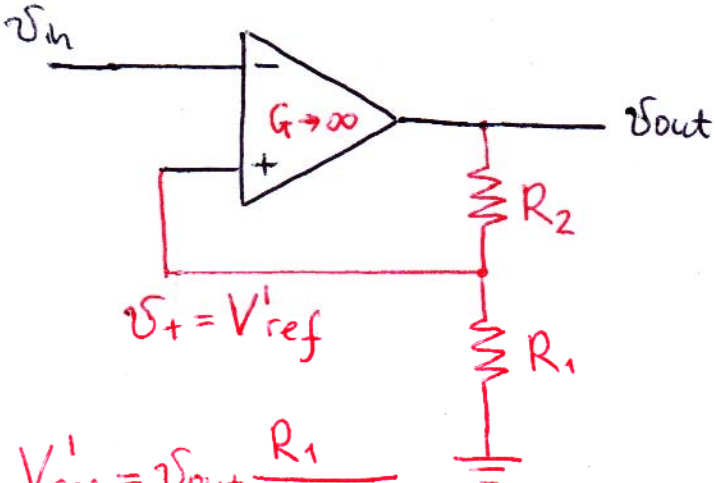
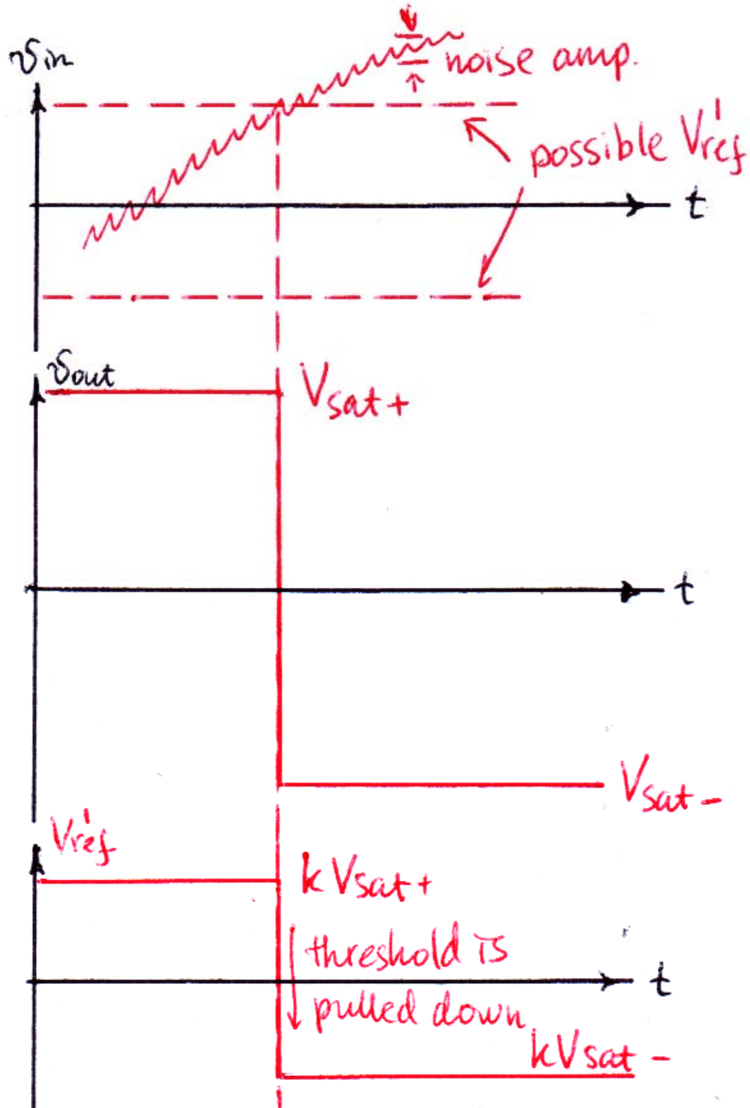
Lecture 6

