EE201 Circuit Theory (Spring 2017)
Final Exam.

(Total: 240 Points / 10 Problems)

Student ID Number:

Name:

1. **(20 points)** Find $i_1(t)$ and $i_2(t)$ for $t \geq 0$ for the circuit shown in Fig. 1.

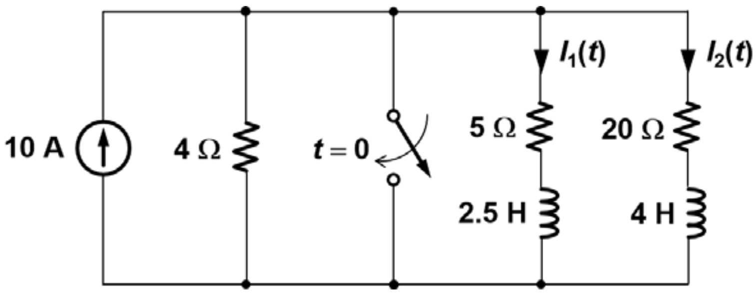

Fig. 1

2. Consider the circuit in Fig. 2(a), where a DC power supply is modeled as a DC voltage source in series with a resistor R_S. The two voltage sources and the single-pole double-throw switch model the disturbance in the power supply voltage, sketched in Fig. 2(a). Let's assume that the load draws a constant current I_L and is modeled as a current source.

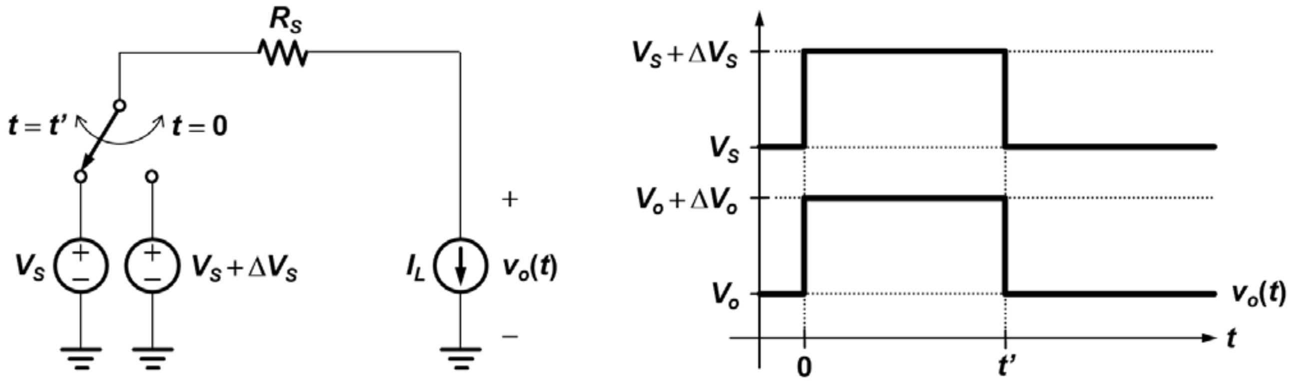

Fig. 2(a)

We wish to design the simplest possible circuit that will isolate the load from disturbances in the power supply voltage. A standard solution to this problem involves the use of a capacitor C_D, as shown in Fig. 2(b). The C_D is called a decoupling capacitor since it decouples disturbances in the input supply voltage from the output voltage applied to the load.

