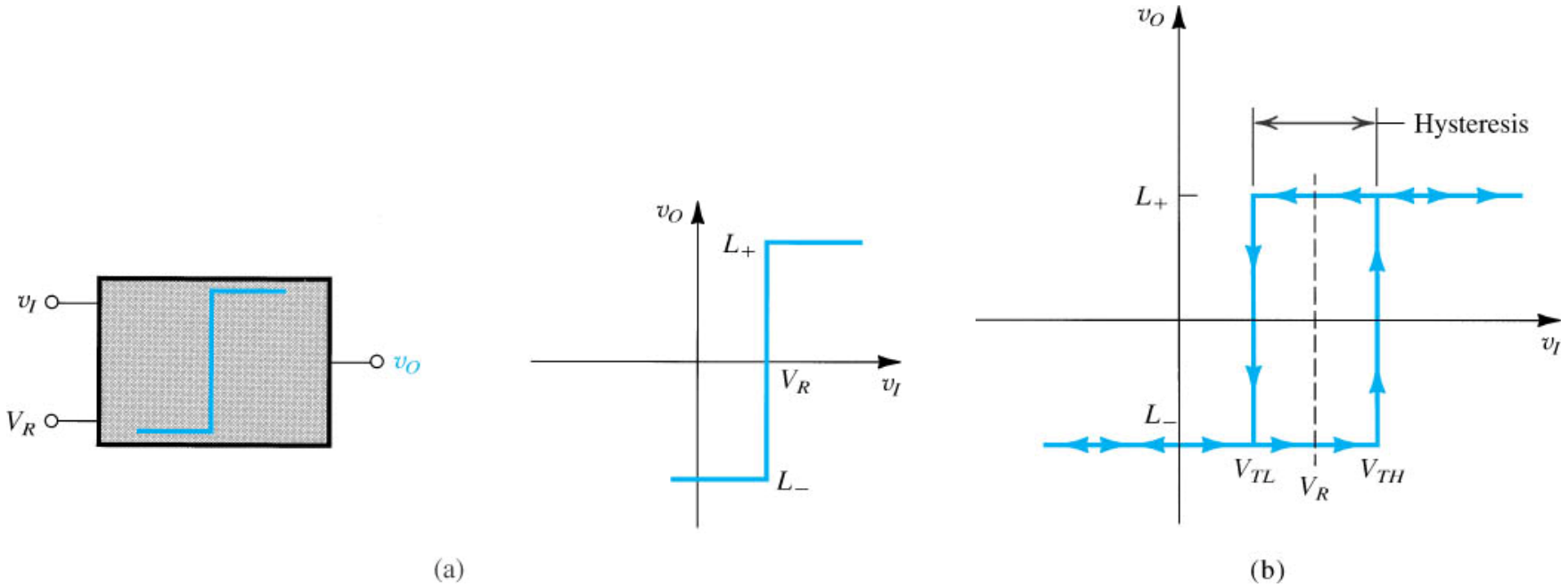
Ao is very high for 741 = 10^6

$V_2 > V_1$ the output is driven to the positive supply voltage
$V_2 < V_1$ the output is driven to the negative supply voltage
The switching time for - to + is limited by the slew rate of the op-amp.

Comparator

It is an op amp operated in an open loop configuration.
It compares two voltages to determine which is larger.
It is used in detecting the level of an input signal relative to a preset threshold value and in the design of analog-to-digital converters.
The comparator simply "compares" the input against a threshold and delivers a binary output that indicates whether the input is above or

