EXAM

1TE717 Digital Technologies and Electronics
Faculty of Engineering Sciences

2023–03–13, 14:00 - 19:00

Location: BMC B1:3

Aids: The following aids are allowed:

- Mathematics and / or Physics handbook,
- a small graphical calculator (e.g. TI-83 and similar),
- one A4 paper (two sides) with formulas or notes.

Note that exercise materials (exercise tasks, old exams, and solutions) are **NOT** allowed.

Observe: Do not treat more than one problem on each page and write a clear answer to each question. Each step in your solutions must be motivated. Lacking motivation will results in point deductions. Mark the total number of pages on the cover or first page

Grades: The *preliminary* grading criterium is

Grade 3: A minimum of 4 points on each problem.

Grade 4: A minimum of 6 points on each problem.

Grade 5: A minimum of 8 points on each problem.

Responsible: Isaac Skog, mobile phone 0708186805.

Good Luck!

1

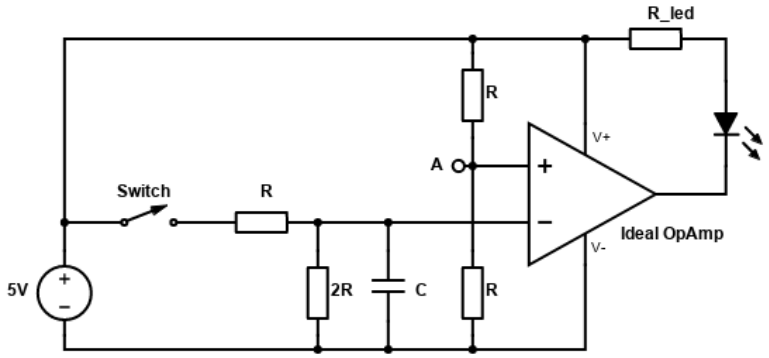

Figure 1: Circuit for problem 1. Crossing wires are only connected if there is a dot.

Consider the circuit in figure 1. Answer the following questions.

1.a) What is the voltage at point A? (1 pt)

3.b) The switch has been open for a long time and is then close at time $t = 0$. What capacitance C should the capacitor have if the led should turn on at time $t = 10$ seconds? (8 pt)

2.c) If the LED requires a current of 10 mA to shine brightly, what value should R_{led} have? The anode to cathode voltage drop is 1.2 V at 10 mA. (1 pt)

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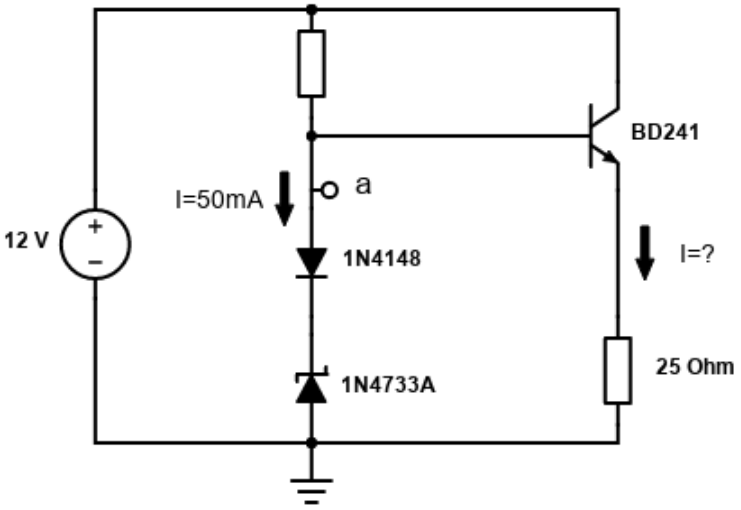


Figure 2: Circuit for problem 2.

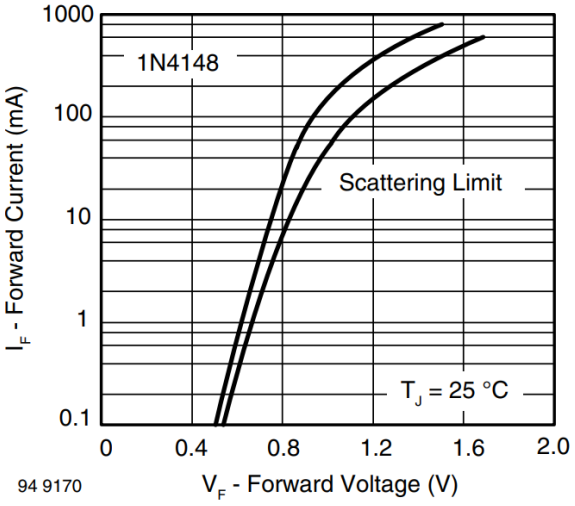
Consider the circuit shown in figure 2. Use the component characteristics shown in figure 3 to answer the following questions. The temperature T_j of the components can be assumed 25° C.

