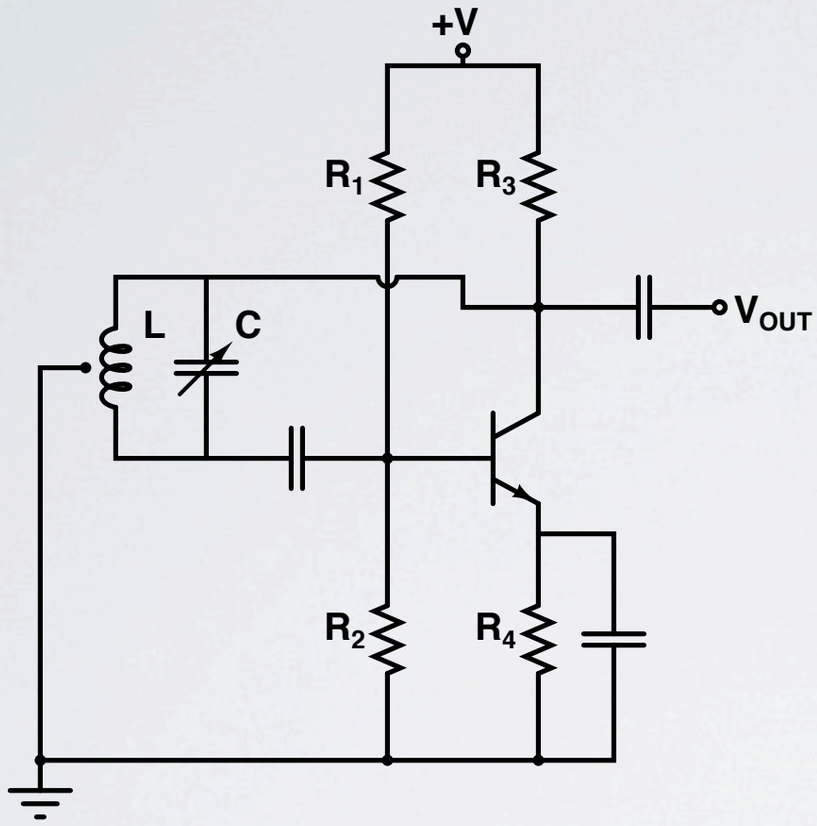
V-F & F-V CONVERTERS

INEL 5205 Instrumentation

- frequency is easily measured
- frequency can be measured with high precision
- frequency is robust to interference, voltage drops and other factors that affect amplitude

Hartley Osc.



C = Capacitive sensor

$$f = \frac{1}{\sqrt{LC}}$$

LM131/LM231 Converter

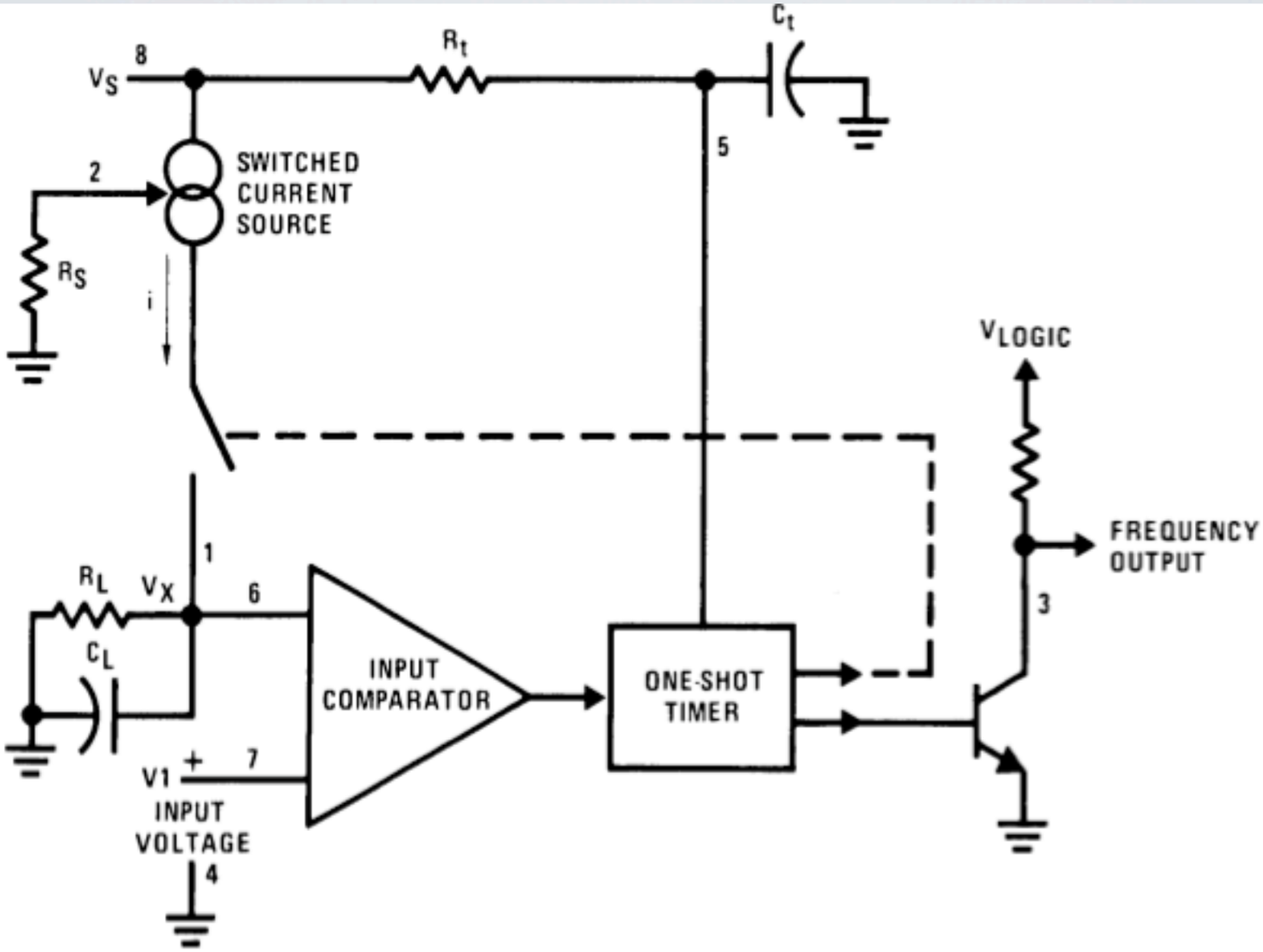


FIGURE 2. Simplified Block Diagram of Stand-Alone Voltage-to-Frequency Converter and External Components

The voltage comparator compares a positive input voltage, V_{IN}, at pin 7 to the voltage, V_x, at pin 6. If $V_{IN} > V_x$

- The comparator will trigger the 1-shot timer.
- The output of the timer will turn ON both the frequency output transistor and the switched current source for a period $t = 1.1 \times R_t C_t$.
- During this period, the current i will flow out of the switched current source and provide a fixed amount of charge, $Q = i \times t$, into the capacitor, C_L.
- This will normally charge V_x up to a higher level than V_{IN}.