Schmitt trigger





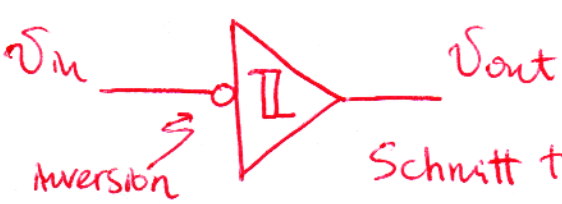
$$V'_{ref} = v_{out}\frac{R_1}{R_1+R_2}$$

$$= v_{out} \cdot k$$

$$\Delta V'_{ref} = k(V_{sat+} - V_{sat-})$$

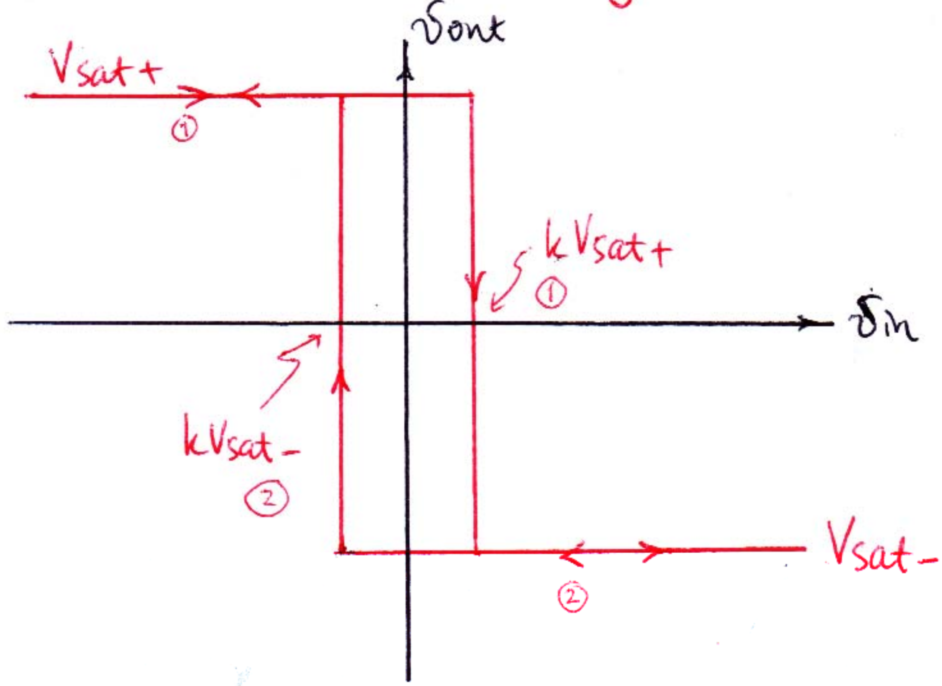
if $\Delta V'_{ref} >$ noise amp. in v_{in} , $\Rightarrow$
switching is insensitive to noise

- this is an example of positive feed back
  (part of v_{out} is returned to v_+ input)
- positive feedback accelerates the current trend through whisking the threshold (limited by S.R.)



Schmitt trigger symbol

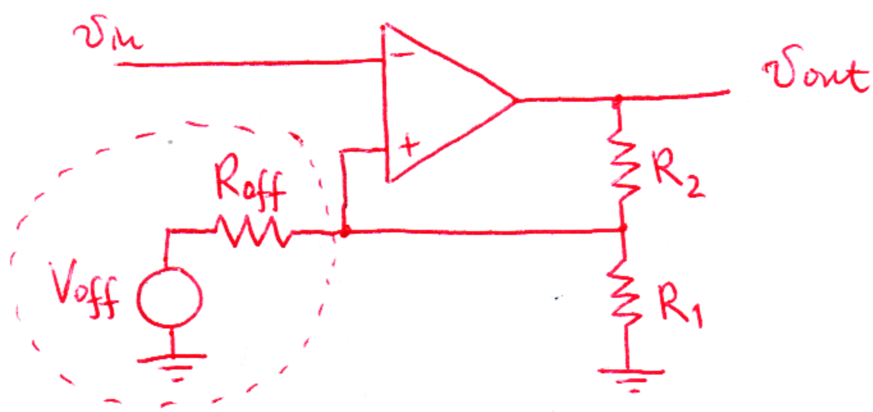
Transfer characteristic (hysteresis)



