ECE3204 Lecture 13

Schmitt Trigger (17.4)

Handout: Lab 3 Preview

TRIP POINT CONDITION: $V_+ = V_-$ (WON'T STAY)

GENERAL FOR V_+

$$V_+ = V_{IN}\left(\frac{R_F}{R_A+R_F}\right) + V_{OUT}\left(\frac{R_A}{R_A+R_F}\right)$$

LOOK AT 2 CASES OF V_{OUT} FOR TRIP PTS

$V_{OUT} = L_+$ $\quad V_+ = 0$ (CONDITION $V_{IN} = V_T$)

$$0 = V_T\left(\frac{R_F}{R_A+R_F}\right) + L_+\left(\frac{R_A}{R_A+R_F}\right)$$

$$V_T R_F = -L_+ R_A \Rightarrow V_T = \left(\frac{-R_A}{R_F}\right)L_+$$

V_{TL} ← POSITIVE

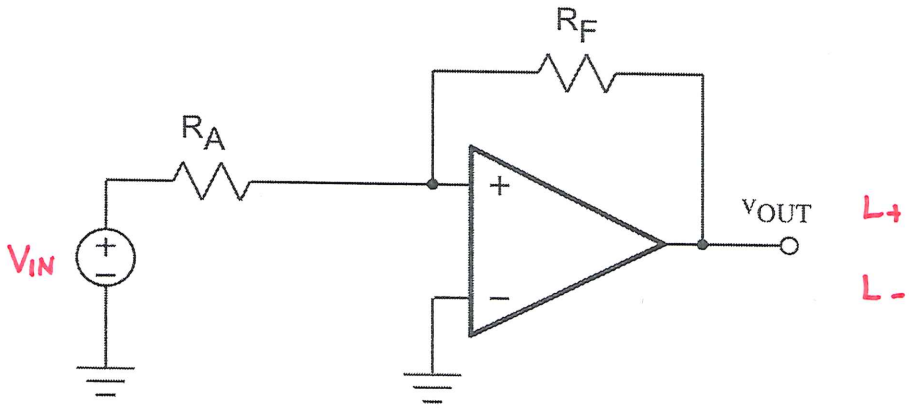
$V_{OUT} = L_-$ $\quad V_+ = 0$

$$0 = V_{TH}\left(\frac{R_F}{R_A+R_F}\right) + L_-\left(\frac{R_A}{R_A+R_F}\right)$$

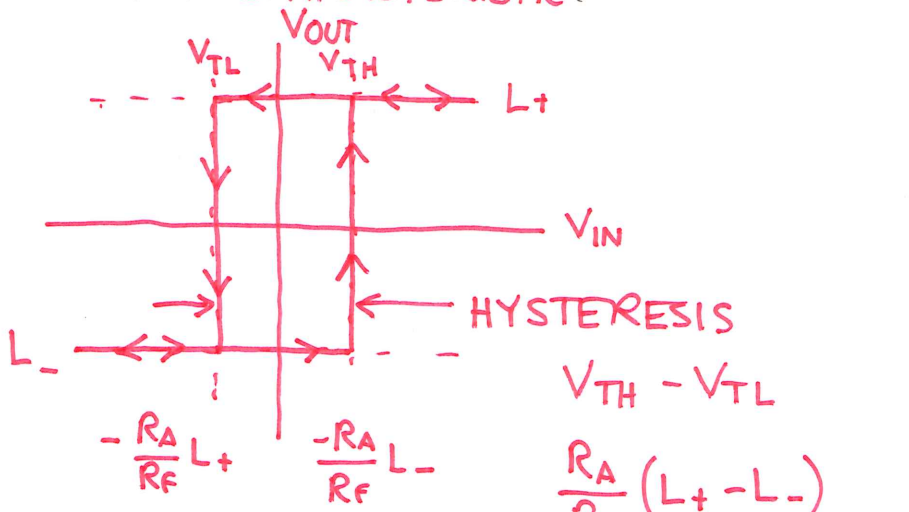
$$V_{TH} = \left(\frac{-R_A}{R_F}\right)L_-$$

