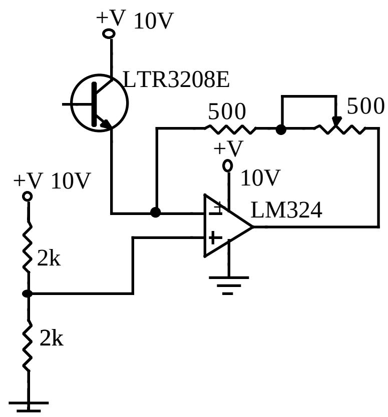
Solution to the Final Exam for ME218a
Fall 1995

Problem 1.1



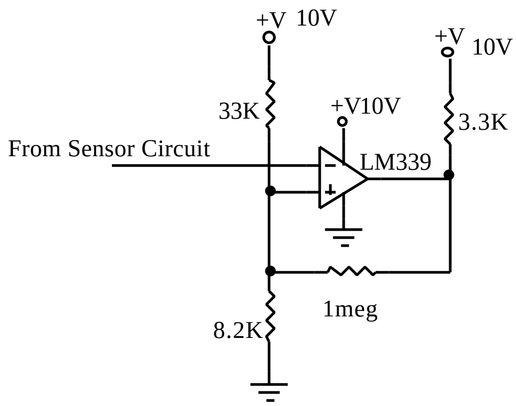
Problem 1.2

At 3mW/cm^2, the voltage is 5V - (3mA*1K) = 2V
At 2mW/cm^2, the voltage is 5V - (2mA * 1K) = 3V
So, as the light level drops the voltage rises by 1V

Problem 1.3

The sensor response is linear from approximately 0 to 5mW/cm^2.
This corresponds to an output voltage range from 5V - 0V in the circuit.
With a 10V supply, the LM324 can easily get it's output up to 5V.
On the lower range, the V_{ol} is listed as 50mV, max. corresponding to a light level of 4.95mW/cm^2,
so we would expect the output to be linear over the range of 0-4.95mW/cm^2.

Problem 1.4



The desired switch point is 3 mW/cm2
This corresponds to a voltage of 5-3 = 2V
in order to get +- 0.03mw/cm2 of hysterisis, set the switch points to
V_{a1} = 2.03V, V_{a2} = 1.97V
choose Rpullup = 3.3k
choose R3 = 1M, since we don't want a lot of hysterisis
then, using the method of AN74

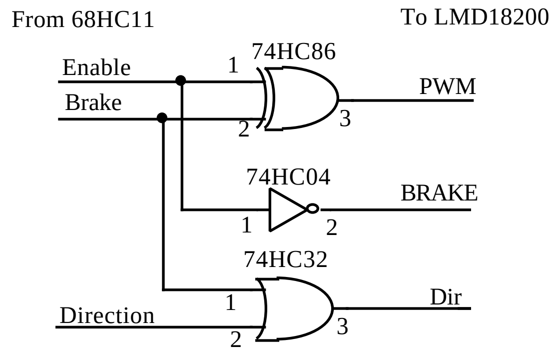
$$n = \frac{\Delta V_a}{V_{a2}} = .030456$$

R1 = nR3 = 30456W

$$R_2 = \frac{R_1 \| R_3}{\frac{V_{cc}}{V_{a1}} - 1} = 7528\Omega$$

If we go back and use the closest available value for R1 and use it to calculate R2, we come up with 33KΩ for R1 and 8.2KΩ for R2, which yields switch points of 2.04V & 1.98V.
For light levels below the threshold, the input would be high, forcing the output low.
For light levels above the threshold, the input would be low, forcing the output high (10V)

Problem 1.5



Mode is ====>	Coast	Brake	Run	Brake
Enable	0	0	1	1
Brake	0	1	0	1
PWM =	0	1	1	0

Relationship is Enable XOR Brake

Mode is ====>	Coast	Brake	Run	Brake
Enable	0	0	1	1
Brake	0	1	0	1
BRAKE =	1	1	0	0

Relationship is NOT Enable

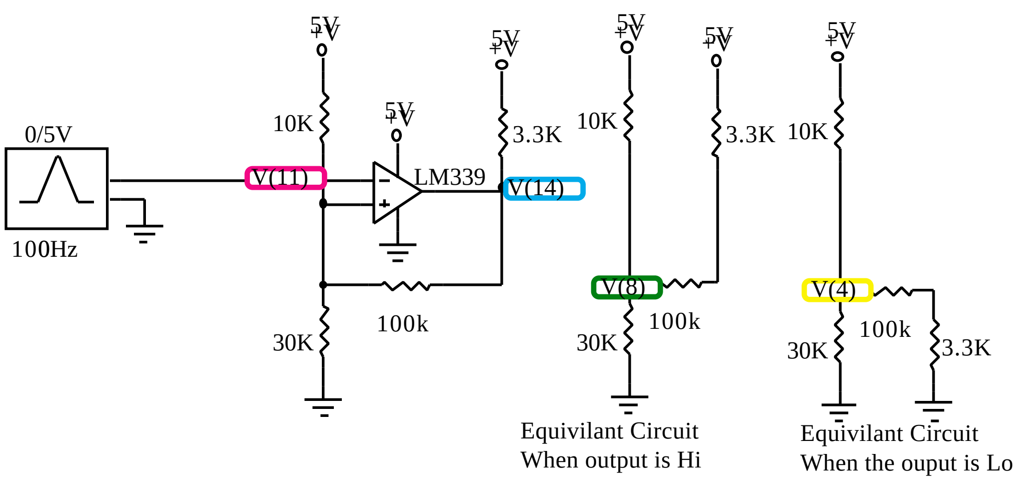
To get the motor leads connected to power when both PWM & BRAKE are high requires that DIR also be high, so OR Direction with BRAKE to insure the if braking, DIR will be high.

