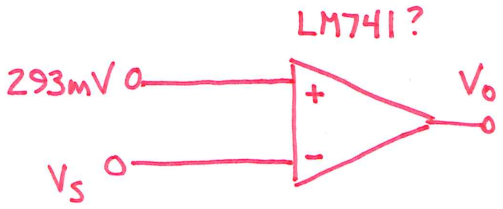
ECE3204 Lecture 12

Comparator
Schmitt Trigger (17.4)
Positive Feedback

Analysis with
- Timing Diagram
- Input-Output Characteristic

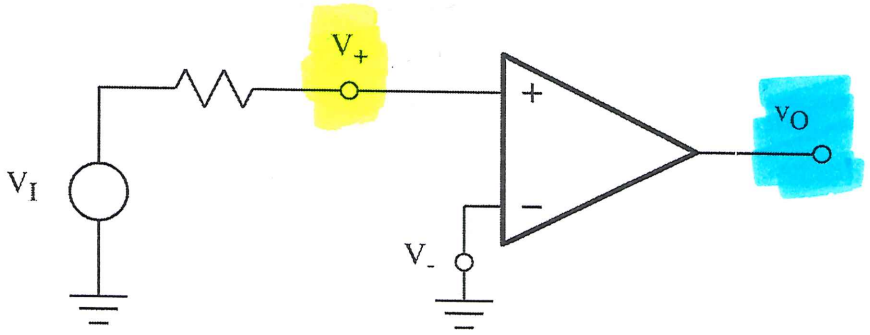
Hand in:
HW 3

FURNACE CONTROL DESIGN

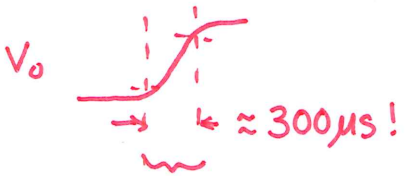


INPUT	OUTPUT	
$V_S > 293\,mV$	L+	1
$V_S < 293\,mV$	L-	0

Comparator

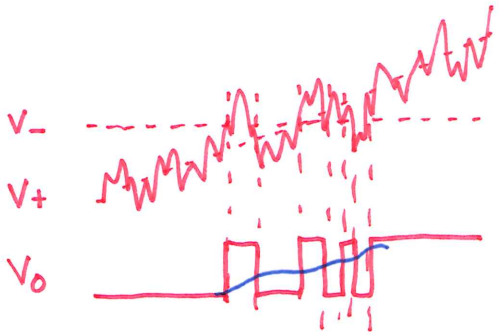


PROBLEM 1: SLOW TRANSITION



FIX: COMPARATOR (LM311 EXAMPLE)

PROBLEM 2: NOISE



BAD MECHANICAL COUNTING EDGES

~~FILTER~~? SLOW EDGE PROBLEM!

DON'T DO THAT!

National Semiconductor

January 2001

LM111/LM211/LM311 Voltage Comparator

1.0 General Description

The LM111, LM211 and LM311 are voltage comparators that have input currents nearly a thousand times lower than devices like the LM106 or LM710. They are also designed to operate over a wider range of supply voltages: from standard ±15V op amp supplies down to the single 5V supply used for IC logic. Their output is compatible with RTL, DTL and TTL as well as MOS circuits. Further, they can drive lamps or relays, switching voltages up to 50V at currents as high as 50 mA.

Both the inputs and the outputs of the LM111, LM211 or the LM311 can be isolated from system ground, and the output can drive loads referred to ground, the positive supply or the negative supply. Offset balancing and strobe capability are provided and outputs can be wire OR'ed. Although slower than the LM106 and LM710 (200 ns response time vs 40 ns) the devices are also much less prone to spurious oscillations. The LM111 has the same pin configuration as the LM106 and LM710.