NEGATIVE

Noninverting Schmitt Trigger



INPUT - OUTPUT CHARACTERISTIC



$V_{TH} - V_{TL}$

$\frac{R_A}{R_F}$ RATIO $\quad (L_+ - L_-)$ LOGIC SWING

CHOOSE HYSTERESIS > NOISE

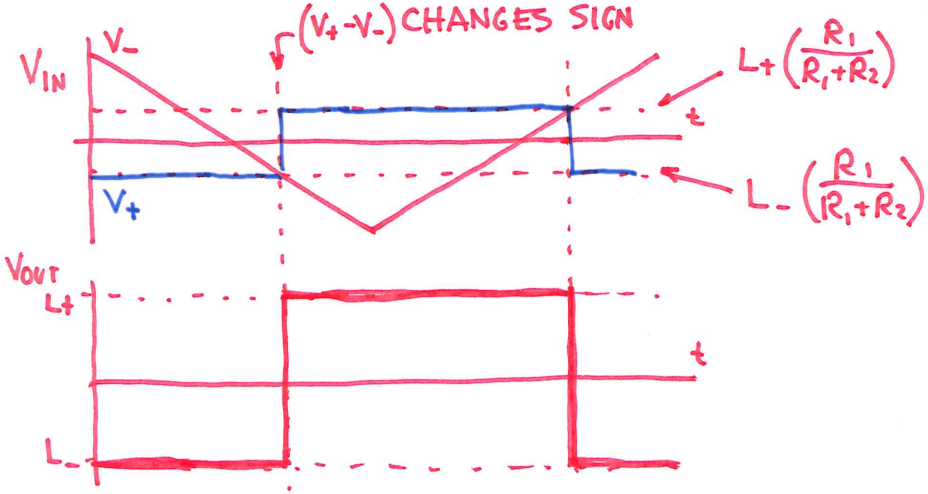
Inverting Schmitt Trigger

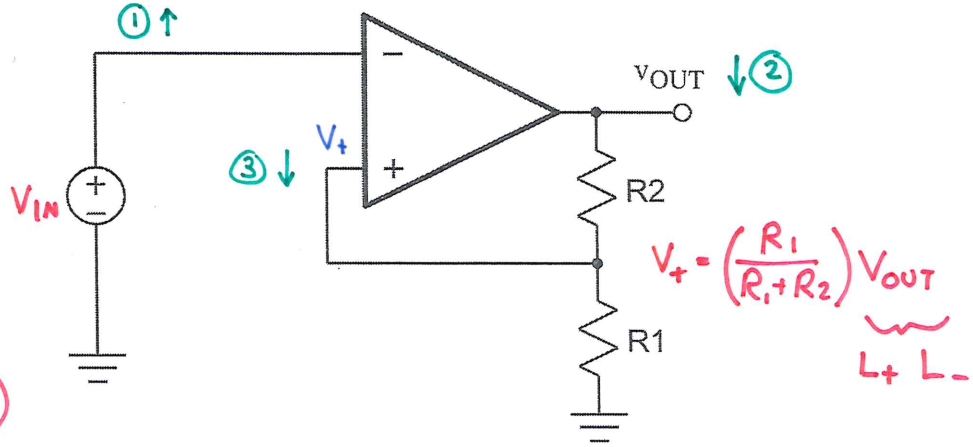
CHECK FEEDBACK

① $V_{IN}\uparrow \Rightarrow$ ② $V_{OUT}\downarrow \Rightarrow$ ③ $V_+\downarrow$ V_+, V_- APART

