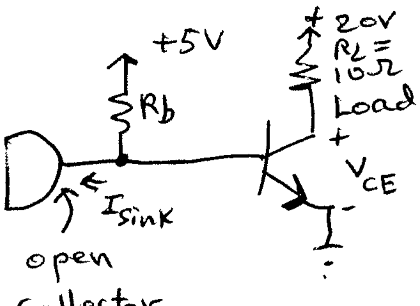
ECE331 Quiz #17 **3 points maximum (Lecture 11 Microcontroller Interfacing)**

Name: Solution **CM** ___________

1) A power NPN BJT with beta = 80 is used to switch a 10 ohm, 20 V resistive load using the upper left circuit of Slide #55. What is the maximum permissible value of Rb? How much current must the open-collector driving gate be able to sink? (Assume Vcesat = 0 V.)



$$V_{CE} = 20V - 10\Omega(80)\left(\frac{5-0.7}{R_b}\right) = 0$$

(R_L, β, $(V_{CE})_{SAT}$)

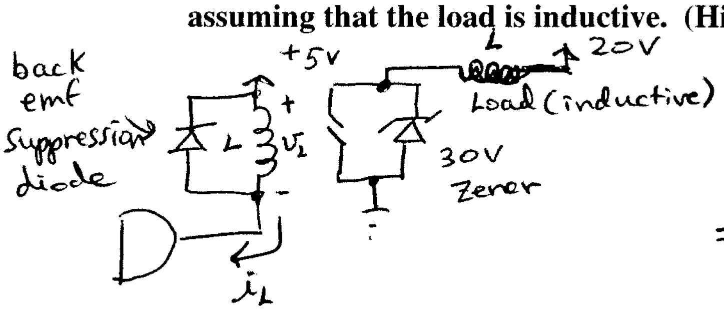
$$\Rightarrow R_b = \boxed{172\,\Omega}$$

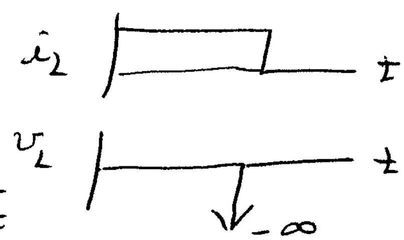
open collector gate must sink

$$I_{sink} = \frac{5V}{172\Omega} = \boxed{29.1\,mA}$$

when load is turned <u>off</u>.

2) Explain the purpose of the "back emf" suppressor diode and the 20 V Zener arc suppressor diode in the reed relay circuit of the lower left circuit of slide #55, assuming that the load is inductive. (Hint: use $v_L(t) = L\,di_L/dt$





when load is on i_L = constant, and diode is off.

when load is turned off $v_L = L\frac{di}{dt} = -\infty$

and large voltage burns out driving gate!

with diode present, as i_L becomes negative, diode turns on, and i_L circulates around diode-coil loop, dying out as $e^{-t/(L/R)} \Rightarrow$ <u>delayed Turn off Time!</u>

3) How long does it take to turn ON the reed relay if the reed relay coil has an inductance of 50 mH, a resistance of 200 ohms, and a pull-in current of 20 mA?

$$i_L = \frac{5V}{200\Omega}\left(1 - e^{-t/(50mH/200\Omega)}\right) = 20mA$$

$$\Rightarrow \boxed{t = 0.4ms}$$

4) How long does it take to turn OFF the reed relay if its break-out current is 10 mA, assuming the back emf suppressor diode has negligible on resistance. How might we speed up this turn off time?

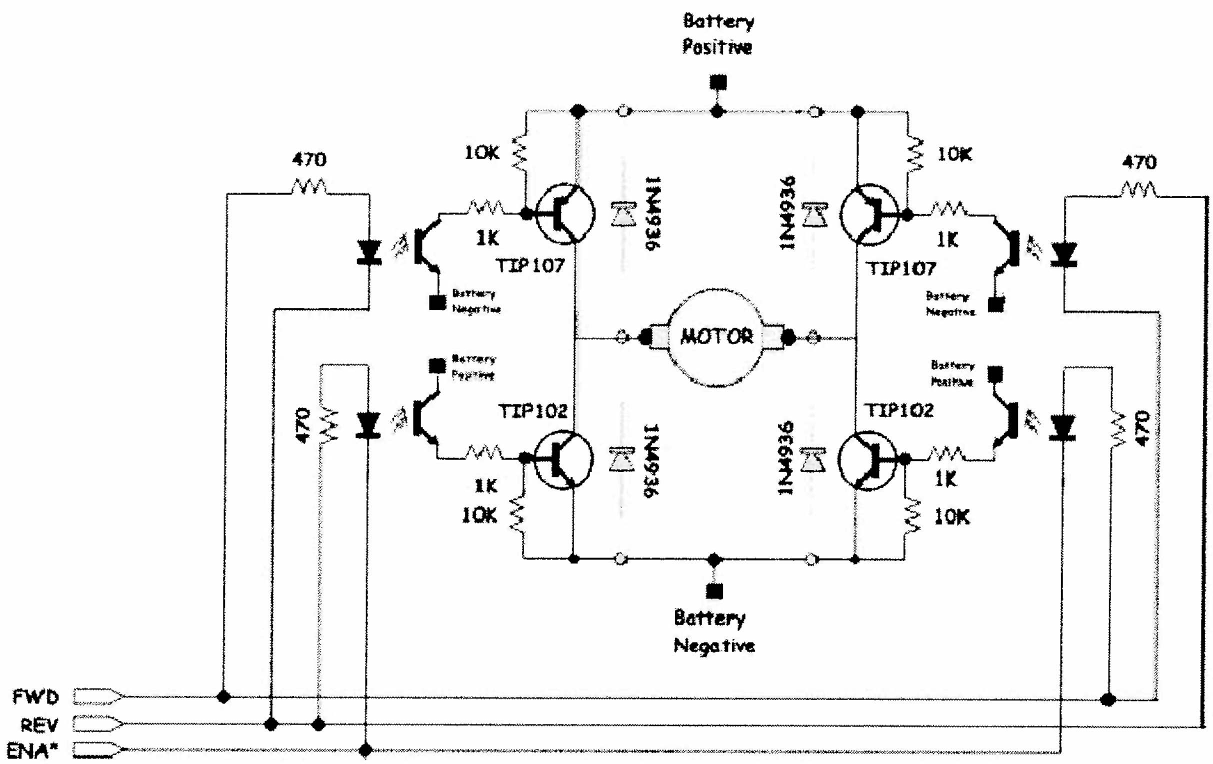
$$i_L = \frac{5V}{200\Omega} e^{-t/(50mH/200\Omega)} = 10mA$$