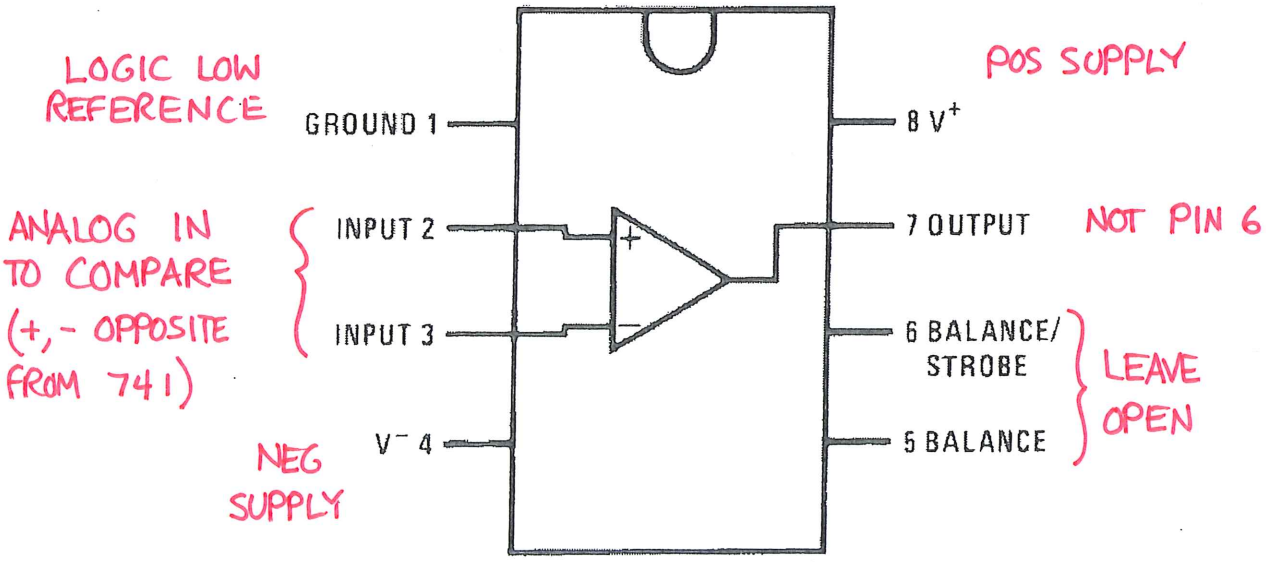
The LM211 is identical to the LM111, except that its performance is specified over a −25°C to +85°C temperature range instead of −55°C to +125°C. The LM311 has a temperature range of 0°C to +70°C.

2.0 Features

- Operates from single 5V supply
- Input current: 150 nA max. over temperature
- Offset current: 20 nA max. over temperature
- Differential input voltage range: ±30V
- Power consumption: 135 mW at ±15V