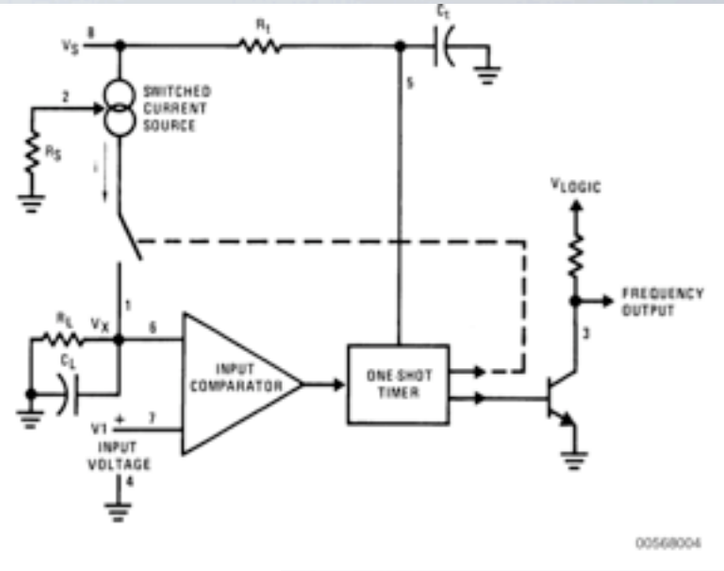
At the end of the timing period $1.1 \times R_t C_t$

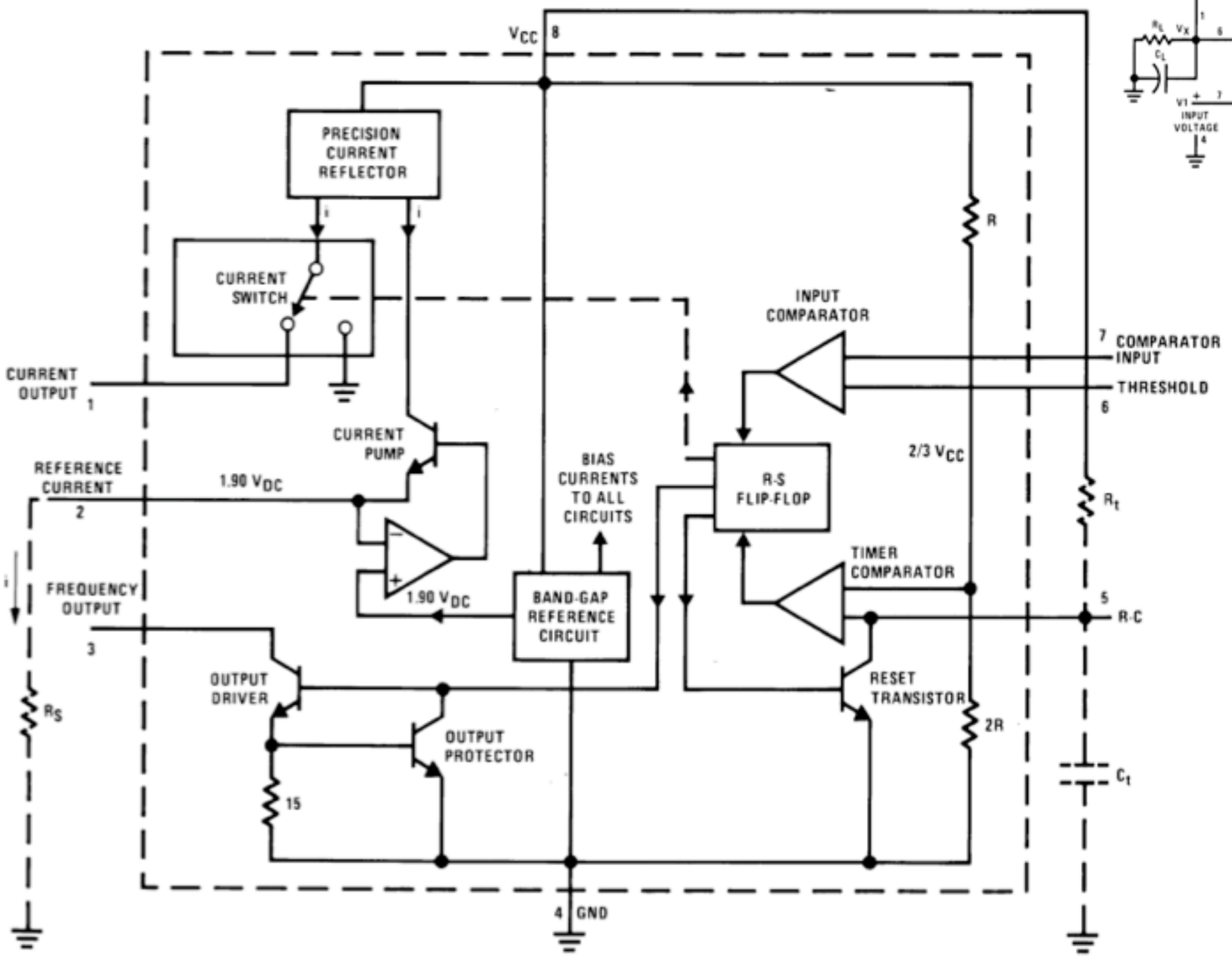
- the timer will reset itself, and the current i will turn OFF,
- Now there is no current flowing from pin 1, and
  - the capacitor C_L will be gradually discharged by R_L until $V_x < V_{IN}$
  - then the comparator will trigger the timer and start another cycle.

