ESc201A: Introduction to Electronics

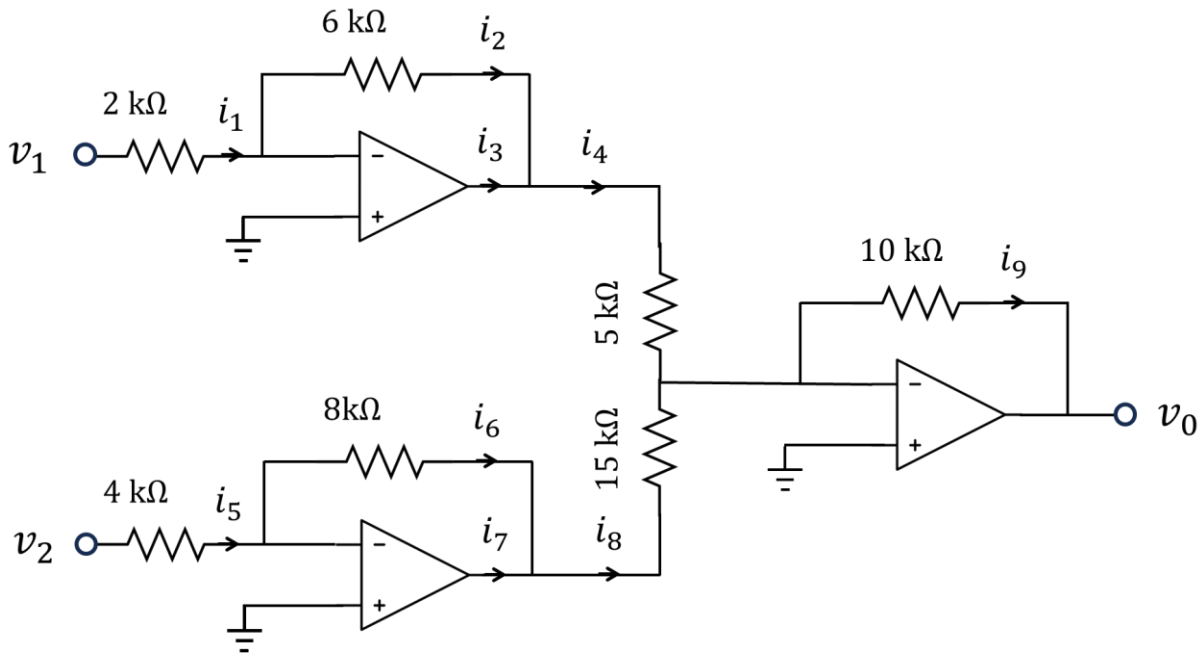
Quiz 2

2 Nov 2023

Question 1

10 marks

Let $v_1 = 1V$ and $v_2 = 2V$. Find the output voltage v_0. Also compute currents i_k for $k = 1,2,\cdots 8$.



Solution:

The circuit is divided into 3 parts

1 st part

v- is 0 volt. [1/2 marks]

Hence $i_1 = \frac{v_1}{2} = 0.5\ mA$ [1/2 marks]

I_in1 is zero. [1/2 marks]

Hence, $i_2 = i_1 = 0.5\ mA$. [1/2 marks]

$v_a = -i_2.6 = -3\ V$ [1 marks]

2nd part

v- is 0 volt. [1/2 marks]

Hence $i_5 = \frac{v_2}{4} = 0.5\ mA$ [1/2 marks]

I_in2 is zero. [1/2 marks]

Hence, $i_6 = i_5 = 0.5\ mA$. [1/2 marks]

$v_b = -i_6 . 8 = -4\ V$ [1 marks]

3rd part

v- is 0 volt. [1/2 marks]

Hence $i_4 = \frac{v_a}{5} = -0.6\ mA$ [1/2 marks]

Hence $i_8 = \frac{v_b}{15} = -0.27\ mA$ [1/2 marks]

