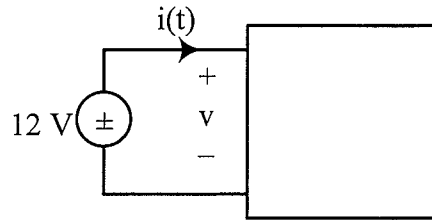


Problem 1 (10 points)

A multimeter is used to measure the voltage v and current $i(t)$. The following readings are recorded:



dc scale (average value): $V_{dc} = 12 \text{ V}$ and $I_{dc} = 2 \text{ A}$

ac scale (true rms): $V_{rms} = 12 \text{ V}$, $I_{rms} = 4 \text{ A}$

a) (5 pts.) Compute P_{avg} from the above information.

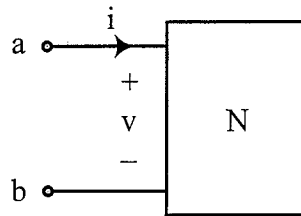
$P_{avg} =$

b) (5 pts.) Justify your choice of measurements using the definition of average power, that is,

$$P_{avg} = \frac{1}{T} \int_0^T v i \, dt$$

Problem 2 (20 points)

The circuit N consists of ideal resistors and possibly independent sources. Your task is to draw the Thevenin and Norton equivalent circuits for the following two scenarios.

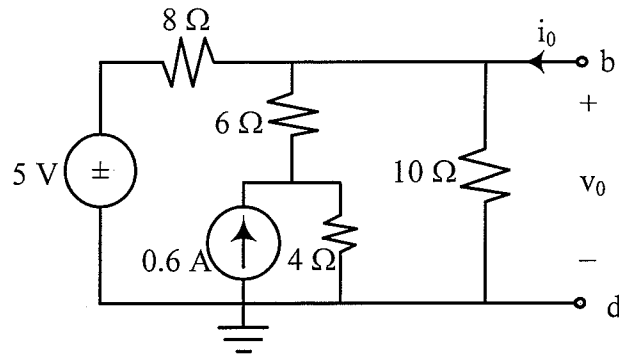


- a) (8 pts.) measurement 1: When $i = 0$, $v = 0$
measurement 2: When $i = 8 \text{ mA}$, $v = 14 \text{ V}$

- b) (12 pts.) measurement 1: When $i = 0$, $v = -6 \text{ V}$
measurement 2: When $i = 8 \text{ mA}$, $v = 6 \text{ V}$

Problem 3 (25 points)

- a) (15 pts.) Use the nodal method to solve for the voltage v_0 when $i_0 = 0$.



$$v_0|_{i_0=0} =$$

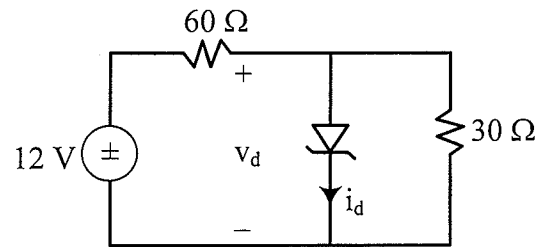
- b) (10 pts.) Find the equivalent resistance at terminals b-d.

$$R_{bd} =$$

Problem 4 (20 points)

Given the Zener diode parameters:

$$V_{on} = 0.7 \text{ V}, I_R \approx 0 \text{ A}, \text{ and } V_Z = 5 \text{ V}$$



For the given circuit, solve for the diode voltage and current.

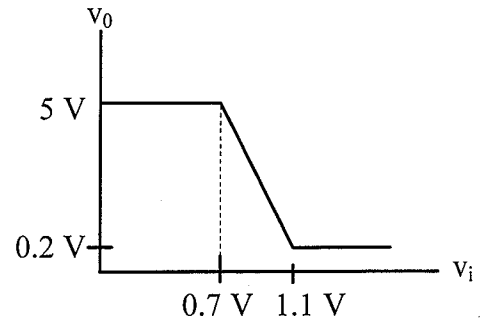
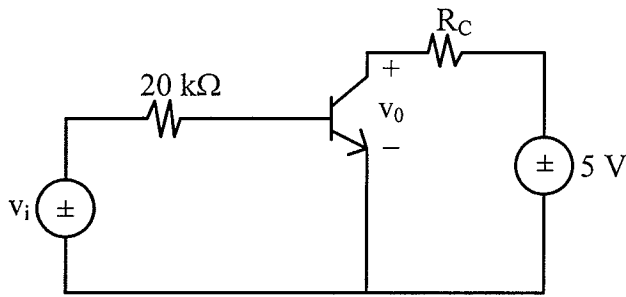
I_R is the current in the reverse region.

$$v_d = \boxed{}$$

$$i_d = \boxed{}$$

Problem 5 (20 points)

- a) (12 pts.) From the given input-output characteristic for the bipolar transistor inverter circuit, calculate the value of R_C .