Current flowing into C_L : $I_{AVE} = i \times (1.1 \times R_t C_t) \times f$
Current flowing out of C_L : $V_x/R_L \approx V_{IN}/R_L$.

If V_{IN} is doubled, the frequency will double to maintain this balance. Even a simple V-to-F converter can provide a frequency precisely proportional to its input voltage over a wide range of frequencies.

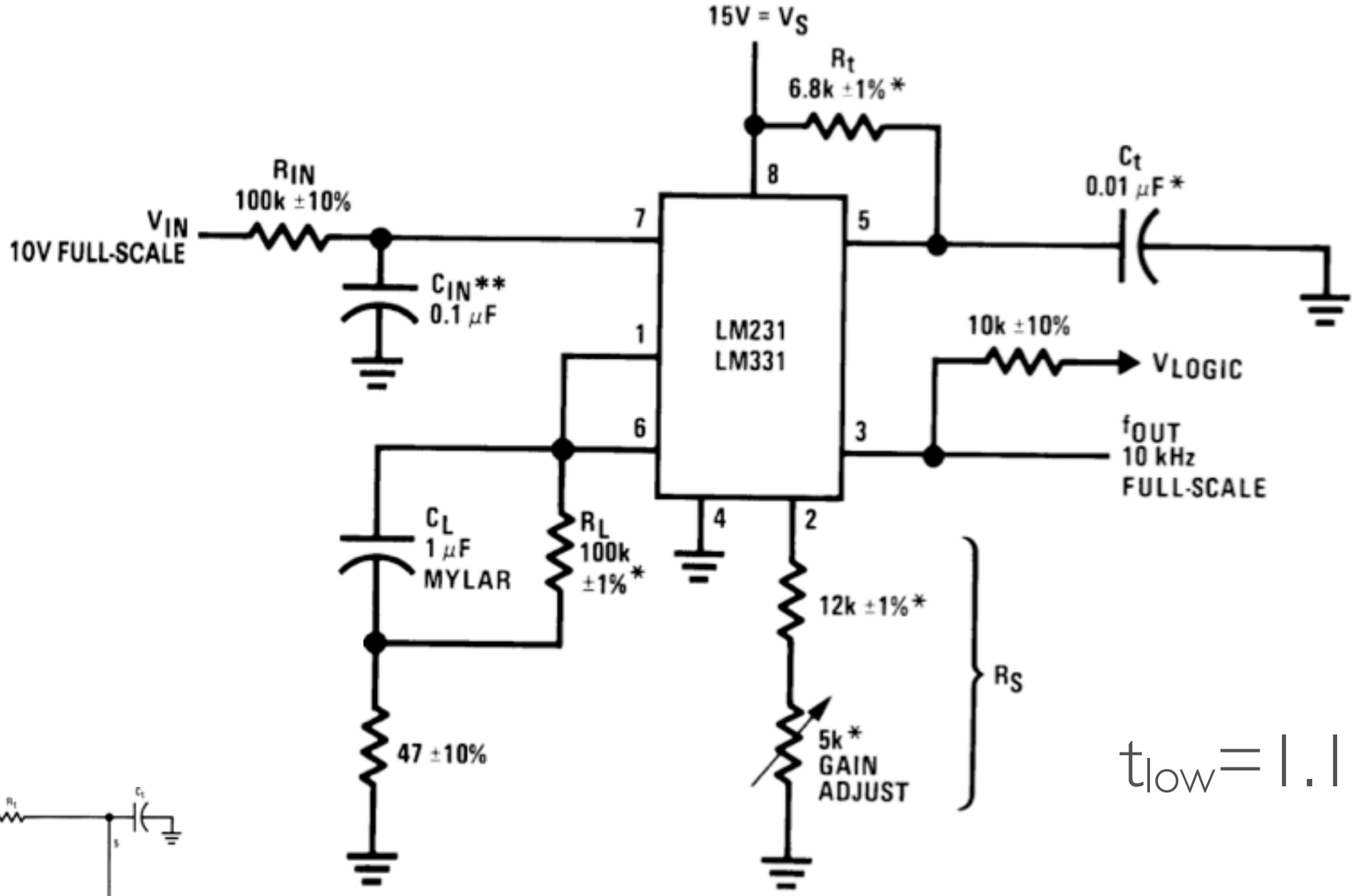
Functional Block Diagram

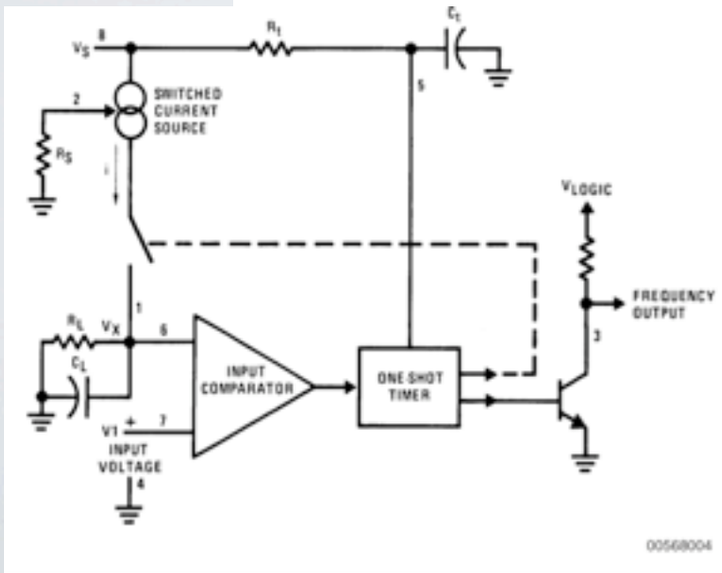




Pin numbers apply to 8-pin packages only.

