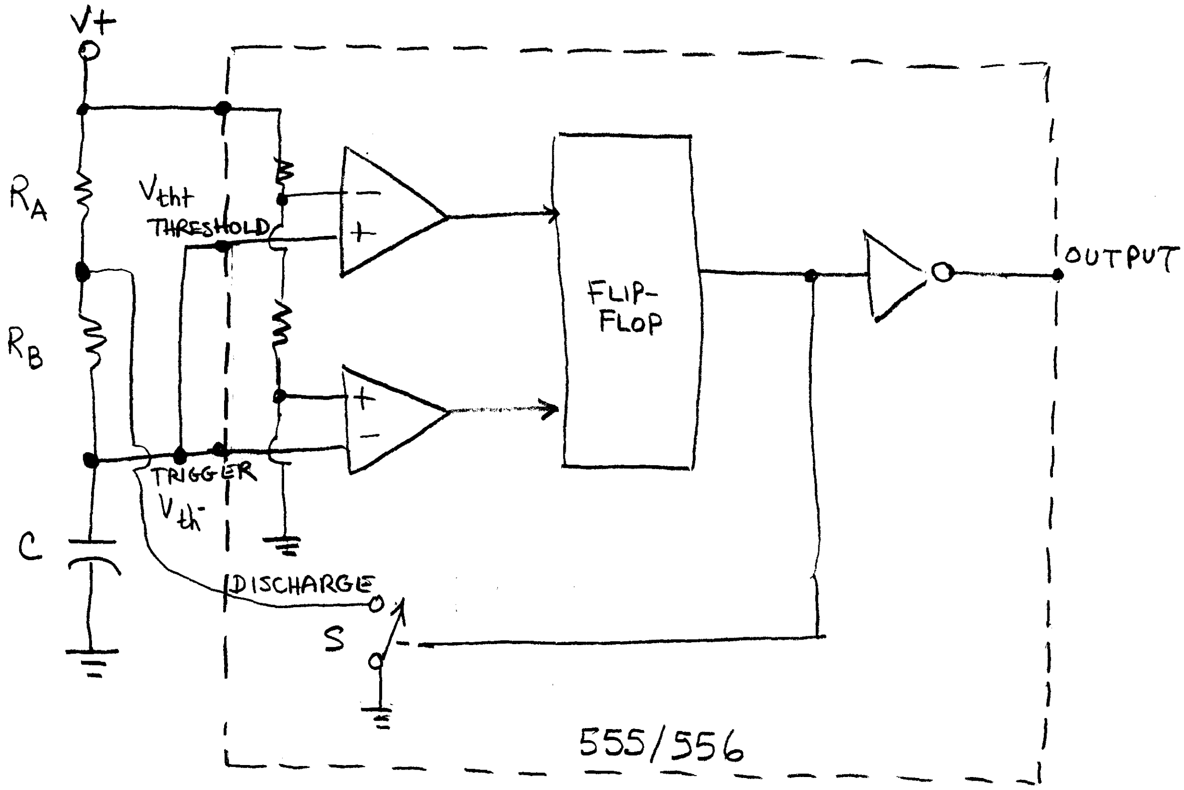
Basic 555/556 Timer Operation



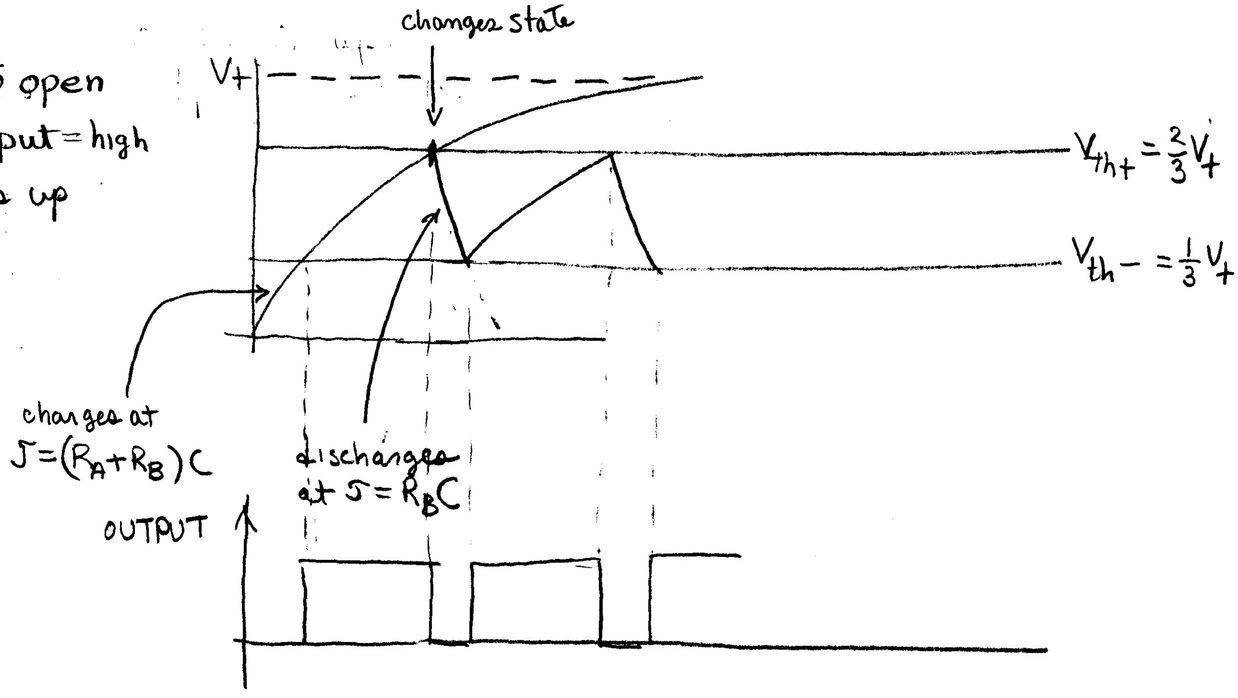
DESIGNED IN 1972 24 transistors
15 resistors