$$\Rightarrow \boxed{t = 0.22ms}$$

Add resistance "R_1" in series with the back emf suppression diode to <u>shorten</u> the time constant

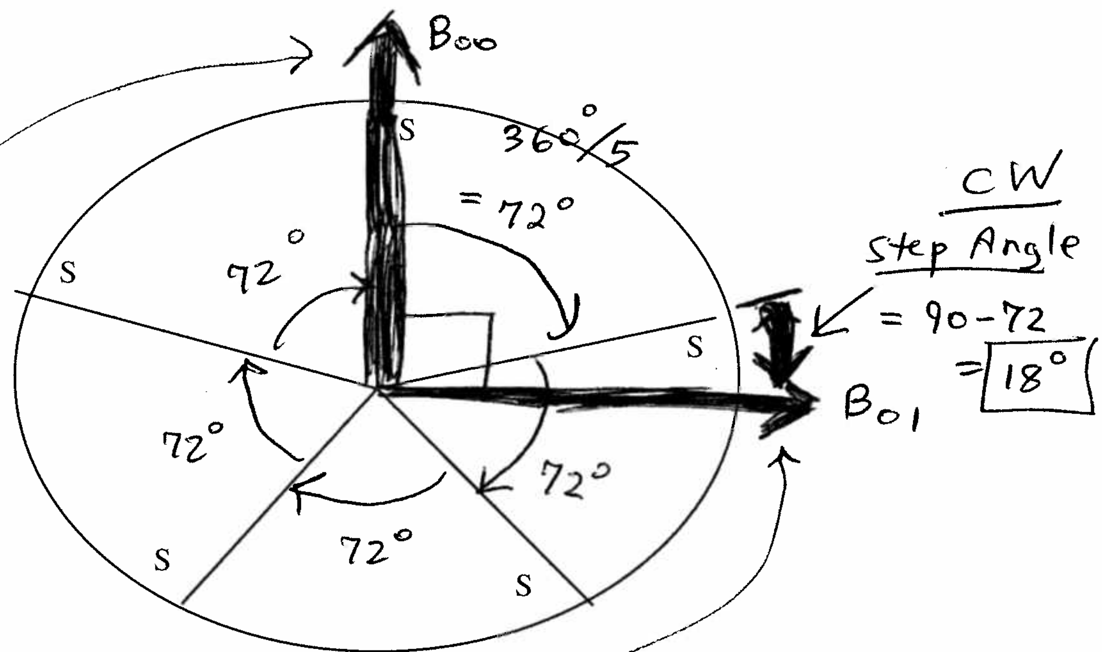
$$\tau = \frac{L_{Load}}{R_{Load} + R_1}$$

5) Consider the practical optocoupled H bridge circuit for bidirectional motor control shown below. Complete the chart below that shows the signal values that must be supplied by the microcontroller for each operating mode. Note that the TIP107 BJTs are PNP (They act as current sourcing switches) and the TIP102 BTs are NPN (they act as current sinking switches)..



FWD	REV	ENA*	Description
1	0	0	Turn on upper left source and lower right sink. (go forward)
1	0	1	Disable lower right sink. When ENA* is fed a PWM signal the bridge modulates the "forward" current through the motor.
1	1	0	Turn on both lower left sink and lower right sink, shorting the motor. This causes a rotating motor to stop rotating so this mode is called "Braking."
1	1	1	Disable both lower sinks. When fed a ENA* is fed a PWM signal the bridge modulates the "braking" of the motor.
0	1	0	Turn on the upper right source and lower left sink. (go backward)
0	1	1	Disable lower left sink. When ENA* is fed a PWM signal the bridge modulates the "reverse" current through the motor.
0	0	x	Turn off all sources and sinks. Motor coasts without any braking.

6) For the permanent magnet (PM) stepping motor of Slide #66 – 67, we found that a 3-magnet rotor would rotate 30 degrees per step in the CCW direction, which implies 360/30 = 12 steps per revolution (Slide #67). Draw a similar figure for a 5-magnet rotor, and determine the number of degrees per step, rotation direction, and steps per revolution.



$$\text{Steps/Revolution} = \frac{360^\circ}{18^\circ} = \boxed{20}$$

Elaboration: The 4 coil stator as shown on Slide # 66 steps the $\vec{B}$ field around in 90° increments (4 positions). Note that 2 coils (adjacent ones) are energized at any time. You can assume that the initial B field position is ($\vec{B}_{00}$), and a South Pole is already lined up with it. Then, the instant the B field steps to its new position ($\vec{B}_{01}$), we see it will attract the nearest South pole on the rotor. Since the nearest South pole is located $90^\circ - 72^\circ = 18^\circ$ away, the shaft will turn 18° Clockwise!