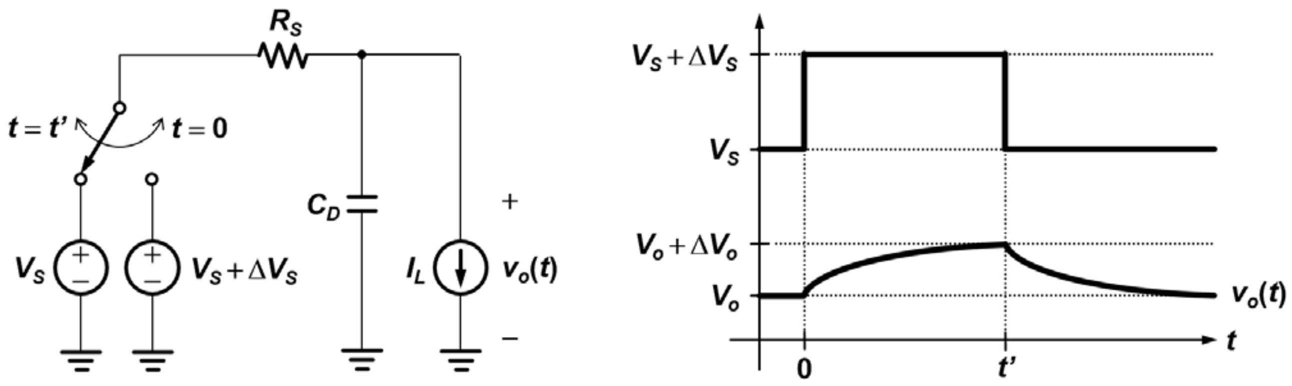

Fig. 2(b)

(a) **(10 points)** Determine $v_o(t)$ for $0 \le t \le t'$ in terms of V_S, ΔV_S, I_L, R_S and C_D, when the decoupling capacitor is employed for the supply disturbance isolation.

(b) (10 points) Find ΔV_o, when the decoupling capacitor is used.

(c) (10 points) From the result of (b), explain how the isolation performance changes for different values of the decoupling capacitance. Consider the case in which V_S is 5 V, R_S is 20 Ω, and the input disturbance is characterized by $\Delta V_S = 1$ V and $t' = 0.5$ ms. If the output changes are to be limited to only 0.2 V, what is the required capacitance value of C_D?

3. The network in Fig. 3 models an automobile ignition system. The voltage source represents the standard 12-V battery. The inductor is the ignition coil, which is magnetically coupled to the starter (not shown). The inductor's internal resistance is modeled by the resistor, and the switch is the keyed ignition switch. Initially, the switch connects the ignition circuitry to the battery, and thus the capacitor is charged to 12 V. To start the engine, we close the switch, thereby discharging the capacitor through the inductor.

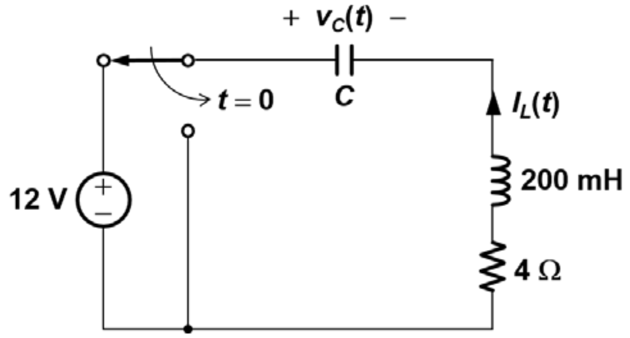

Fig. 3

(a) (30 points) Assuming that optimum starter operation requires an overdamped response for $i_L(t)$ that reaches 1 A within 100 ms after switching and remains above 1 A for longer than 1 s, find a value for the capacitor that will produce such a current waveform.

(b) (20 points) Determine the expression and draw a rough sketch of $i_L(t)$ for $t \geq 0$ when the capacitor value found in (a) is used.

4. **(20 points)** Given the network in Fig. 4, find the Thévenin's equivalent circuit of the network at terminals *A*–*B*.

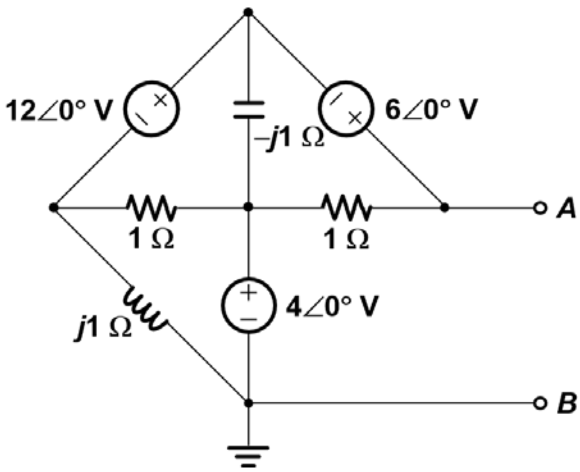

Fig. 4

5. A sinusoidal signal, $v_1(t) = 2.5 \cos \omega t$, when added to a DC level of $V_2 = 2.5$ V, provides a 0- to 5-V clock signal used for a microprocessor. If the oscillation frequency of the signal is to be 1 GHz, let us design the appropriate circuit.