FAST OUTPUT $\frac{dV}{dt}$ >> SLEW RATE

Dual-In-Line Package



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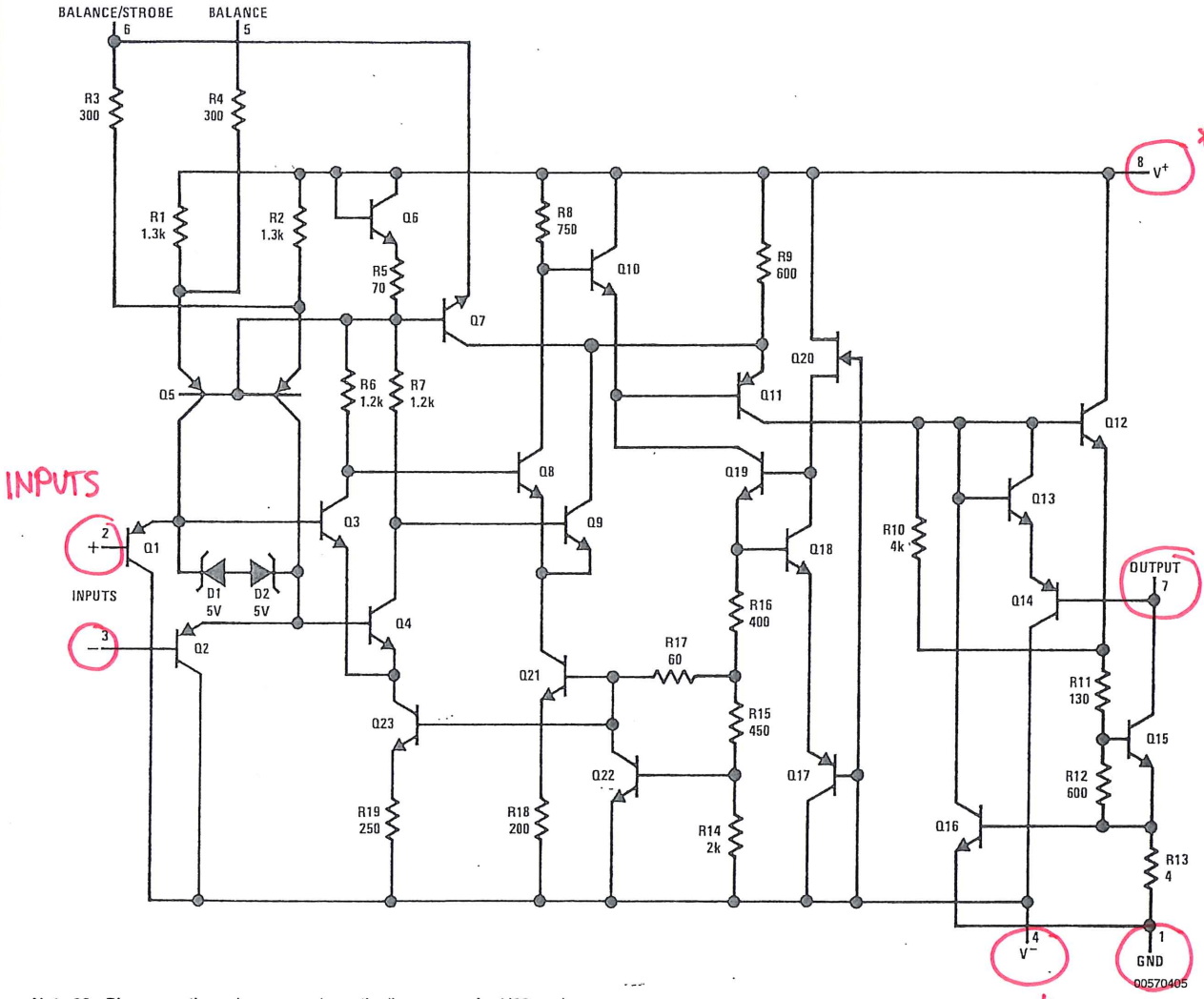
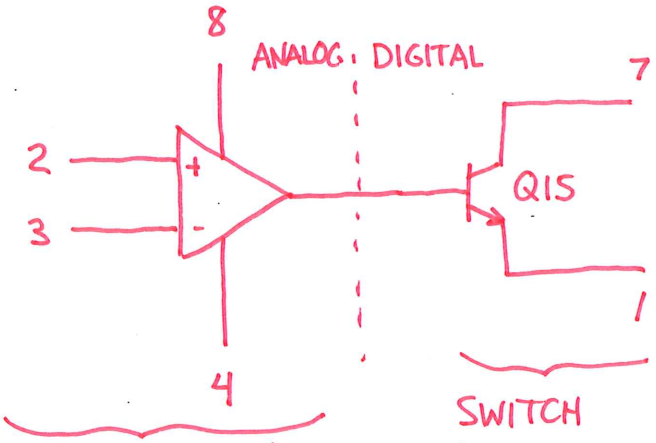
Top View

10.0 Schematic Diagram (Note 20)

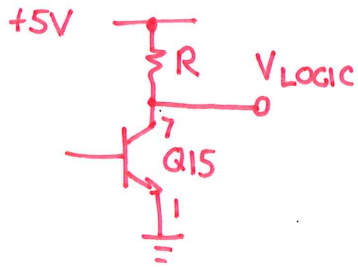


Note 20: Pin connections shown on schematic diagram are for H08 package.