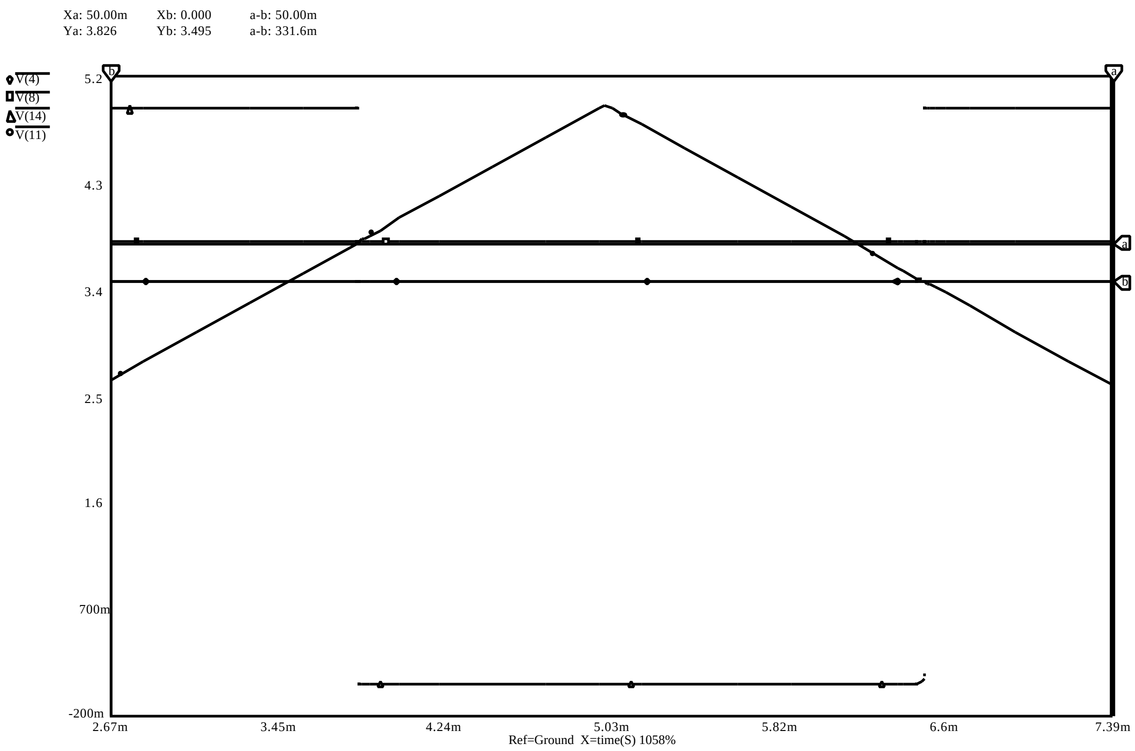
Problem 1.6

```
HEX

0000 CONSTANT TIMER
B004 CONSTANT PORTB
01 CONSTANT ENABLE_HI
FE CONSTANT ENABLE_LO
80 CONSTANT DIR_CW
7F CONSTANT DIR_CCW
20 CONSTANT BRAKE_HI
DF CONSTANT BRAKE_LO

2SECONDS CONSTANT 1E8 ( 488 TICKS = 2 SEC )
HALF_SECOND CONSTANT 7A ( 122 TICKS = 0.5 SEC )

: DELAY ( TICKS - )
      TIMER @
      +            ( ADD NUMBER OF TICKS TO DELAY )
      BEGIN
            DUP
            TIMER @
            =
      UNTIL        ( WAIT TILL TIMER = NEW VALUE )
      DROP
;
```

```
: DELAY2SECONDS ( - )
    2SECONDS
    DELAY
;
: DELAY_HALF_SECOND ( - )
    HALF_SECOND
    DELAY
;
: Coast ( - )
    PORTB C@
    ENABLE_LO AND
    BRAKE_LO AND
    PORTB C!
;
: Forward ( - )
    PORTB C@
    ENABLE_HI OR
    BRAKE_LO AND
    DIR_CW OR
    PORTB C!
    DELAY2SECONDS
    Coast
;
: Reverse ( - )
    PORTB C@
    ENABLE_HI OR
    BRAKE_LO AND
    DIR_CCW AND
    PORTB C!
    DELAY2SECONDS
    Coast
;
: Brake ( - )
    PORTB C@
    BRAKE_HI OR
    PORTB C!
    DELAY_HALF_SECOND
    Coast
;
```