POSITIVE FEEDBACK

~~$V_- \approx V_+$~~ V_{OUT} EITHER L_+ OR L_-

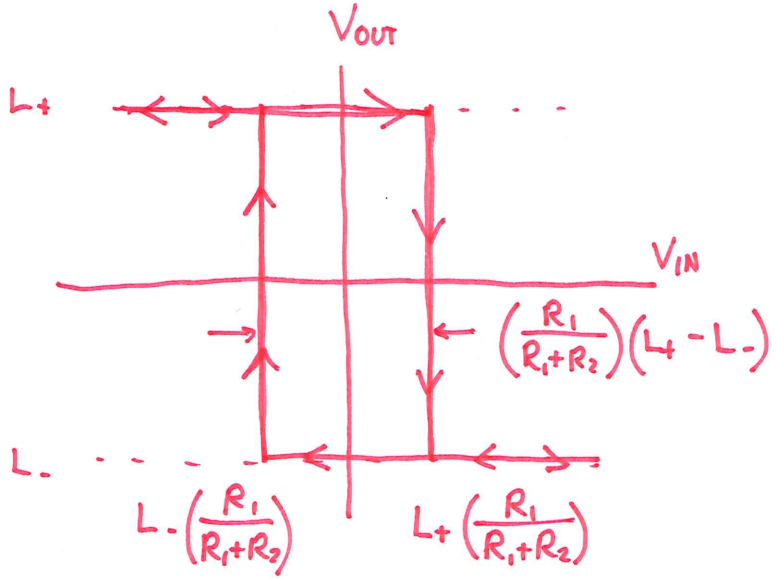




AT TIME $t = 0$, V_{IN} AT V_- > EITHER POSSIBLE VALUE AT $V_+ \Rightarrow V_{OUT} = L_-$ (LOW)

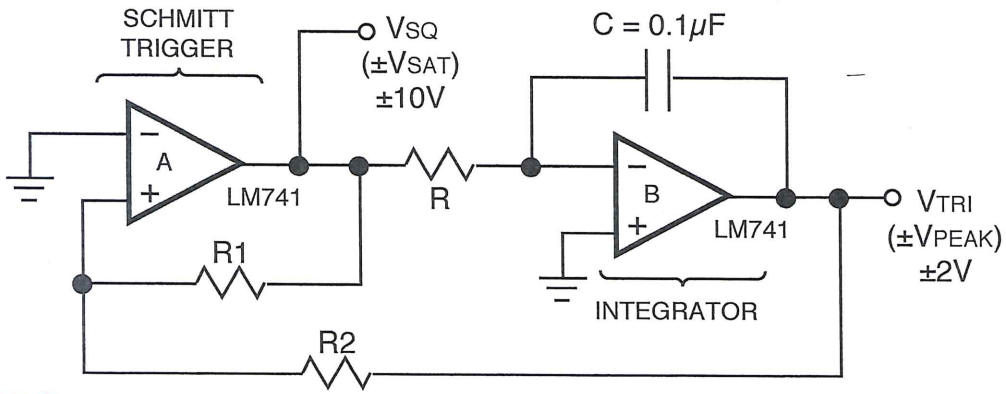
WHEN $(V_+ - V_-)$ CHANGES

$V_{OUT}\uparrow = L_+ \Rightarrow V_+ = L_+\left(\frac{R_1}{R_1+R_2}\right)$



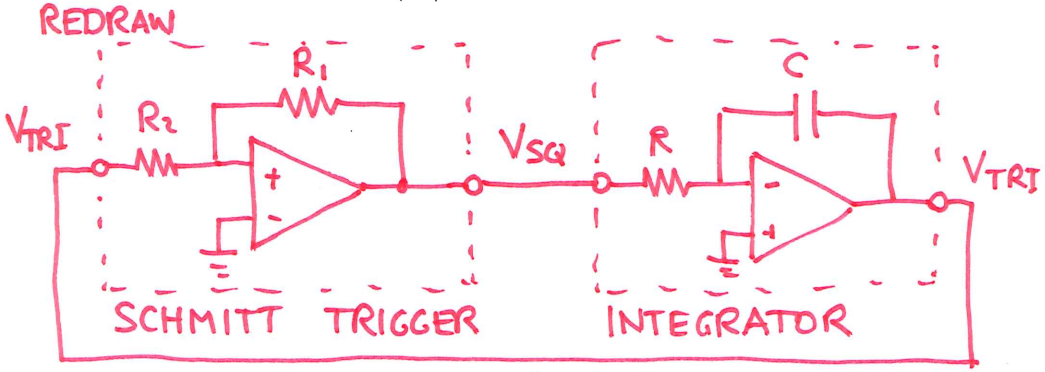
ECE3204 Lab 3

P1. Function generator: Figure 3.1 shows a function generator circuit that produces both square wave and triangular wave outputs.



