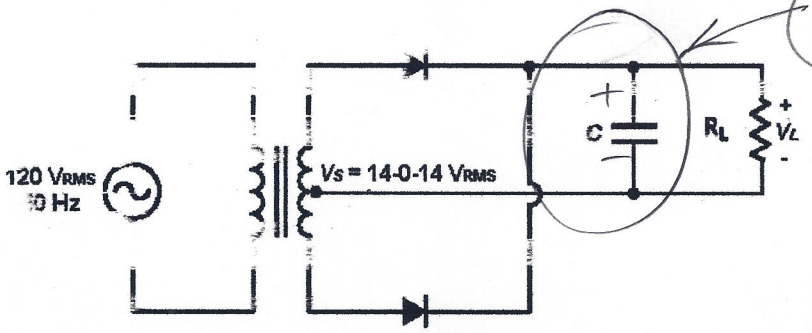
ME-ISE 3511 • Exam IV • 30 October 2020 NAME SOLUTION

1. What type of rectifier is seen here? Is it half-wave or full-wave?



+1

center-tap

full-wave +2

If C = 470 µF and R_L = 240 Ω, determine the ripple voltage in $V_{P\text{-}P}$ and the approximate final V_L, assuming silicon diodes with the constant-drop model.

$V_{peak\ (center\text{-}tap)} = V_s\sqrt{2} - V_D = 14\sqrt{2} - 0.7 = 19.10\ V$ +2

-- assume $V_{ripple} \ll V_{peak}$; then $I_L \approx \frac{19.10\ V}{240\ \Omega} = 0.07958$

or 79.58 mA +2

$V_{ripple} \approx \frac{I_L}{2fC} = \frac{.07958}{2 \cdot 60 \cdot 470 \times 10^{-6}} = 1.411\ V_{P\text{-}P}$

$V_L = V_{peak} - \frac{1}{2} V_{ripple} = 19.10 - \frac{1}{2} \cdot 1.411 = 18.39\ V$

[plugging this back into I_L, V_{ripple}, and V_L eqns. only changes final answer 0.16%!]

Determine the required voltage rating of the capacitor and indicate the correct polarity on the schematic. Also choose a suitable 1N400X-series diode.