$\beta = 50, V_{BEON} = 0.7 \text{ V}, V_{CESAT} = 0.2 \text{ V}$

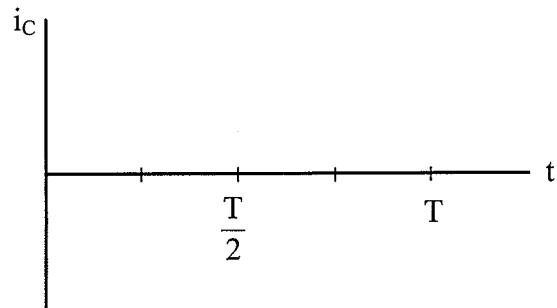
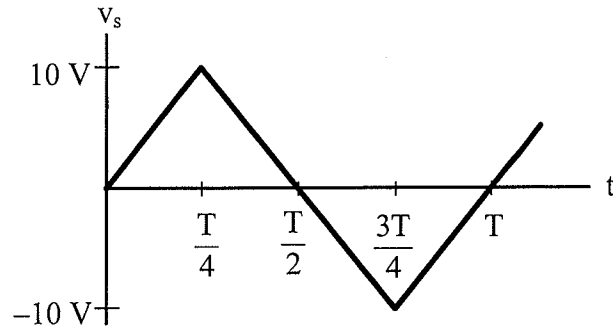
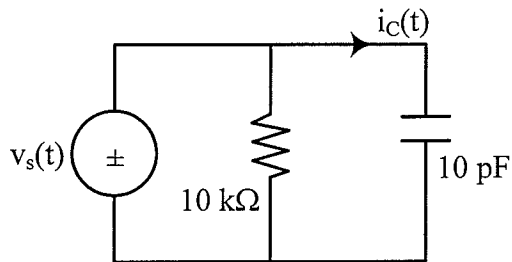
$R_C =$

- b) (8 pts.) What is the voltage gain in the active region?

Voltage Gain =

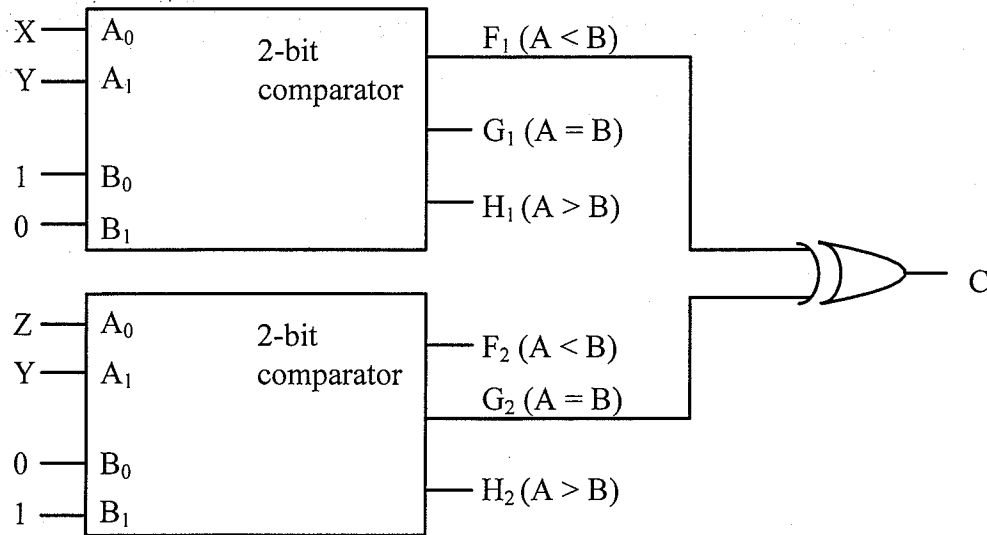
Problem 6 (20 points)

- a) (12 pts.) For the given voltage waveform in the circuit below draw and label the current waveform $i_c(t)$. Express the current as a function of the period T .



- b) (8 pts.) Discuss how the amplitude of the current waveform depends on the frequency $f = 1/T$ of the voltage waveform.