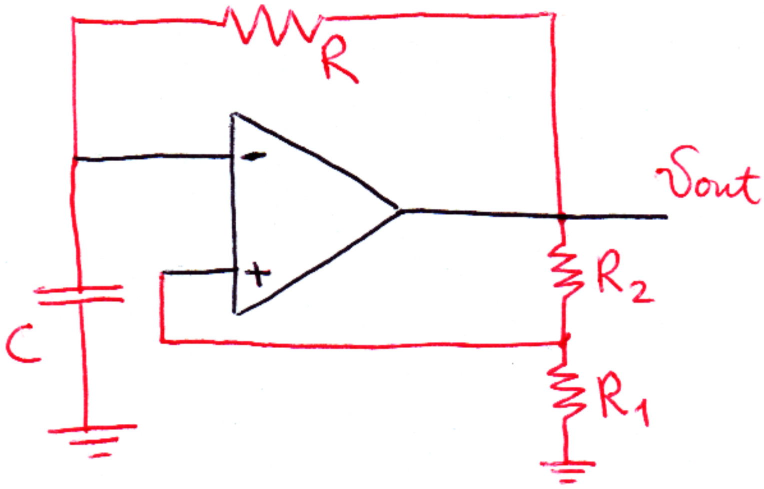
- threshold now depends on past history

The thresholds are symmetric around 0 ($|V_{sat-}| = V_{sat+}$)

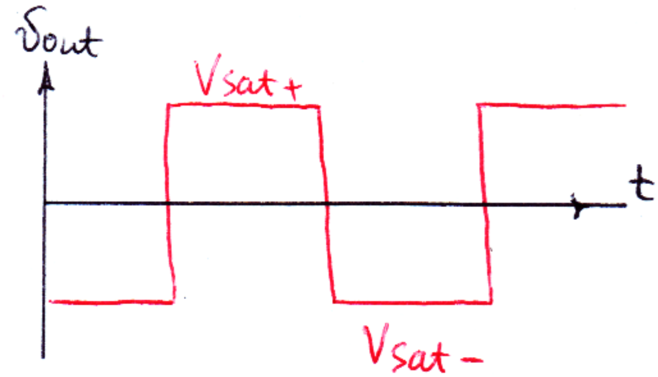
Q: How to make them asymmetric?



Astable multivibrator (oscillator)



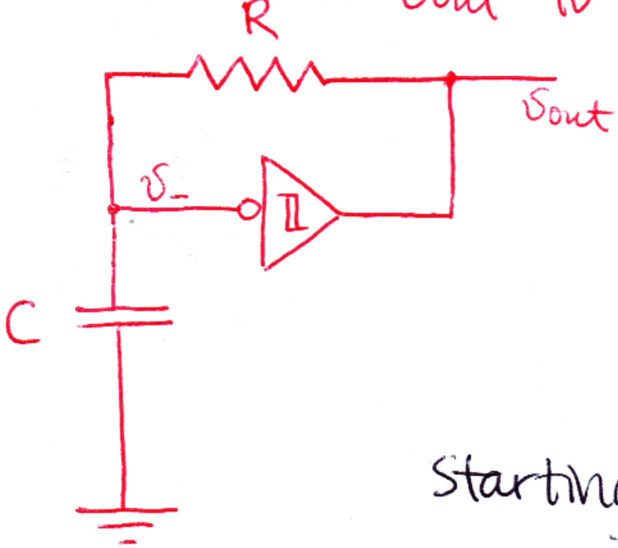
- op-amp supplies its own input



Strategy for solving unknown circuits:

recognize the parts we already know

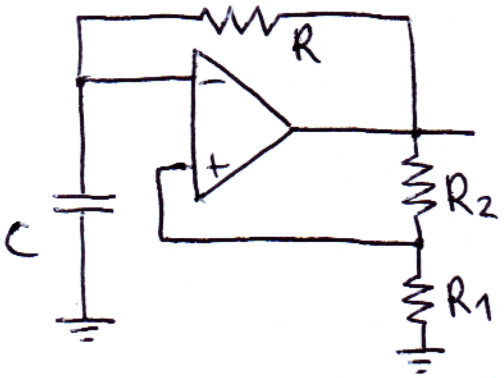
R_1, R_2, op-amp = Schmitt trigger
R, C = lo-pass filter (transmitting v_{out} to v_-)



$\Rightarrow$ v_- follows v_{out} with a time lag $\sim$ RC

Starting oscillations:

- assume ideal op-amp ($G \to \infty$)
- there is always noise, so $v_+ = v_-$ is never true for long



e.g. $v_+ > v_-$

a) $v_{out} \to V_{sat+}$, $V'_{ref} = v_+ = k \cdot V_{sat+}$

b) $v_c \to V_{sat+}$, crosses V'_{ref} after ~RC time

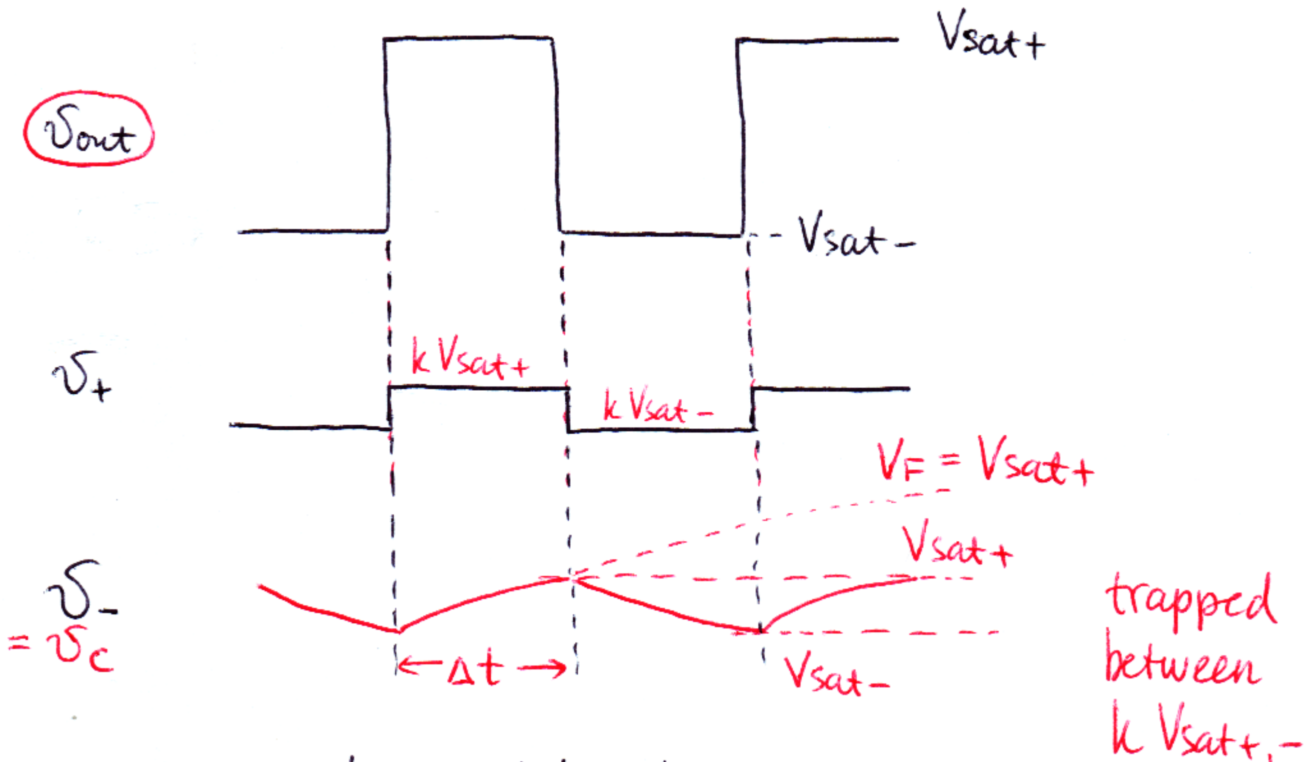
c) $v_{out} \to V_{sat-}$, $V'_{ref} = k \cdot V_{sat-}$

d) $v_c \to V_{sat-}$, crosses V'_{ref}

e) go to a)

Analyze oscillator

volt. vs time



For simplicity $V_{sat+} = |V_{sat-}| = V_{sat}$

$$v_c(\Delta t) = V_F + (V_I - V_F)\, e^{-\frac{\Delta t}{RC}} \qquad (*)$$

$V_I = -kV_{sat}$, $V_F = V_{sat}$ (volt. cap. would have if $\Delta t \to \infty$)

$v_c(\Delta t) = kV_{sat}$. Substitute into $(*)$

$$kV_{sat} = V_{sat} + (-kV_{sat} - V_{sat})\, e^{-\frac{\Delta t}{RC}}, \Rightarrow \Delta t = RC \ln \frac{1+k}{1-k}$$

period $= 2 \times \Delta t$; freq. $= 1/(2 \times \Delta t)$.