-- cap voltage must exceed 19.10V; 25V is standard +1

Center tap: $PIV > 2\sqrt{2} V_{s(RMS)}$

$> 2\sqrt{2} \cdot 14$

$PIV > 39.6\ V$ +1

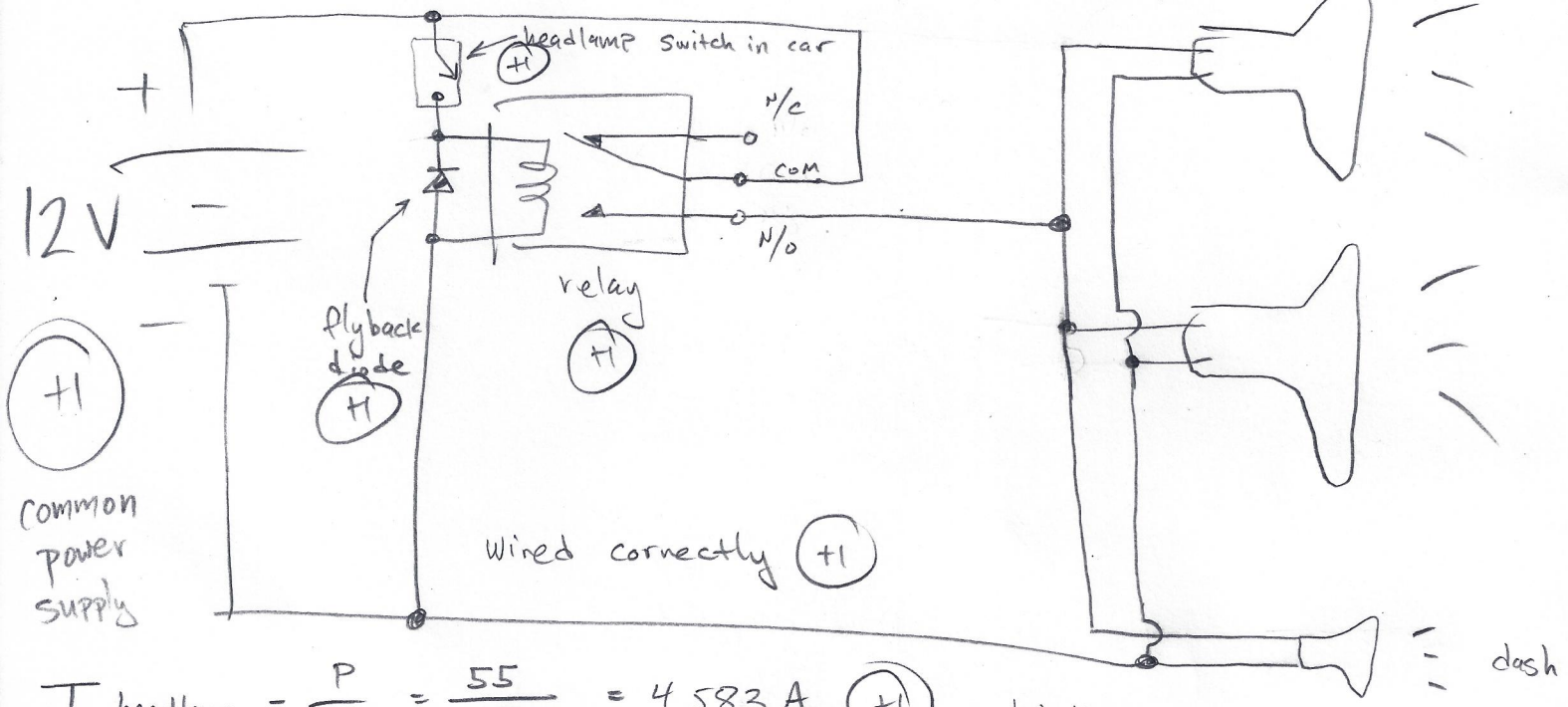
1N4001 @ 50V will be fine +1

2) The headlamp switch in your car simultaneously turns on your headlamps and dashboard light. Design a relay circuit that accomplishes this task, given the following specs:

Headlamps:	Dashboard Light:	Relay:
12 VDC, 55 W ea. (two lamps)	12 VDC, 640 mA	12 VDC, supplied from same system as lamps 72-Ω coil w/ flyback diode SPDT, N/O and N/C contacts

Draw the complete circuit. Determine the current in the switch wiring and the current in the relay contacts. What relay contact voltage and current ratings do we need?

dashboard ! headlamps in parallel (+1)



$I_{headlamp} = \frac{P}{V} = \frac{55}{12} = 4.583\,A$ (+1)

dash light

$I_{relay\ contacts} = 4.583 \times 2 + 0.640 = 9.8\,A$ (+2)

$I_{relay\ coil} = \frac{V}{R} = \frac{12}{72} = 0.1667\,A$ (+1)

Use at least 12V, 10A relay (+2)

Does the dashboard light *really* need to be switched with a relay, or could we possibly get away with switching it directly with the headlamp switch? Explain your answer.

Since $I_{dash} \ll I_{headlamp}$, and it's in the hundreds of mA range like relay coil, we could probably switch directly if close by.

(+2)

3) A hysteresis-synchronous motor used in a precision tape transport has 12 poles. Compute the resulting RPM of this motor when connected to the designed line frequency of 50 Hz at the correct voltage.

two-pole motor : one revolution per Hz

$\therefore$ $50 \text{ rev/s} \cdot \frac{60 \text{ s}}{\text{min}} = 3000 \text{ RPM}$

12-pole motor is then $\frac{12}{2} = 6$ times slower

$\therefore$ $\frac{3000}{6} = 500 \text{ RPM}$

+3

If the motor is a European model designed to run on 50 Hz and the owner unwittingly uses it in the USA at 60 Hz, compute the speed error in percent.

$\frac{60}{50} = 1.2$

$\therefore$ 20% faster

+1