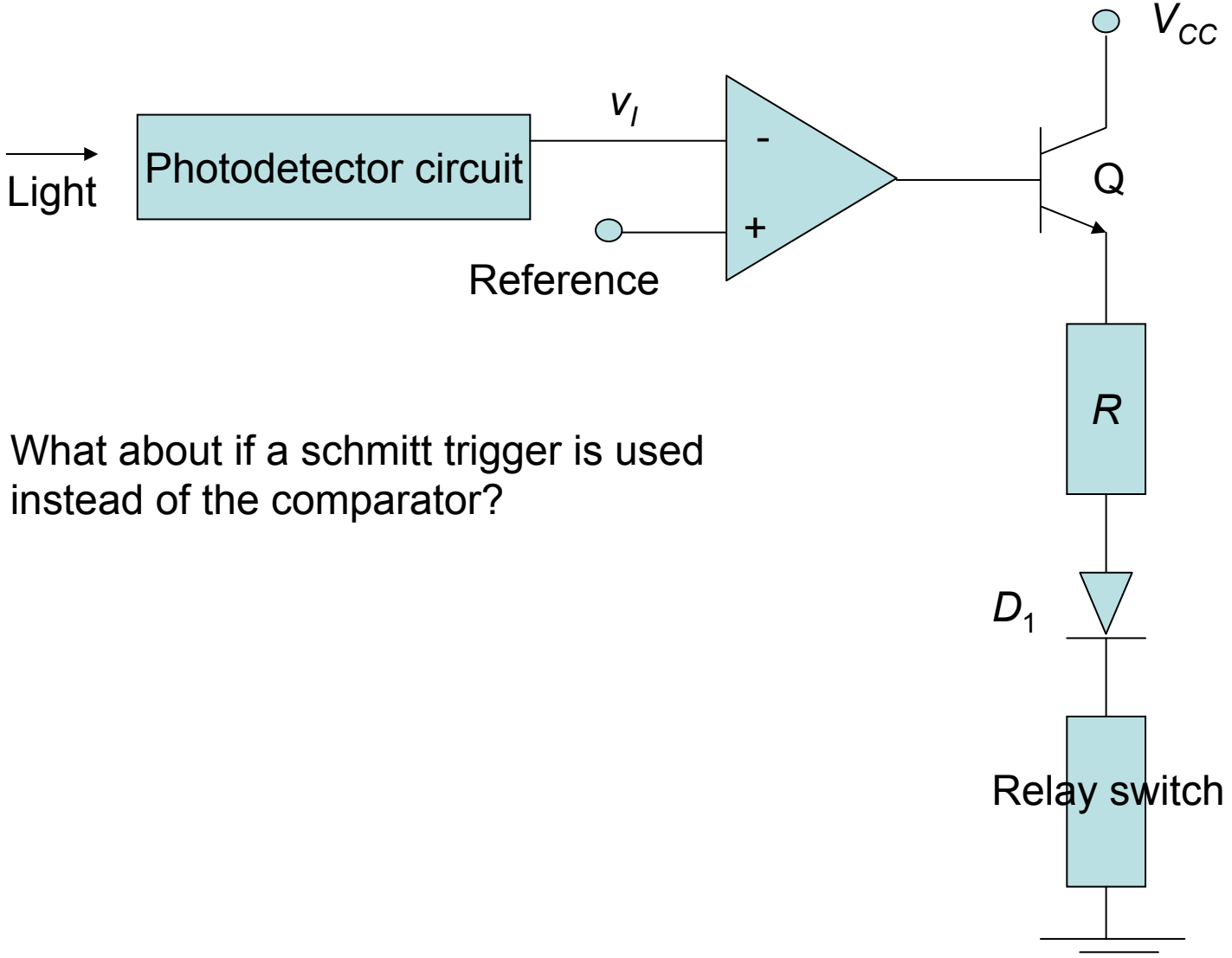
below the threshold.



The Schmitt Trigger

- The Schmitt trigger is a comparator application which switches the output negative when the input passes upward through a positive reference voltage.
- It then uses negative feedback to prevent switching back to the other state until the input passes through a lower threshold voltage, thus stabilizing the switching against rapid triggering by noise as it passes the trigger point.
- A noisy input signal to a logic gate could cause unwanted state changes near the voltage threshold. Schmitt trigger logic reduces this problem by using two voltage thresholds: a high threshold to switch the circuit during low-to-high transitions and a lower threshold to switch the circuit during high-to-low transitions. Such a trigger scheme is immune to noise as long as the peak-to-peak amplitude of the noise is less than the difference between the threshold voltages. A gate with the Schmitt trigger feature has a small hysteresis curve drawn inside the gate symbol. Schmitt triggers are mostly used in inverters or simple gates to condition slow or noisy signals before passing them to more critical parts of the logic circuit.

Example of Comparator Application: The Street Light Control



What about if a schmitt trigger is used instead of the comparator?