FIGURE 1.





$$f_{OUT} = \frac{V_{IN}}{2.09\ V} \bullet \frac{R_S}{R_L} \bullet \frac{1}{R_t C_t}$$

$t_{low} = 1.1 R_t C_t$

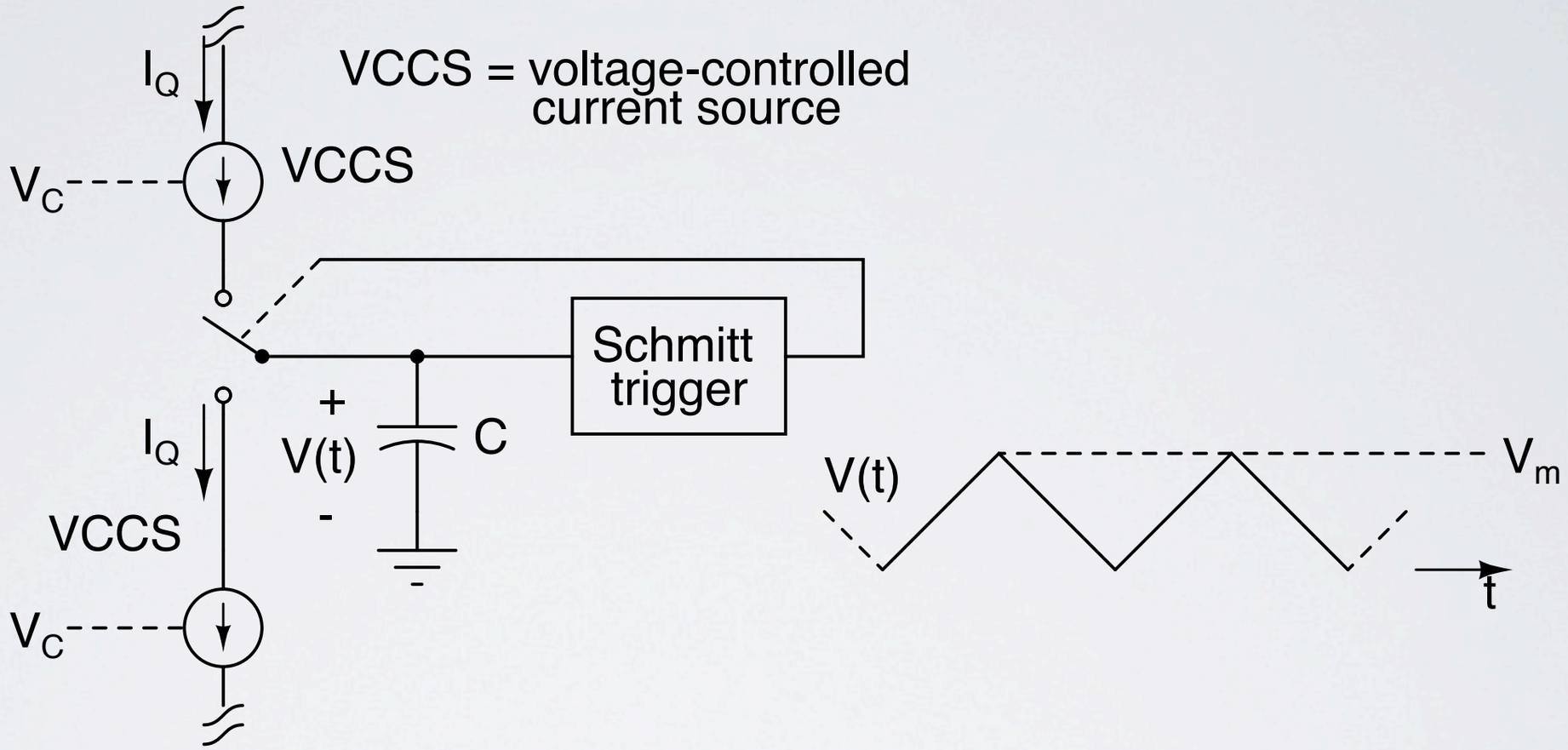
00568001

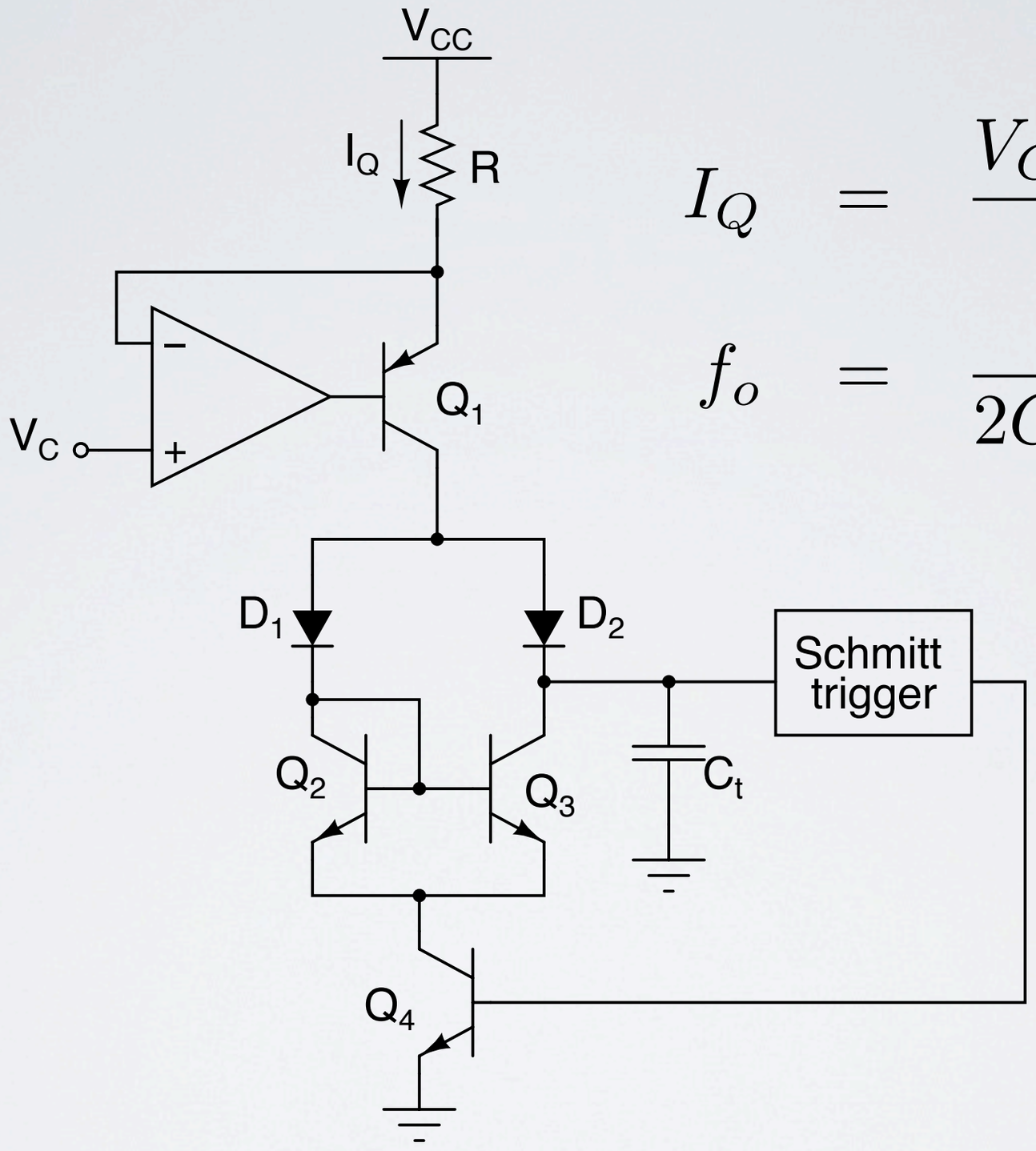
$f_{out} = 1000 V_{in}$
for gain adj = 2.5k