Problem 7 (20 points)



a) (15 pts.) Fill in the table below for the circuit above.

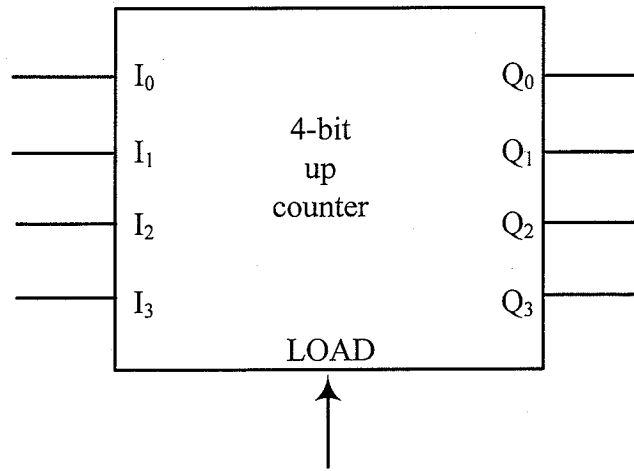
X Y Z	F ₁	G ₁	F ₂	G ₂	C
0 0 0					
0 0 1					
0 1 0					
0 1 1					
1 0 0					
1 0 1					
1 1 0					
1 1 1					

b) (5 pts.) Deduce a canonical SOP for output C.

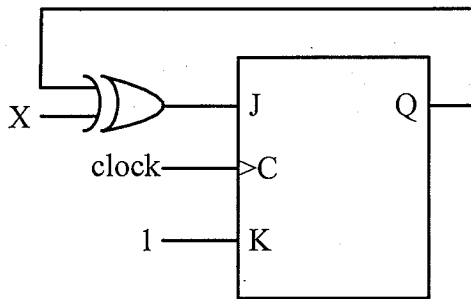
$C(X, Y, Z) =$

Problem 8 (15 points)

a) (8 pts.) Design a counter that produces the sequence 2, 3, 4, 5, 2, ...



b) (7 pts.) Fill in the table for consecutive clock pulses for the circuit below.



clock	1	2	3
X	1	1	0
Q	0		
J			
K			

Problem 9 (20 points)

Consider the five symbols A, B, C, D, and E with respective frequencies $5/12$, $3/12$, $2/12$, $1/12$, and $1/12$.

- a) (5 pts.) Compute the minimum number of bits per symbol for any possible coding:

$$N = \boxed{}$$

- b) Consider the Huffman coding A:0, B:10, C:111, D:1101, E:1100 (you do not need to show how it was obtained).

- (i) (5 pts.) Give the corresponding code tree.

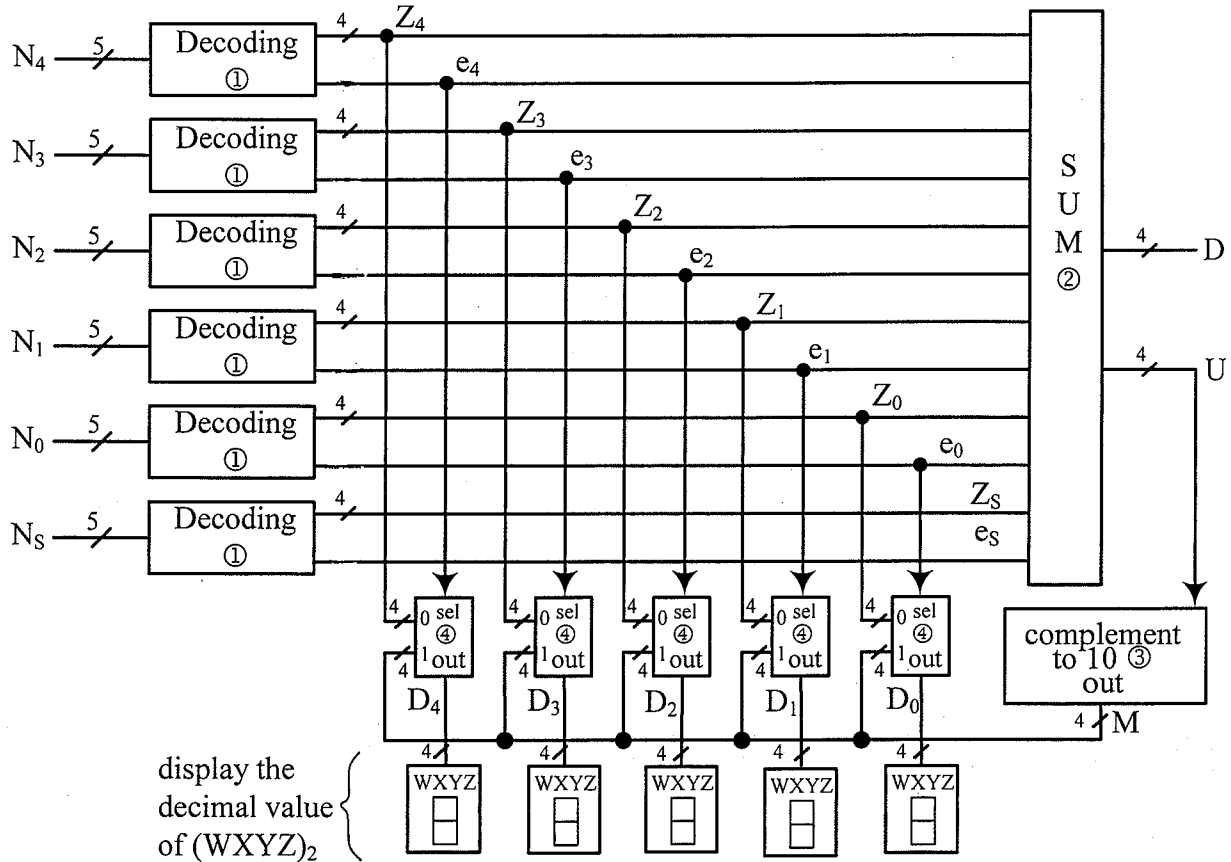
- (ii) (5 pts.) Compute the average codeword length.