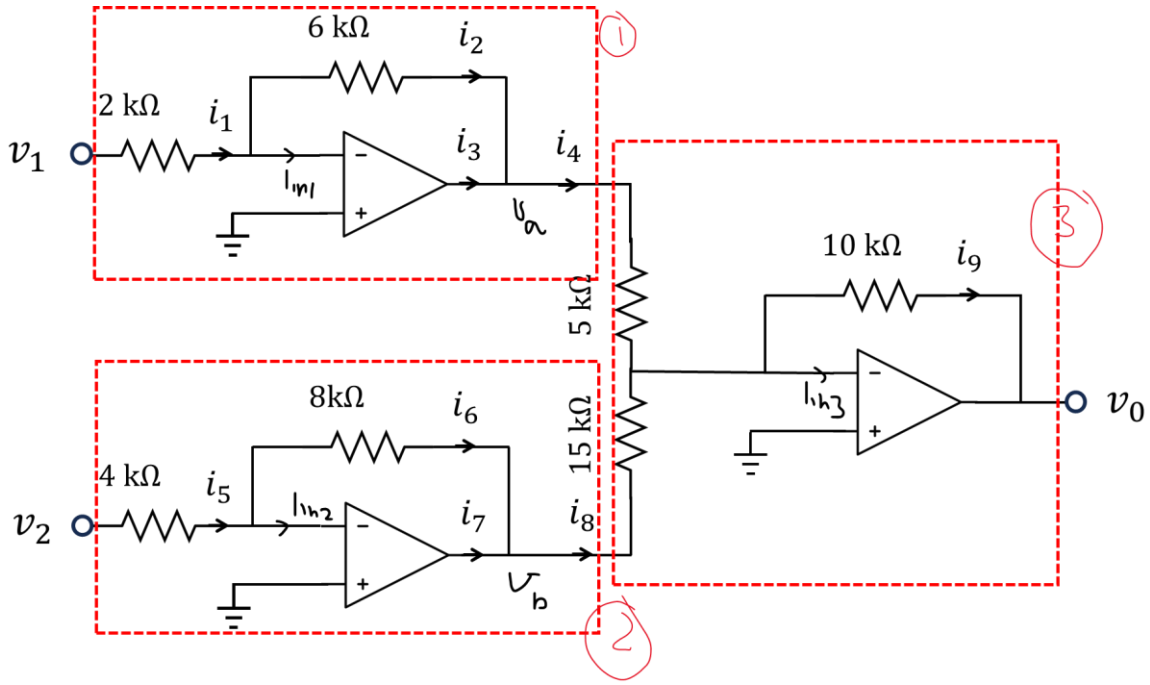
I_in3 is zero. [1/2 marks]

Hence, $i_9 = i_4 + i_8 = -.87\ mA$. [1/2 marks]

$v_o = -i_9 . 10 = 8.7\ V$ [1/2 marks]

$i_3 = i_4 - i_2 = -0.6 - 0.5 = -1.1\ mA$ [1/2 marks]

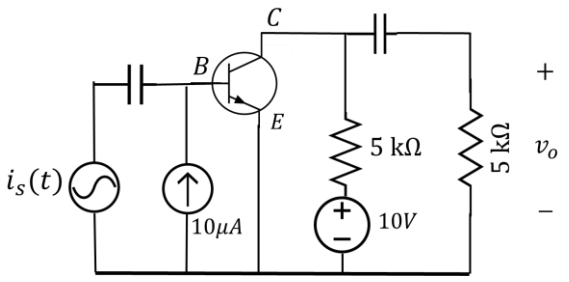
$i_7 = i_8 - i_6 = -0.27 - 0.5 = -.77\ mA$ [1/2 marks]



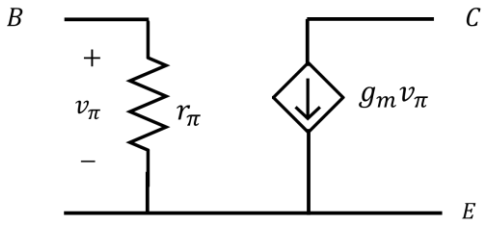
Question 2

8 marks

Assume that BJT in the circuit (a) is biased in forward active mode and β= 100. The small signal model of BJT is given in (b). Compute the value of all the parameters.



a



b

Carry out small signal analysis to determine the ratio v_o/i_s.

Solutions

$I_B = 10\mu A$ [1 marks]

$I_C = 1mA$ [1 marks]

$V_{CE} = 10 - I_C 5 = 5V$

$r_\pi = \frac{V_T}{I_B} = \frac{25\ mV}{10\ \mu A} = 2.5k\Omega$ [2 marks]

$g_m = \frac{I_C}{V_T} = \frac{1\ mA}{25\ mV} = .04\ \Omega^{-1}$ [2 marks]

IN small signal analysis

$v_\pi = r_\pi i_s$ [1 marks]

$v_o = -g_m v_\pi\ (5\ k\Omega || 5\ k\Omega) = -g_m r_\pi 2.5\ k\Omega \times i_s$

$\frac{v_o}{i_s} = -g_m r_\pi 2.5\ k\Omega = -.04 \times 2.5\ k \times 2.5\ k\ \Omega = -250\ k\Omega$ [1 marks]

Question B-1

13 marks

In this question, we will make a digital circuit which triples a n-bit number

Consider a 3-bit number $S = (S_2S_1S_0)$.

Output $Y = (Y_4Y_3Y_2Y_1Y_0)$ is a 5 bit number which is triple of S. (Example: if S is 011 (which is 3 in decimal) then Y= 01001 (which is 9 in decimal).