Example 4-11: Design a V-to-f converter that will output a 20kHz signal when $V_{in,\,max} = 5V$. If $V_{in,\,min} = 1V$, what is the frequency range?

Example: Use a V-to-f converter and a counter to build an 8-bit ADC with a conversion rate of 100Hz and an input voltage range of 0 to 1V

VCO

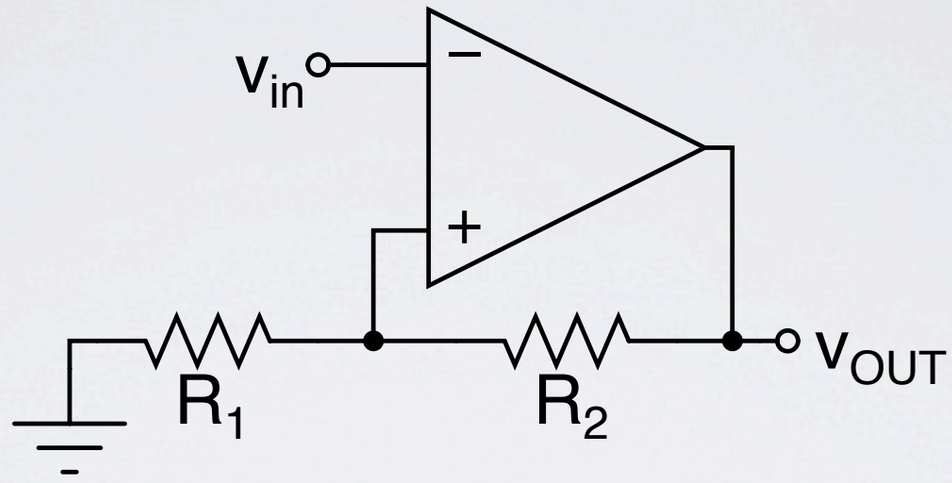

I_Q
VCCS = voltage-controlled current source
VCCS
V_C
Schmitt trigger
+
V(t)
-
C
I_Q
VCCS
V_C
V(t)
V_m
t