$$L = \boxed{}$$

- (iii) (5 pts.) Decode the message 1011010111101100.

Problem 10 (30 points)

The circuit below displays the 5-digit zip code for any USPS coding. $N_4N_3N_2N_1N_0$ is the five 5-bit USPS input code and N_s is 5-bit check sum digit (the start and stop bars are not included in the input). The circuit allows error detection and correction. The different units of the circuit are described below. \overline{n} represents a bus of n wires. Assume 1-bit error at most.



Unit ① (Decoding) All six units are identical.

If there is no error in the USPS digit (e.g., N_2), the bit error outputs are 0 ($e_2 = 0$) and the output number is the 4-bit number corresponding to the USPS code (Z_2). If there is an error, then the bit error is 1 ($e_2 = 1$) and the output number is set to 15 (e.g., $Z_2 = 1111$).

Unit ② (Sum)

It computes the sum of all the error-free binary numbers in the six-number set ($Z_4, Z_3, Z_2, Z_1, Z_0, Z_s$). For example, if there are no errors, all six binary numbers are added. If one error is detected, it adds only the five error-free binary numbers. The two digits $D \cdot 10^1 + U \cdot 10^0$ are output in binary, for example if sum = $(31)_{10}$, then the outputs are $D = (0011)_2$ and $U = (0001)_2$.

Unit ③ (Complement to 10)

For input U it outputs M such that the sum of U and M is equal to $(1010)_2 = (10)_{10}$.

Unit ④

It is a quadruple 2×1 MUX. All five units are identical.

Answer questions on the next page.

Problem 10 (continued)

a) (18 pts.) Fill out the tables below for the two given input USPS codings.

(i)



	decimal	binary			
Z ₄					
e ₄					
Z ₃					
e ₃					
Z ₂					
e ₂					
Z ₁					
e ₁					
Z ₀					
e ₀					
Z _S					
e _S					
D					
U					
M					
D ₄					
D ₃					
D ₂					
D ₁					
D ₀					

display:

--	--	--	--	--

(decimal)

(ii)



	decimal	binary			
Z ₄					
e ₄					
Z ₃					
e ₃					
Z ₂					
e ₂					
Z ₁					
e ₁					
Z ₀					
e ₀					
Z _S					
e _S					
D					
U					
M					
D ₄					
D ₃					
D ₂					
D ₁					
D ₀					

display:

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(decimal)

b) (7 pts.) Give the truth table for Unit ③. Use output of 0 for any case that does not matter.

U	M
0 0 0 0	
0 0 0 1	
0 0 1 0	
0 0 1 1	
0 1 0 0	
0 1 0 1	
0 1 1 0	
0 1 1 1	

U	M
1 0 0 0	
1 0 0 1	
1 0 1 0	
1 0 1 1	
1 1 0 0	
1 1 0 1	
1 1 1 0	
1 1 1 1	