COMPARE V_+, V_- IN ANALOG WORLD
ANYTHING BETWEEN PIN 8 PIN 4 OK

SWITCH
LOGIC LEVEL
INDICATION



Q15 ON:
V_{LOGIC} PULLS DOWN
TO ≈ 0.2V

Q15 OFF
R PULLS UP
V_{LOGIC} = +5V

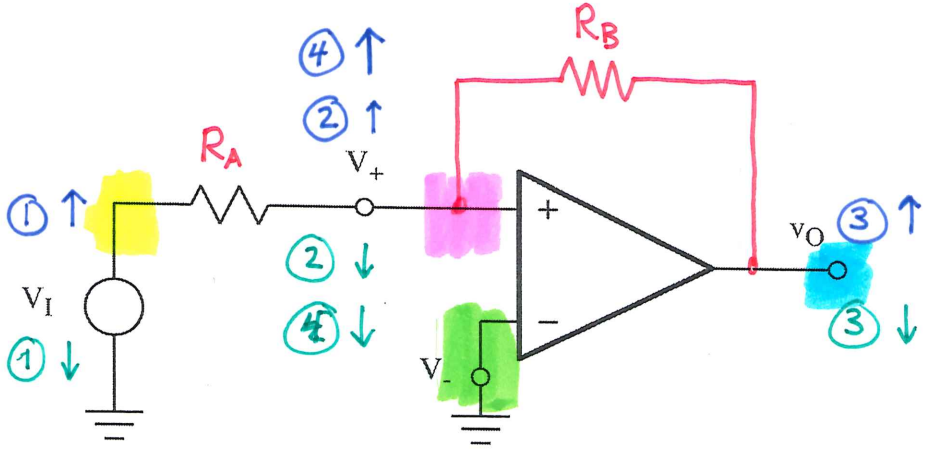
Schmitt Trigger (17.4) POSITIVE FEEDBACK

FEEDBACK: START
WITH $V_-, V_+, V_o = 0 = V_I$

① $V_I \uparrow \Rightarrow$ ② $V_+ \uparrow \Rightarrow$ ③ $V_o \uparrow \Rightarrow$ ④ $V_+ \uparrow$
DRIVING V_+ AWAY FROM V_-

① $V_I \downarrow \Rightarrow$ ② $V_+ \downarrow \Rightarrow$ ③ $V_o \downarrow \Rightarrow$ ④ $V_+ \downarrow$
ALSO DRIVES V_+, V_- APART

MUCH FASTER V_o TRANSITIONS



VOLTAGE DIVIDER + SUPERPOSITION FOR V_+

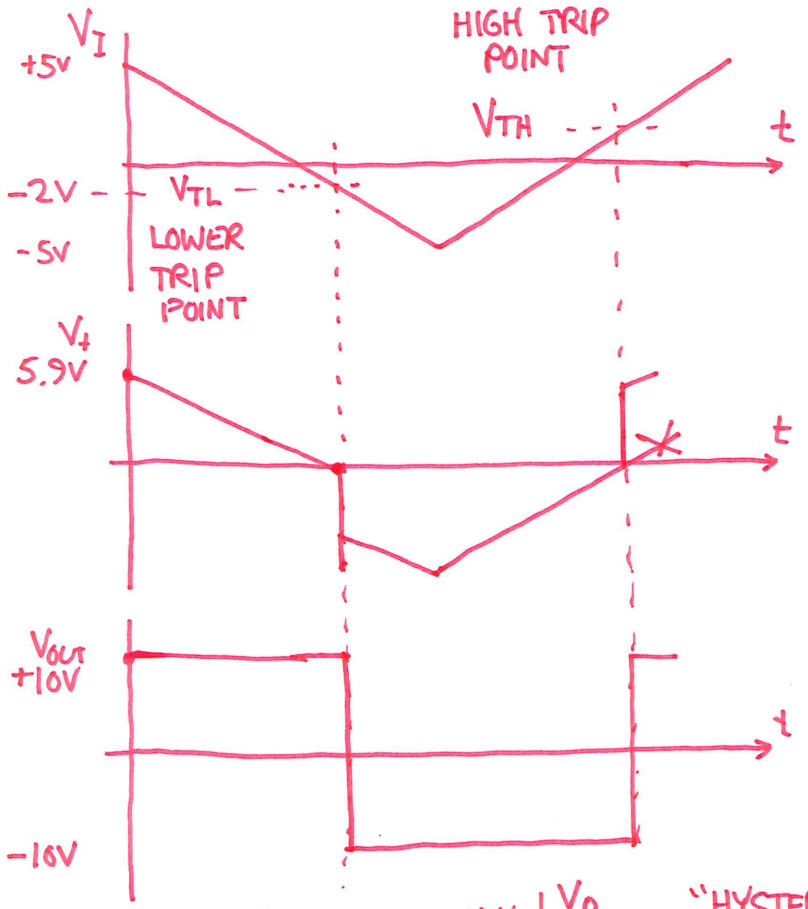
$$V_+ = \left(\frac{R_B}{R_A+R_B}\right)V_I + \left(\frac{R_A}{R_A+R_B}\right)V_o$$