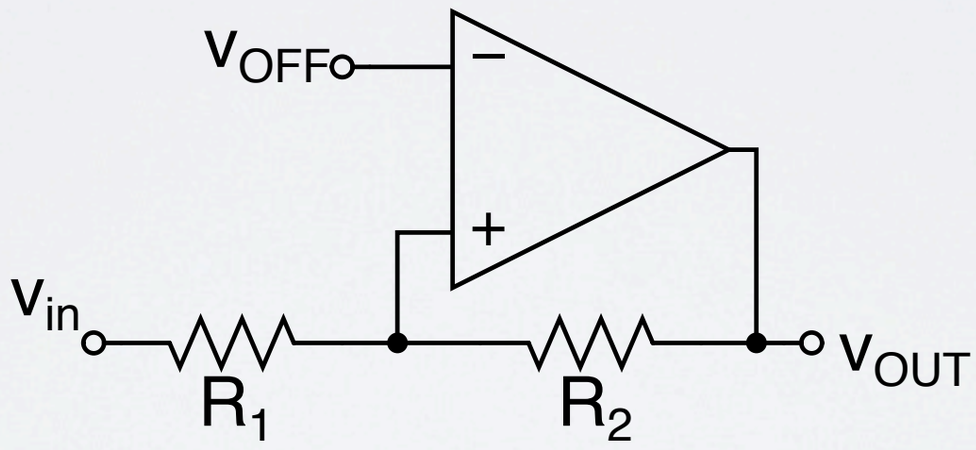


$$I_Q = \frac{V_{CC} - V_C}{R}$$

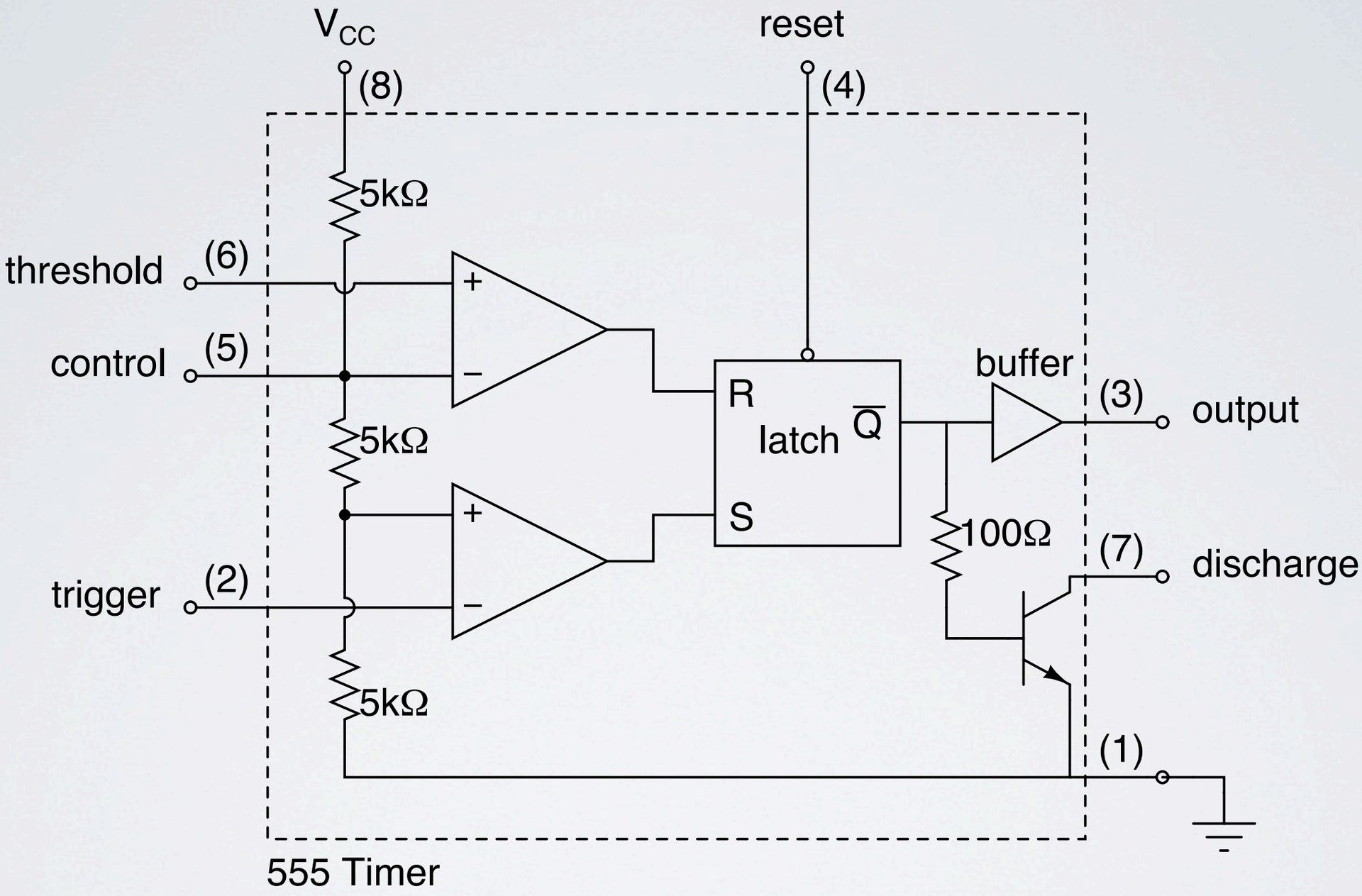
$$f_o = \frac{I_Q}{2C(V_H - V_L)}$$

Schmitt Trigger



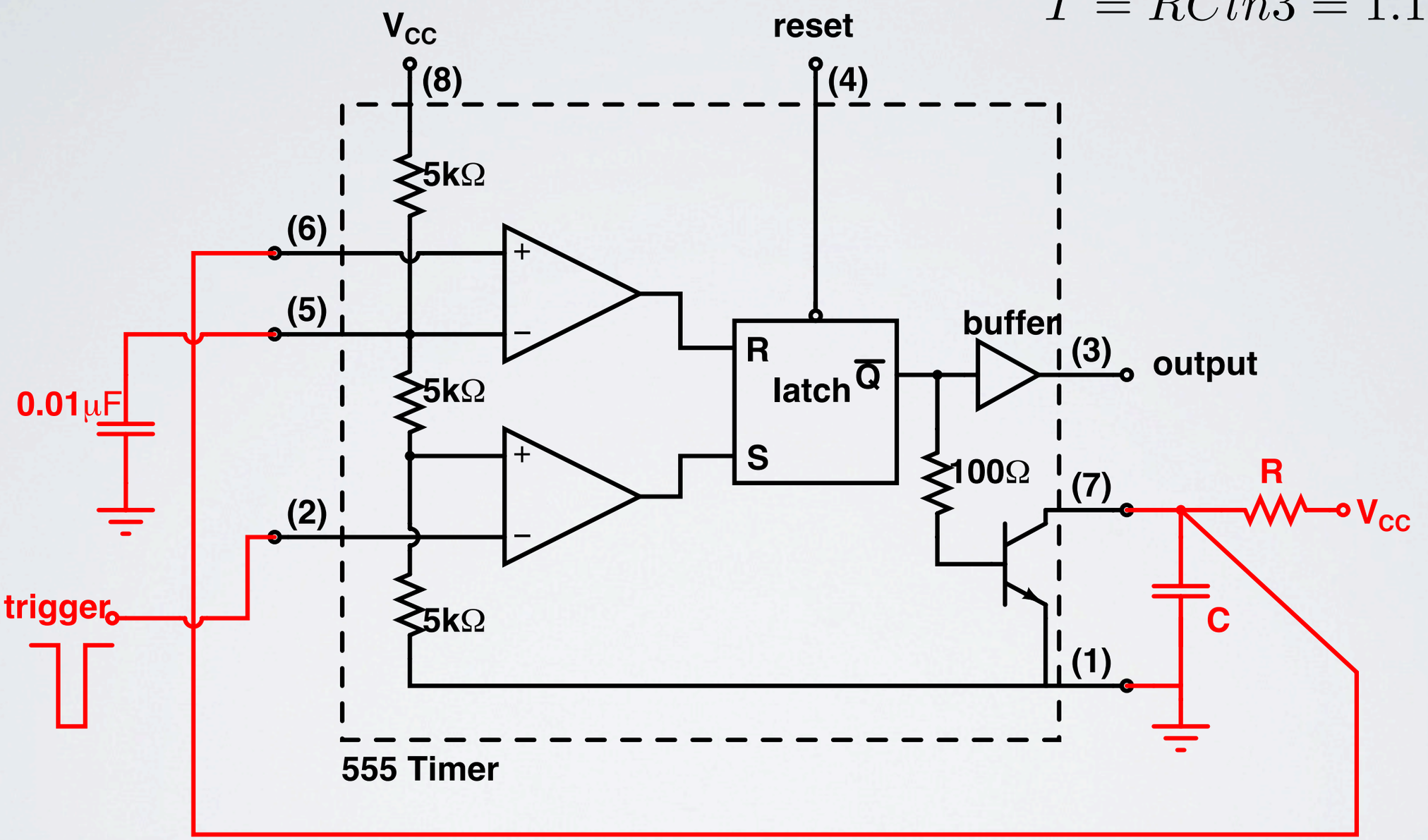


555 Timer


V_{CC}
(8)
reset
(4)
5kΩ
threshold
(6)
control
(5)
+
–
R
latch
S
$\overline{Q}$
buffer
(3)
output
5kΩ
+
–
100Ω
(7)
discharge
trigger
(2)
5kΩ
(1)
555 Timer