2.a) What is the approximate voltage at point (a) in the circuit? (4 pt)

2.b) What is the approximate current I passing throw the 25 Ω resistor? (3 pt)

2.c) What is the approximate bias current of the transistor? (2 pt)

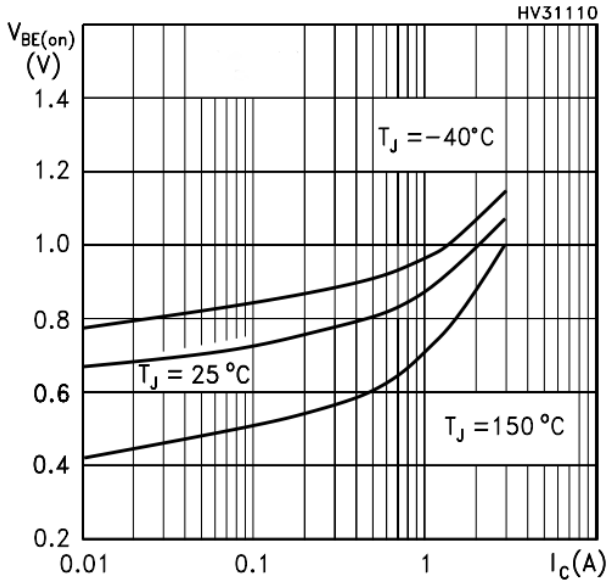
2.d) How much power is dissipated in the 25 Ω resistor? (1 pt)



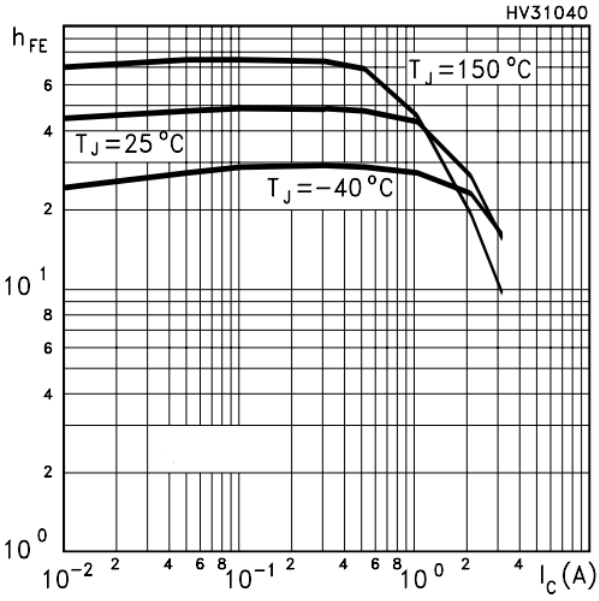
(a) Lower and upper limit (Scattering limits) of the current versus voltage curve for 1N4148 in forward biasing mode.

Device	V_Z (V) @ I_Z (Note 1)			Test Current I_Z (mA)
	Min.	Typ.	Max.	
1N4728A	3.315	3.3	3.465	76
1N4729A	3.42	3.6	3.78	69
1N4730A	3.705	3.9	4.095	64
1N4731A	4.085	4.3	4.515	58
1N4732A	4.465	4.7	4.935	53
1N4733A	4.845	5.1	5.355	49
1N4734A	5.32	5.6	5.88	45
1N4735A	5.89	6.2	6.51	41
1N4736A	6.46	6.8	7.14	37
1N4737A	7.125	7.5	7.875	34
1N4738A	7.79	8.2	8.61	31
1N4739A	8.645	9.1	9.555	28
1N4740A	9.5	10	10.5	25
1N4741A	10.45	11	11.55	23
1N4742A	11.4	12	12.6	21

(b) Electric characteristics (zener voltage) of zener diode 1N47XXA in backward biasing mode.



(c) Electric characteristics of the BD241 transistor.



(d) DC current gain characteristics of the BD241C transistor.

Figure 3: Component characteristics for problem 2.

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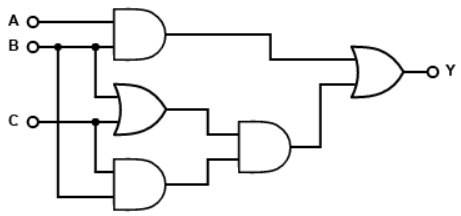

Figure 4: Circuit for problem 3b.