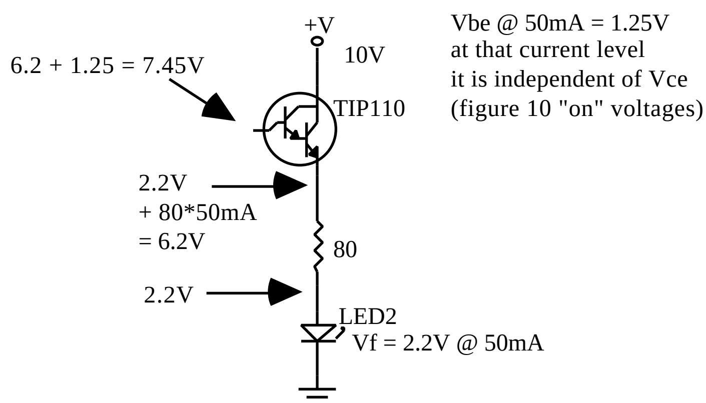
Problem 2.1



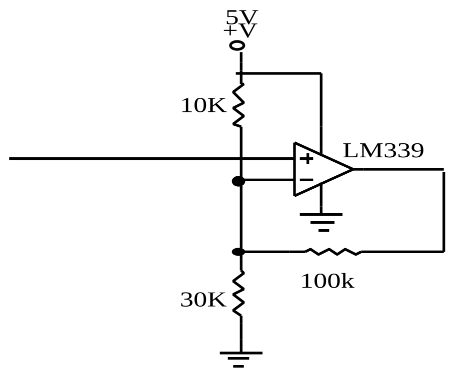


The switch points are at 3.496V & 3.835V

Problem 2.2

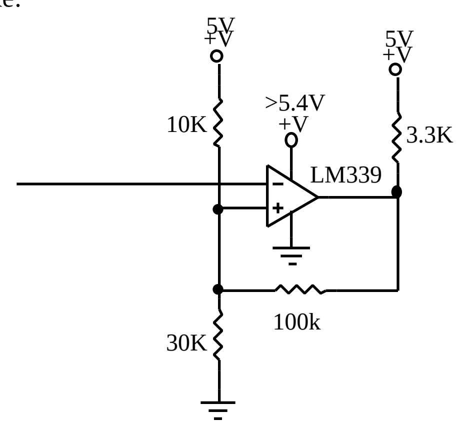


Problem 3.1



What's wrong?
1) It is configured for negative, not positive feedback.
2) there is no pull-up, the 339 has an open collector output.
3) The upper set-point exceeds the common mode voltage range.

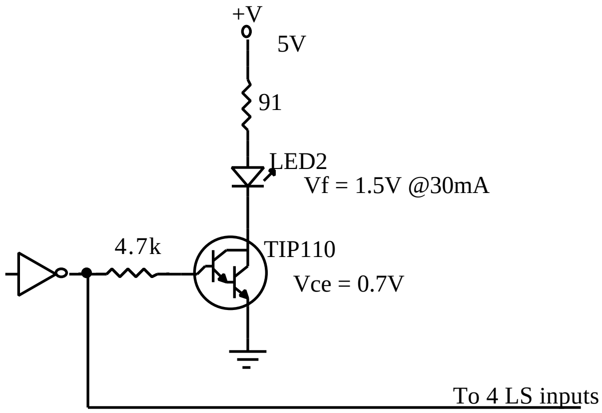
To fix it, make it something like:



Problem 3.2

What's wrong?
The voltage required at the base of the TIP110 is 1.5 + (30mA*80W) + 1.25 V = 5.15V
This can never be achieved by the 74LS14, so the TIP110 will remain off, even though it will supply a legal high to the downstream gates.

To fix it, re-configure it like:



The 4.7kΩ resistor was sized by noting that the voltage required at the base of the TIP110 is 1.25V, while the minimum output voltage supplied by the LS14 is 2.7V, so 1.45V must be dropped across the resistor, while passing 0.3mA (30mA/100). This indicates the need for a 4.83kΩ resistor, 4.7kΩ is the closest size that will deliver the required current. This will result in 1.45/47kΩ = 309mA flowing. The 'LS14 is capable of sourcing 400mA, while maintaining an output voltage of 2.7V. The 4LS inputs to be driven will require a total of 80mA (4 * 20mA), so the total required output current is 389mA, well within the 400mA the 'LS14 is guaranteed to deliver.
The 91Ω resistor was sized by noting that the voltage at the top of the LED needs to be 2.2V (0.7V + 1.5V) when 30mA is passing through the LED. this sets the ΔV across the resistor, and the current is determined by the required 30mA to the LED. This indicates the need for a 93.3Ω resistor. 91Ω is the closest standard size that will provide at least 30mA, in fact it will provide 30.8mA,

Problem 3.3

What's wrong?

1) The semicolon at the end of the for statement will insure that nothing gets executed by the for loop.
2) the comparisons to A, B & C use the assignment operator '=', not the comparison operator '=='.

To fix it:
1) remove the trailing semi-colon
2) correct the comparison operators.