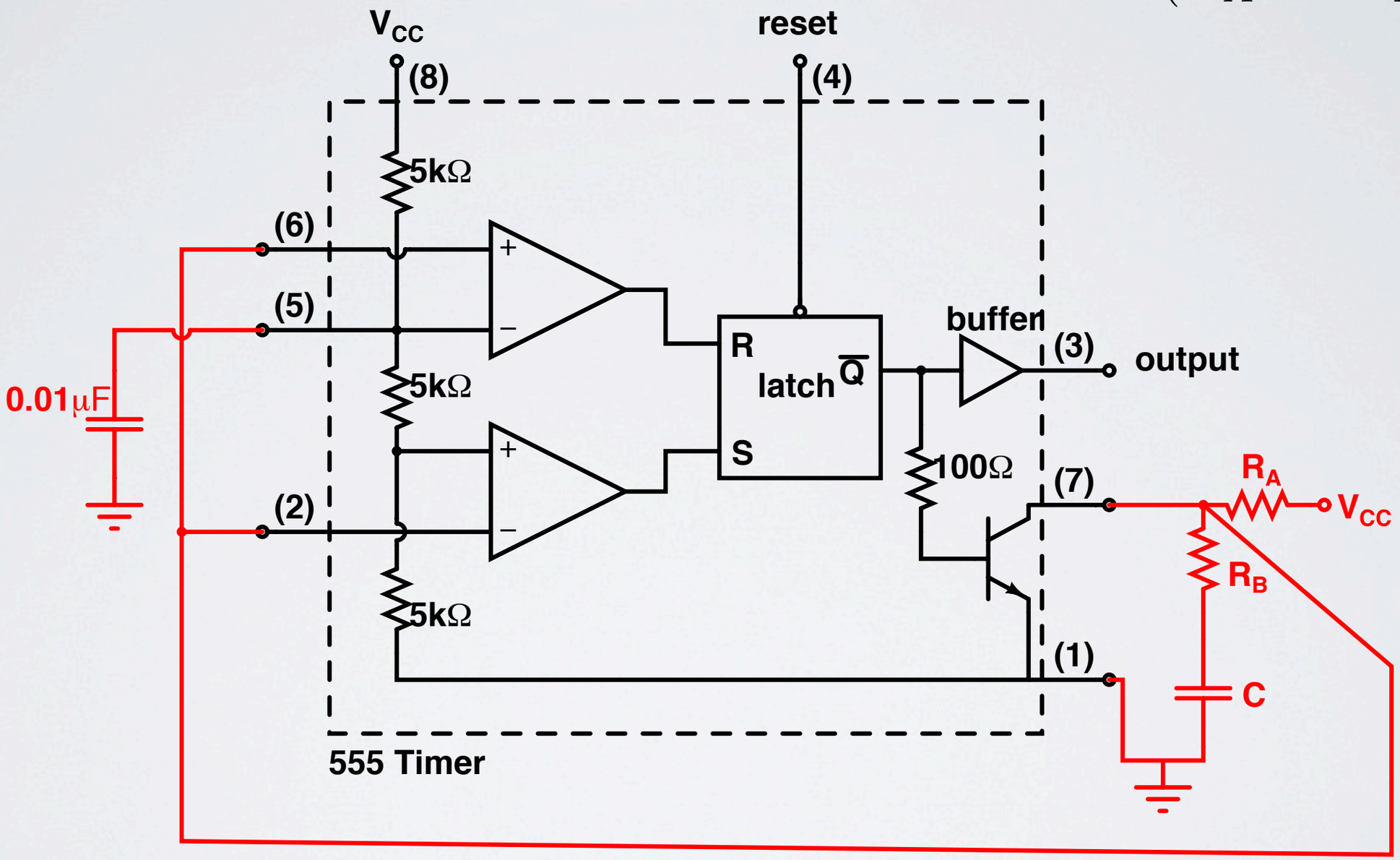
Monostable Multivibrator (one shot)