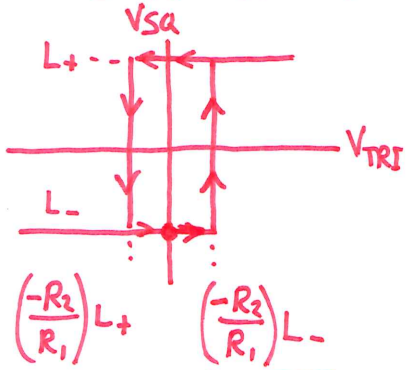
INPUT?!?

REDRAW



BEHAVIOR OF EACK BLOCK

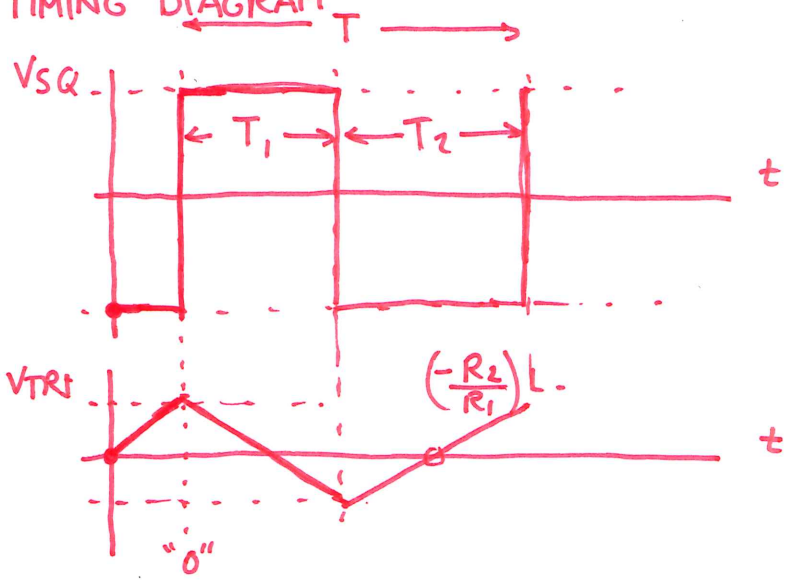
$\frac{V_{TRI}}{V_{SQ}} = \frac{-1}{jwRC}$



$$V_{TRI}(t) = \underbrace{V_{TRI}(t_0)}_{\text{INIT COND}} - \frac{1}{RC}\int_{t_0}^{t} V_{SQ}\,dt$$

ANALYSIS: TIME DOMAIN (SCHMITT TRIGGER)

TIMING DIAGRAM



WHAT DO WE KNOW? OUTPUT OF SCHMITT TRIGGER MUST BE L_+ OR L_-

LABEL L_+, L_- ON TIMING DIAGRAM

START WITH $V_{TRI}(t=0) = 0$ [SHORT CAP]

GUESS! $V_{SQ} = L_-$

WHAT DOES INTEGRATOR DO? ↗ RAMP UP

RAMP UNTIL V_{TH}

V_{SQ} ↑ ⇒ INTEGRATOR ↘ RAMP DOWN

OSCILLATOR FREQ $f = \frac{1}{T}$ } PERIOD

DURING T_1

$$\underbrace{V_{TRI}(T_1)}_{\left(\frac{-R_2}{R_1}\right)L_+} = \underbrace{V_{TRI}(0)}_{\left(\frac{-R_2}{R_1}\right)L_-} - \frac{1}{RC}L_+\,T_1$$

SYMMETRIC L_+, L_-

$L_- = -L_+$