Consider the circuit in Fig. 5 where inputs $v_1(t)$ and V_2 are connected to yield the output $v_o(t)$. The component *A* should block any DC component in $v_1(t)$ from reaching the output but permit the 1-GHz signal to pass right through. Thus, the impedance of component *A* should be infinite at DC but very low at 1 GHz. Similarly, the component *B* should pass the DC component of V_2 while blocking any high-frequency signal. Therefore, the impedance of component *B* should be zero at DC but very high at high frequency.

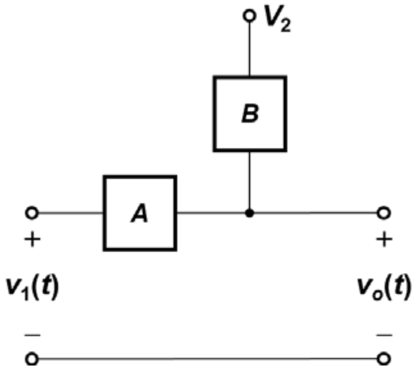

Fig. 5

(a) (10 points) Draw the simplest possible circuit network which is implemented using actual circuit elements by replacing the components *A* and *B* with circuit elements.

(b) (10 points) Determine the values of the used circuit elements so that the impedance of component *A* becomes 1 Ω and at 1 GHz and the impedance of component *B* becomes 10 kΩ at 1 GHz.

6. **(20 points)** The op-amp circuit shown in Fig. 6 is called inductance simulator. Derive the input impedance Z_{in} (= V_{in} / I_{in}) of the given circuit.

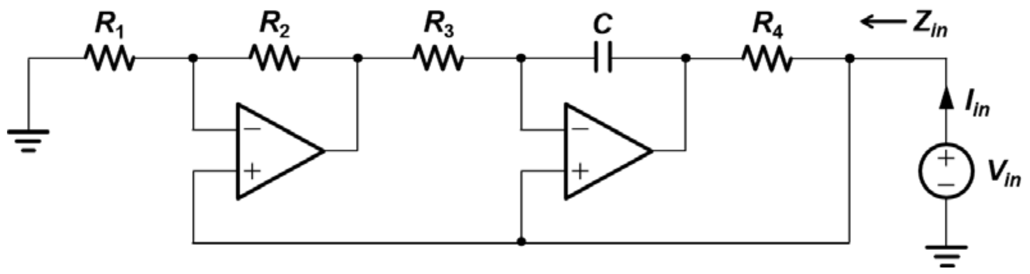

Fig. 6

7. **(20 points)** Determine the impedance Z_L for maximum average power transfer and the value of the maximum average power transferred to Z_L for the circuit in Fig. 7.

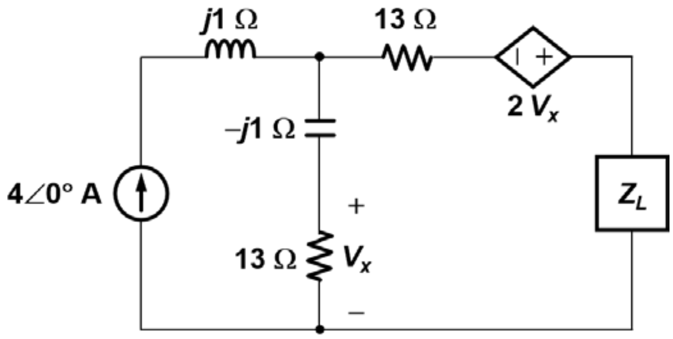

Fig. 7

8. **(20 points)** Given the network in Fig. 8, find the input source voltage and the input power factor.

