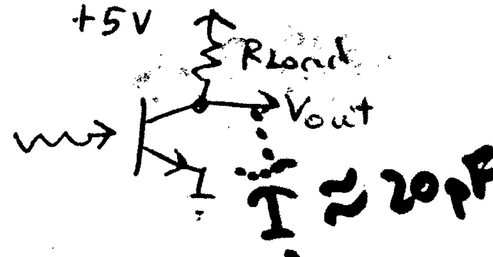
ECE331 Class Quiz #12 3 points maximum (Lecture 11 Microcontroller Interfacing)

Name:____ CM Box: _________

1) Refer to the phototransistor PT on the left of Slide #31. Assume the PT has $\beta = 50$, and that the light level illuminating the transistor stimulates 25 μA of equivalent base current to flow.



a) Find the output voltage if the light is blocked (dark PT).

$V_{out} = 5V - R_{Load}(0) = \boxed{5V}$

b) If Rload = 2 kΩ, find the output voltage level.

$V_{out} = 5V - (2k\Omega)(50)\cdot(25\mu A)$

$= 5 - 2.5 = \boxed{2.5V}$ ← Not valid digital "Low" level!

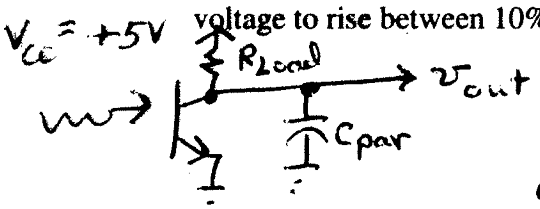
c) Find the minimum value of Rload = Rload(min) for the PT to saturate (output voltage = Vce(sat) = essentially 0 V).

$5 - R_{Load}\cdot 50 \cdot 25\mu A = 0$

$\Rightarrow R_{Load} = \boxed{4k\Omega}$

d) Assuming that the unwanted (parasitic) capacitance at the output (collector node) of the PT is Cpar = 500 pF, and that Rload = Rload(min). Find the rise time of the output voltage as the light is suddenly switched off, if rise time is defined as the time it takes for the output voltage to rise between 10% and 90% of the way from 0 V to 5 V.

$\tau = R_{Load} C_{par}$



$V_f = 5V,\ V_i = 0V$

$v_{out} = 5 - 5e^{-t/R_{Load}C_{par}} = 5 - 5e^{-t/\tau}$

$0.1(5) = 5 - 5e^{-t_{10}/\tau} \Rightarrow t_{10} = 0.1054\tau$

$0.9(5) = 5 - 5e^{-t_{90}/\tau} \Rightarrow t_{90} = 2.3026\tau$

$T_{rise} = t_{90\%} - t_{10\%} = 2.30\tau - 0.11\tau = 2.2\tau$

$T_{rise} = 2.2(4k\Omega)(500pF) = \boxed{4.4\mu s}$

e) Find the rise time if, in order to make the light detector more sensitive and also make it consume less dc power, Rload = 10*Rload(min);

$T_{rise} = 2.2(40k\Omega)(500pF) = \boxed{44\mu s}$

⇒ "Tradeoff" between sensitivity, dc power, Trise

2) Refer to the PhotoDarlington transistor on the right side of Slide #21. Assume both transistors have $\beta = 50$, and that a MUCH LOWER light level illuminating the transistor stimulates only 5 μA of equivalent base current to flow in the phototransistor (only 1/5 as much light as before). If RL = 2 kΩ, find the output voltage. Recall that this value of RL was not large enough to saturate the PT circuit of Problem 1, even with five times the light intensity.

$$V_{out} = 5 - 2000\left[(\beta+1)(\beta)(5\mu A) + \beta(5\mu A)\right]$$
$$= -20.5V \Rightarrow V_{out} = V_{ce_{sat}} \cong \boxed{0\,V}$$

($\beta = 50$)

3) When the reflective optoelectronic switch is over a black area, the output voltage is _________ when over a white area, the output voltage is __________

4) The optoelectronic switch of Problem 3 may be used as a UPC bar code scanning wand. Study Slide #33, and then determine all 12 digits of the following UPC code, where +5V out = "1".

0 9 3 1 5 4 8 7 2 6 4 (7) ← check sum

5) Verify the UPC code above by calculating the 12th digit (mod 10 check digit) from the leftmost 11 digits using the following algorithm (where the leftmost digit is D1, the next is D2, etc., and the checksum digit is D12):

D12 = 10 - [3*(D1 + D3 + D5+D7+D9+D11) + (D2+D4+D6+D8+D10)] %10

Where "% 10" means the remainder after division by 10. For example 10 – 34 % 10 = 6

$$3\cdot\underbrace{[0+3+5+8+2+4]}_{3\cdot 22} + \underbrace{[9+1+4+7+6]}_{27} = 93$$

$$10 - 3 = \boxed{7}$$

6) Why are the odd-numbered digit values multiplied by 3?

Catch (Guard against) single-digit transposition errors when typing in a UPC Bar Code by hand!