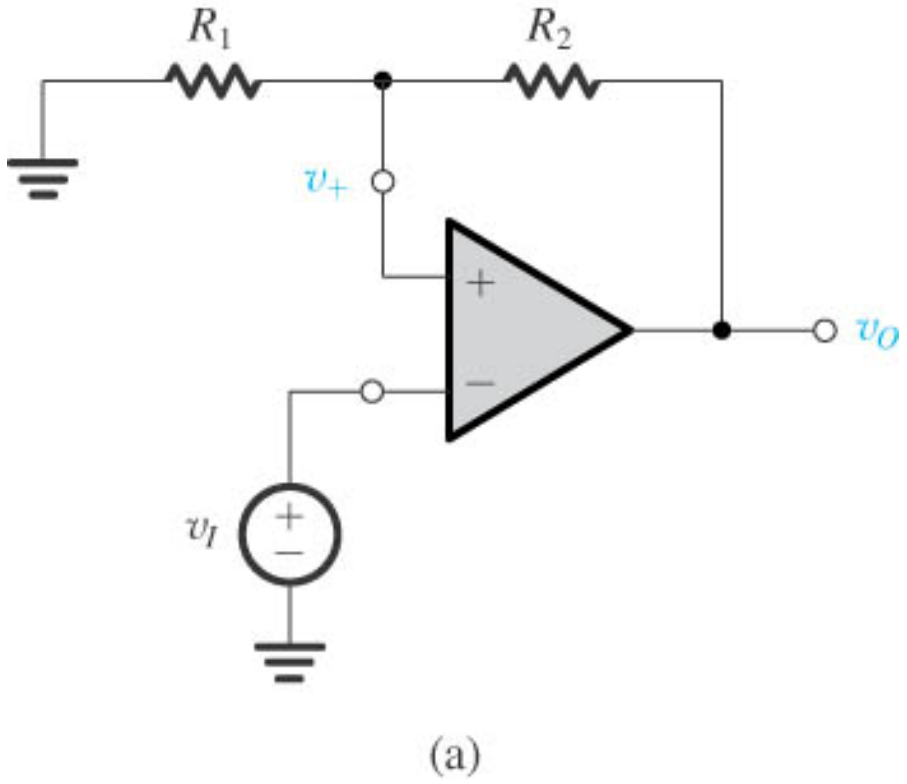
Exercise D13.11: The op amp in the bistable circuit has output saturation voltages of ±13 V. Design the circuit to obtain threshold voltages of ±5 V. For R_1 = 10 kΩ find the value of R_2.

$$V_{TH} = V_{TL} = \beta \left| L \pm \right|$$

$$5 = \frac{R_1}{R_1 + R_2} \times 13$$

$$\frac{R_2}{R_1} = 1.6$$

$$R_2 = 16\,\text{k}\Omega$$



(a)

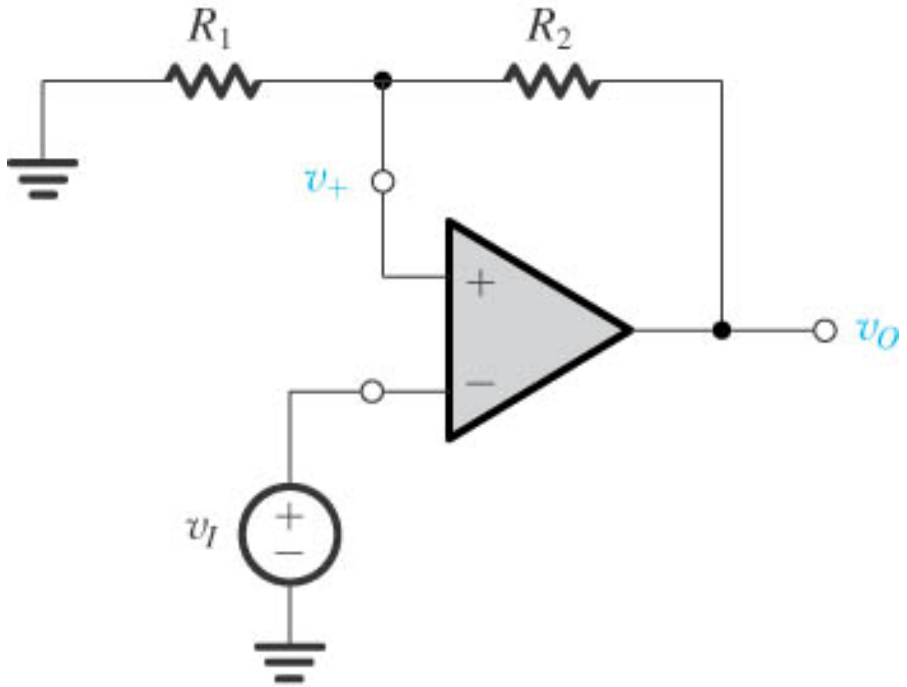
Exercise D13.12: The op amp in the circuit has output saturation voltages of ±10 V. Design the circuit to obtain threshold voltages of ±5 V. Give suitable component values.

$$V_{TH} - V_{TL} = \frac{R_1}{R_2}|L|$$

$$5 = \frac{R_1}{R_2} \times 10$$

$$R_2 = 2R_1$$

$$R_1 = 10\,\text{k}\Omega \quad R_2 = 20\,\text{k}\Omega$$



(a)