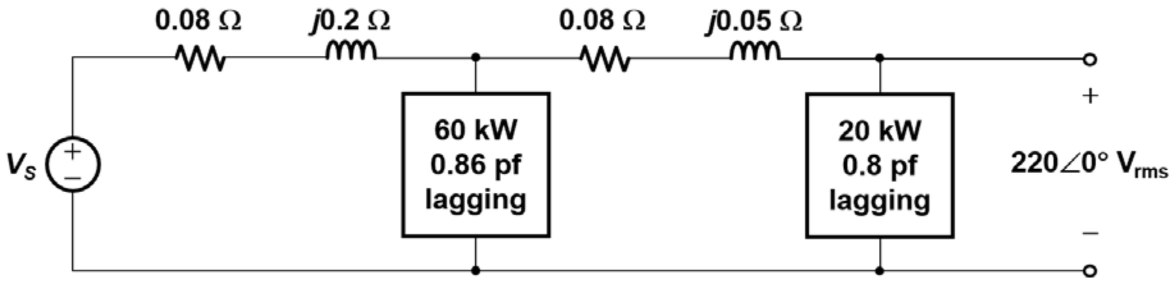

Fig. 8

9. Consider the circuit in Fig. 9. Assume that the frequency *f* is 60 Hz.

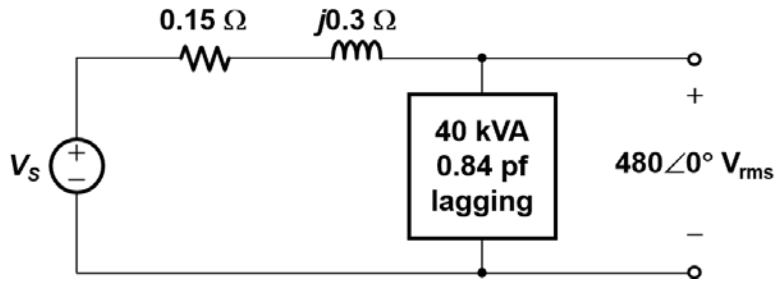

Fig. 9

(a) **(10 points)** Determine the value of capacitance that must be connected in parallel with the load so that the power factor of the combined load and capacitor is unity.

(b) **(10 points)** Calculate the complex power supplied by the source after the power factor has been corrected to unity.

10. **(20 points)** A student has discovered that her tape player has the limited high-frequency response shown in Fig. 10a. She decides to insert a "treble boost" circuit between the tape deck and the main amplifier that has the transfer function shown in Fig. 10b. Passing the tape audio through the boost should produce a "flat" response out to about 20 kHz. The circuit in Fig. 10c is her design. Show that the circuit's transfer function has the correct form, and select the component values for R_1 and R_2 for proper operation.

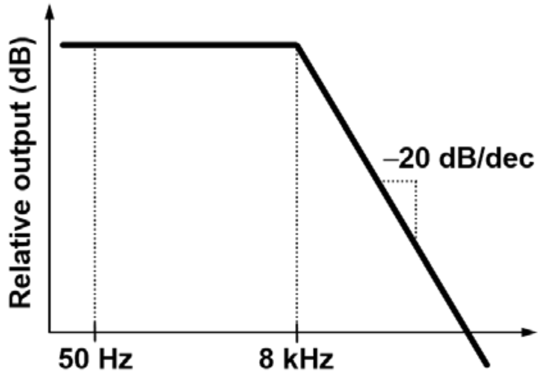

Fig. 10a

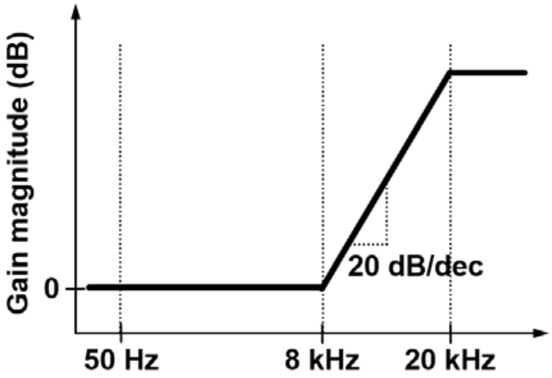

Fig. 10b

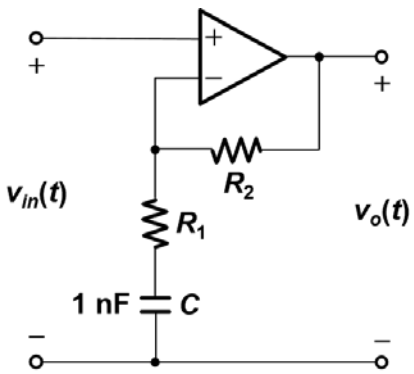

Fig. 10c