$$T = RCln3 = 1.1RC$$

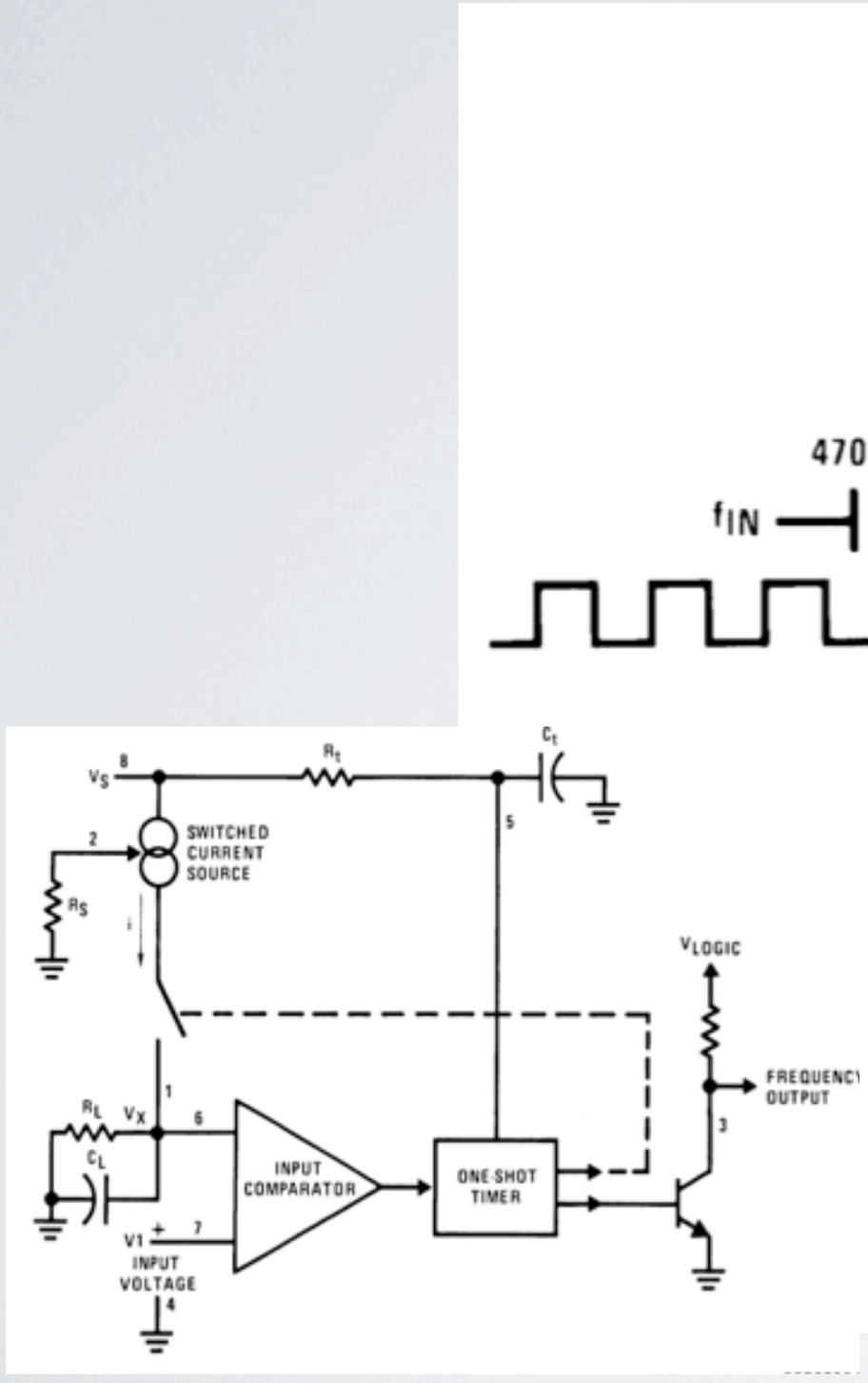


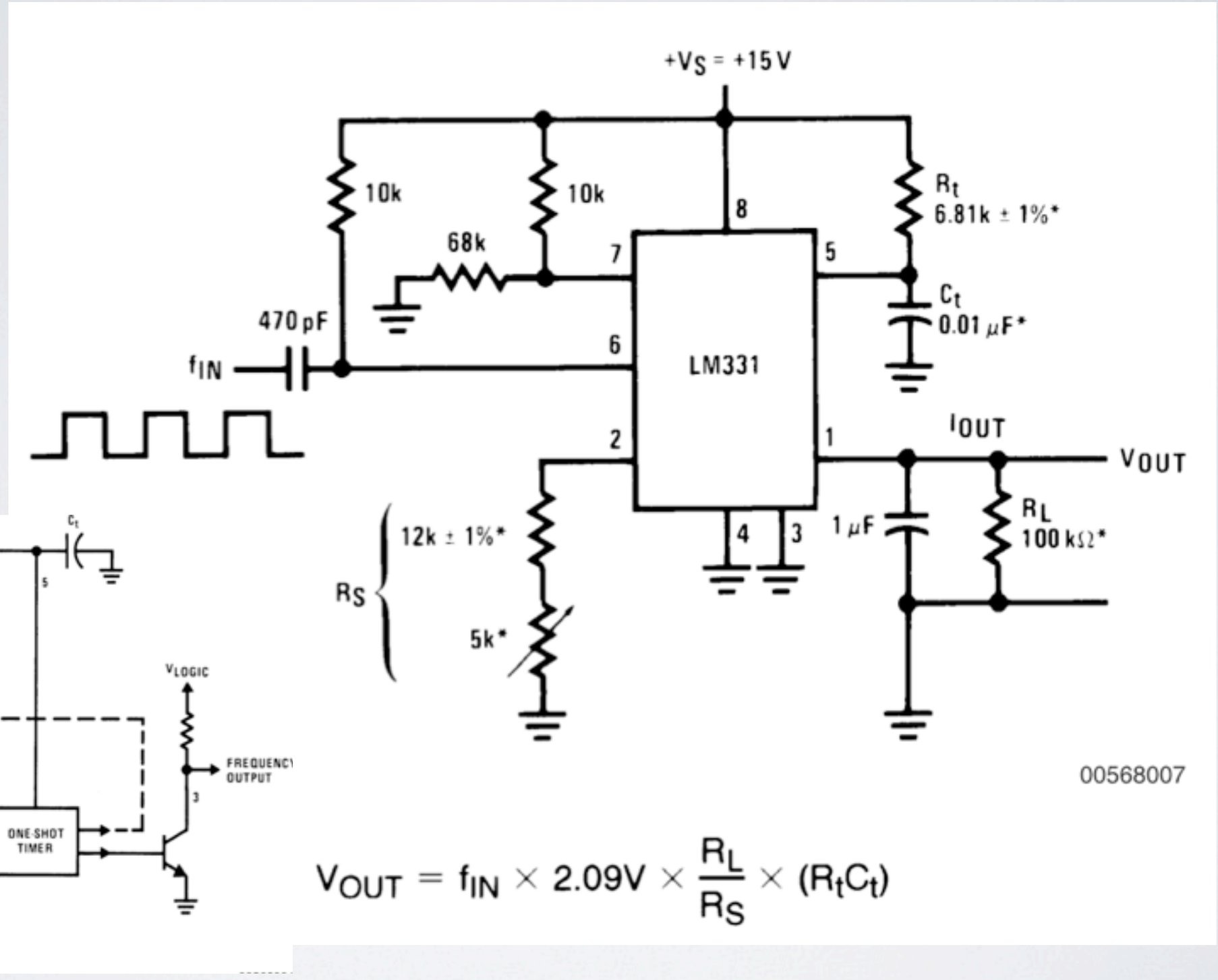
Astable Multivibrator

$$f = \frac{1}{0.693(R_A + 2R_B)C}$$



F-to-V Conversion using the LM131/LM2231/LM331





$$V_{OUT} = f_{IN} \times 2.09V \times \frac{R_L}{R_S} \times (R_t C_t)$$