3.a) Design a digital circuit that repeatedly generates the bit sequence $\{1, 1, 1, 0\}$ using as few D-flip-flops as possible. That is, the output should be $\{1, 1, 1, 0, 1, 1, 1, 0, \ldots, 1, 1, 1, 0, 1, 1, 1, 0, \ldots\}$. Draw the circuit diagram of the resulting circuit. (5 pt)

3.b) From the output of a 5V logical circuit you want to control a light emitting diode (LED). The output of your logical circuit can only deliver a maximum of 1 mA. This is not enough to power the LED diode, which requires a current of 10 mA. Design a circuit using only a transistor and two resistors that solves this problem. The LED should be turned on when the logical output is false. The voltage drop over the LED at a current of 10 mA is 1.2 V. (2 pt)

3.c) Simplify the circuit in figure 4 so that only two gates are needed. (3 pt)

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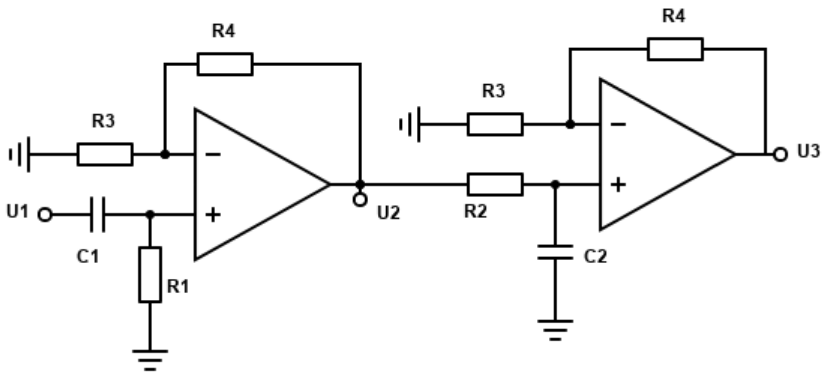

Figure 5: Circuit for problem 4.

Consider the circuit in figure 5 and assume that input $u_{in}(t) = cos(\omega t)$.

4.a) Determine the frequency function $H_{u_1,u_2}(j\omega)$ from u_1 to u_2 and the frequency function $H_{u_2,u_3}(j\omega)$ from u_2 to u_3. (5 pt)

4.b) Assume that $R_1 = 10k\Omega$, $R_2 = 1k\Omega$, $R_3 = 10k\Omega$, $R_4 = 100k\Omega$, $C_1 = C_2 = 100\mu F$. Determine the low-frequency ($\omega \to 0$) gain, the high-frequency ($\omega \to \infty$) gain, and cut-off frequency for $H_{u_1,u_2}(j\omega)$ and $H_{u_2,u_3}(j\omega)$, respectively. (3 pt)

4.c) What type of filter does the circuit in figure 5 implement? That is, what type of filter does $H_{u_1,u_3}(j\omega) = H_{u_1,u_2}(j\omega)H_{u_2,u_3}(j\omega)$ correspond to? (2 pt)

5

5.a) Determine the voltage across the resistors R_2 and R_3 in the circuit shown in figure 6. (5pt)

5.b) For the circuit in figure 7, what is the equivalent resistance as seen from voltage source? (5pt)

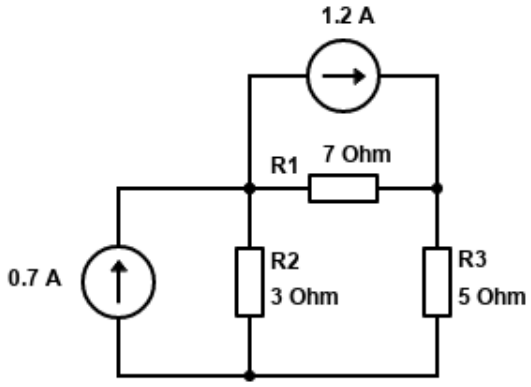

Figure 6: Circuit for problem 5a.

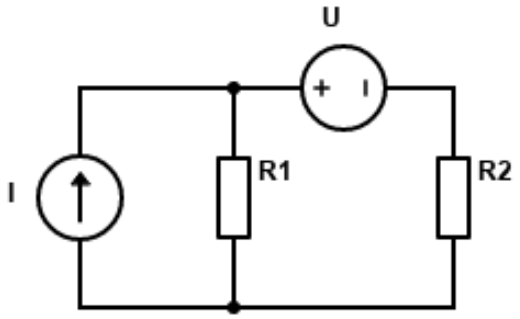

Figure 7: Circuit for problem 5b.