THRESHOLD — $\frac{2}{3}V_{cc}$ CAUSES OUTPUT TO GO LOW

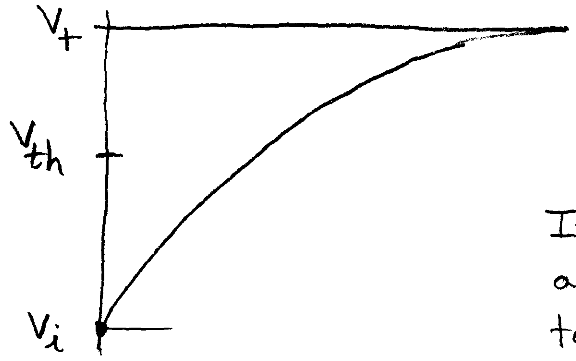
TRIGGER — $\frac{1}{3}V_{cc}$ CAUSES OUTPUT TO GO HIGH,

DISCHARGE — SHORTS out capacitor to discharge it.
WHEN output is low

① Assume S open
and Output = high
⇒ C charges up



Fundamental exponential equation



If exponential waveform starts at V_i and changes to V_+ how long T does it take to reach V_{th}?

basic waveform $\quad v(t) = (V_+ - V_i)(1 - e^{-t/\tau}) + V_i$

to reach V_{th} in T seconds

$$V_{th} = (V_+ - V_i)(1 - e^{-T/\tau}) + V_i$$

Solving for T

$$V_{th} - V_i = (V_+ - V_i)(1 - e^{-T/\tau})$$

$$\frac{V_{th} - V_i}{V_+ - V_i} = 1 - e^{-T/\tau}$$

$$e^{-T/\tau} = 1 - \frac{V_{th} - V_i}{V_+ - V_i} = \frac{V_+ - V_i - V_{th} + V_i}{V_+ - V_i} = \frac{V_+ - V_{th}}{V_+ - V_i}$$

take log.

$$\ln e^{-T/\tau} = \ln\left[\frac{V_+ - V_{th}}{V_+ - V_i}\right]$$

$$-\frac{T}{\tau} = \ln\left[\frac{V_+ - V_{th}}{V_+ - V_i}\right]$$

$$T = -\tau \ln\left[\frac{V_+ - V_{th}}{V_+ - V_i}\right] = \tau \ln\left[\frac{V_+ - V_i}{V_+ - V_{th}}\right].$$

For circuits $\tau = RC$

$$T = T_{charge} + T_{discharge}$$

$$= (R_A + R_B)C \ln\left[\frac{V_+ - \frac{1}{3}V_+}{V_+ - \frac{2}{3}V_+}\right] + R_B C \ln\left[\frac{0 - \frac{2}{3}V_+}{0 - \frac{1}{3}V_+}\right]$$

for $V_{th} = \frac{2}{3}V_+$ for $V_{th} = \frac{1}{3}V_+$

$V_i = \frac{1}{3}V_+$ $V_i = \frac{2}{3}V_+$

final voltage V_+ final voltage $V_+ = 0$

$$= (R_A + R_B)C \ln\left[\frac{2/3}{1/3}\right] + R_B C \ln\left[\frac{-2/3}{-1/3}\right]$$

$$= (R_A + R_B)C \ln 2 + R_B C \ln[2]$$

$$= (R_A + 2R_B)C \ln 2$$

$$= 0.693\,(R_A + 2R_B)C$$