Write down the truth table of Y for all possible values of S. (Hint: write table for each bit of Y)

Find out the Minimized SOP Boolean expression of Y using the K Map.

Implement the expression using logic gates.

Solutions:

The truth table :

S_2	S_1	S_0	Y[4]	Y[3]	Y[2]	Y[1]	Y[0]
0	0	0	0	0	0	0	0
0	0	1	0	0	0	1	1
0	1	0	0	0	1	1	0
0	1	1	0	1	0	0	1
1	0	0	0	1	1	0	0
1	0	1	0	1	1	1	1
1	1	0	1	0	0	1	0
1	1	1	1	0	1	0	1

[3] Marks

Y[4]

S2\S1,S0	00	01	11	10
0	0	0	0	0
1	0	0	1	1

Y[4]=S2 S1

[1 marks]

Y[3]

S2\S1,S0	00	01	11	10
0	0	0	1	0
1	1	1	0	0

Y[3]=S2 S1'+S2' S1S0

[1 marks]

Y[2]

S2\S1,S0	00	01	11	10
0	0	0	0	1
1	1	1	1	0

Y[2]= S2 S1'+S2' S1S0'+S2 S0

[1 marks]

Y[1]

S2\S1,S0	00	01	11	10
0	0	1	0	1
1	0	1	0	1

Y[1]= S1 XOR S0

[1 marks]

Y[0]

S2\S1,S0	00	01	11	10
0	0	1	1	0
1	0	1	1	0

Y[0]= S0

[1 marks]

Implementation

Y[4]=S2 S1

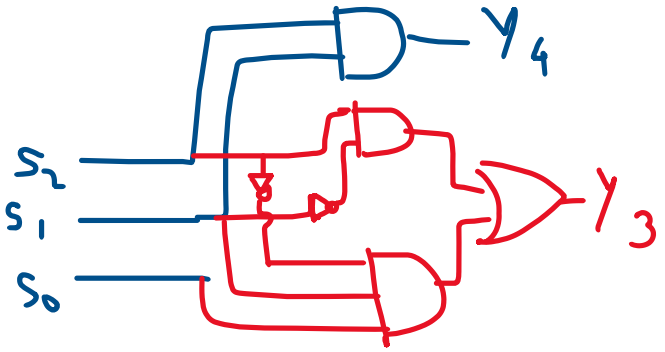
Y[3]=S2 S1'+S2' S1S0

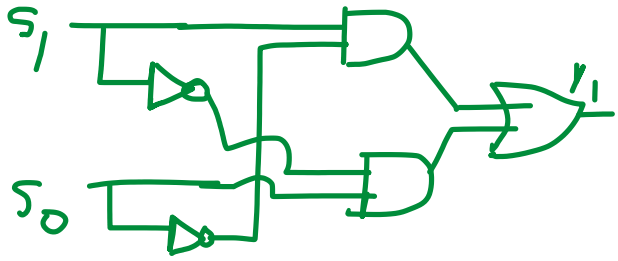
Y[2]= S2 S1'+S2' S1S0'+S2 S0

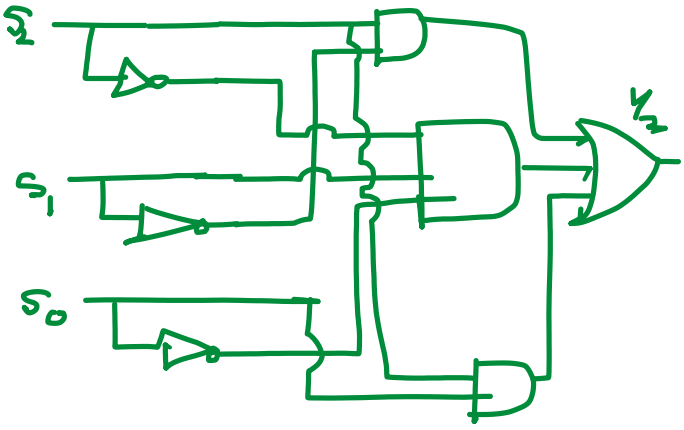
Y[1]= S1 XOR S0

Y[0]= S0

1 mark for each implementation







Question B-2

5 marks

Consider a binary number system consisting of signed 8 bit numbers. What is the range of decimal numbers this system can represent?

Now consider

A = 00010001

B = 11110101

Compute C=A+B by summing the two numbers in binary number system.

Write the equivalent decimal numbers for A,B and C and verify the summation is correct.

Solutions

A = 0001 0001

B = 1111 0101

\+ 0000 0110

[1.5 marks]

A=17

[0.5 mark]

B is negative number, hence we need to compute 2s complement.

FLIP = 0000 1010

Add 1= 0000 1011 which is 11. Hence,

B=-11

[2.5 mark]

C=6

[0.5 mark]