↑ MUST BE BETWEEN V_I, V_o

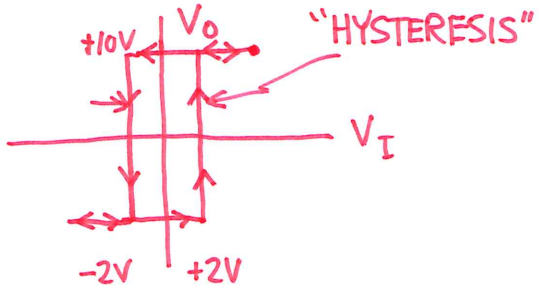
Analysis of Noninverting Schmitt Trigger

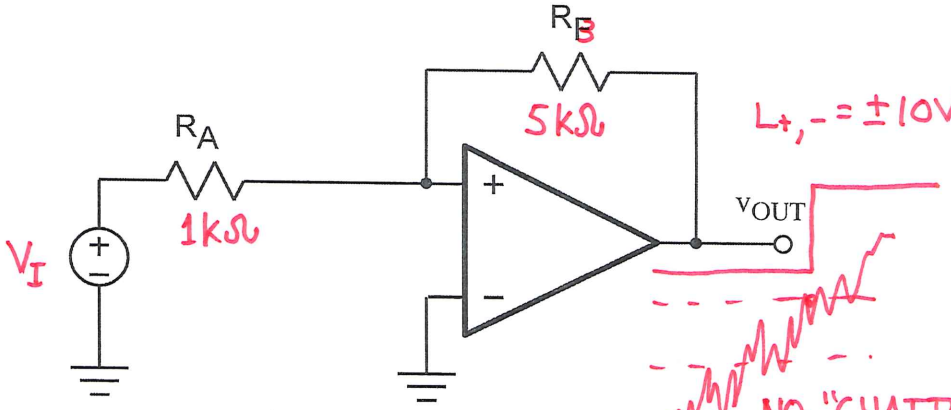
~~TRANSFER FUNCTION~~

TIMING DIAGRAM



INPUT OUTPUT PLOT





NO "CHATTER" IF HYSTERESIS $V_{TH} - V_{TL} >$ NOISE

$$V_+ = \frac{1}{6} V_{OUT} + \frac{5}{6} V_{IN}$$

V_O CAN ONLY BE +10V OR -10V

$$V_+ = \underbrace{0.17\, V_{OUT}}_{\pm 1.7} + \underbrace{0.83\, V_{IN}}_{+5V} \Rightarrow V_+ \text{ POSITIVE}$$

$V_O = +10V$

$$+1.7 + 0.83\,5V$$

V_O WON'T GO TO -10V UNTIL V_+ GOES < 0V

CONDITION FOR V_{TL} : $V_+ = 0$

$$0 = \frac{1}{6}(+10V) + \frac{5}{6}(V_{TL}) \Rightarrow V_{TL} = -2V$$

CONDITION FOR V_{TH}

$$0 = \frac{1}{6}(-10V) + \frac{5}{6}(V_{TH}) \Rightarrow V_{TH} = +2V$$