Q1. Fig 1 below shows 2 equivalent circuits (a) and (b). In circuit (a) the 2 coupled inductors have self- inductances L_1 and L_2 as shown and a mutual inductance M. Find L_A, L_B and L_C in terms of L_1, L_2 and M

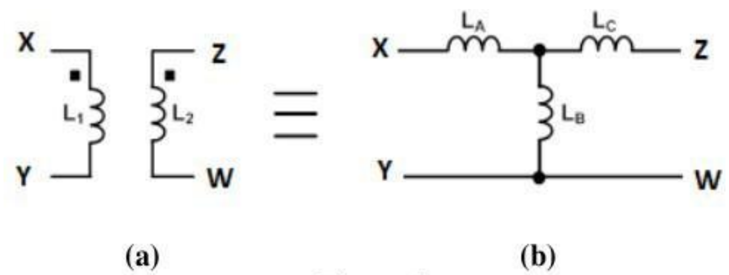
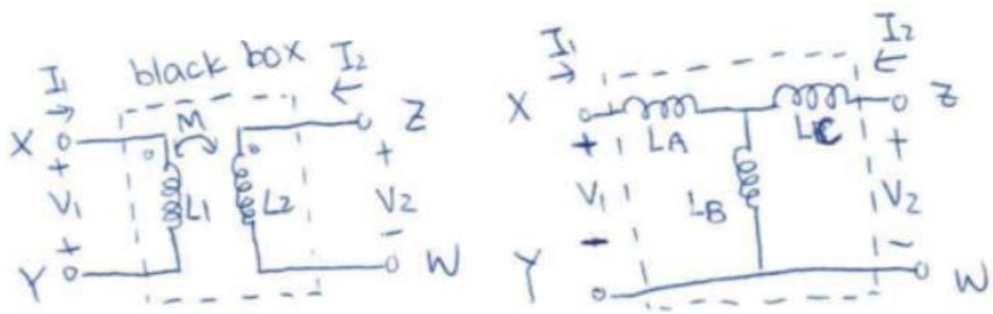


Figure 1



In (a), $V_1 = L_1\frac{dI_1}{dt} + M\frac{dI_2}{dt}$ and $V_2 = L_2\frac{dI_2}{dt} + M\frac{dI_1}{dt}$

In (b), the current through LB is $I_1 + I_2$, hence

$V_1 = L_A\frac{dI_1}{dt} + L_B\frac{d}{dt}(I_1 + I_2)$ and $V_2 = L_C\frac{dI_2}{dt} + L_B\frac{d}{dt}(I_1 + I_2)$

To make (a) and (b) equivalent, we will have

$L_1\frac{dI_1}{dt} + M\frac{dI_2}{dt} = L_A\frac{dI_1}{dt} + L_B\frac{d}{dt}(I_1 + I_2)$ and $L_2\frac{dI_2}{dt} + M\frac{dI_1}{dt} = L_C\frac{dI_2}{dt} + L_B\frac{d}{dt}(I_1 + I_2)$

So $L_1 = L_A + L_B, M = L_B, L_2 = L_C + L_B$

$L_A = L_1 - M$

$L_B = M$

$L_C = L_2 - M$

Q2. Use a series of source transformations to find the current i_o in the circuit given in the Fig 2 below.

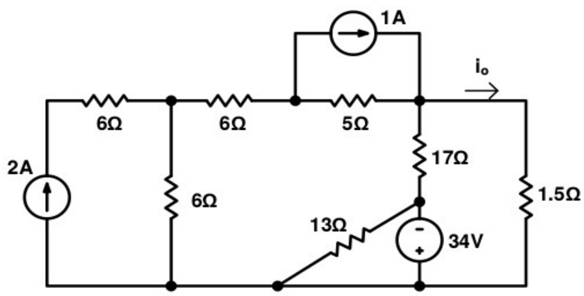
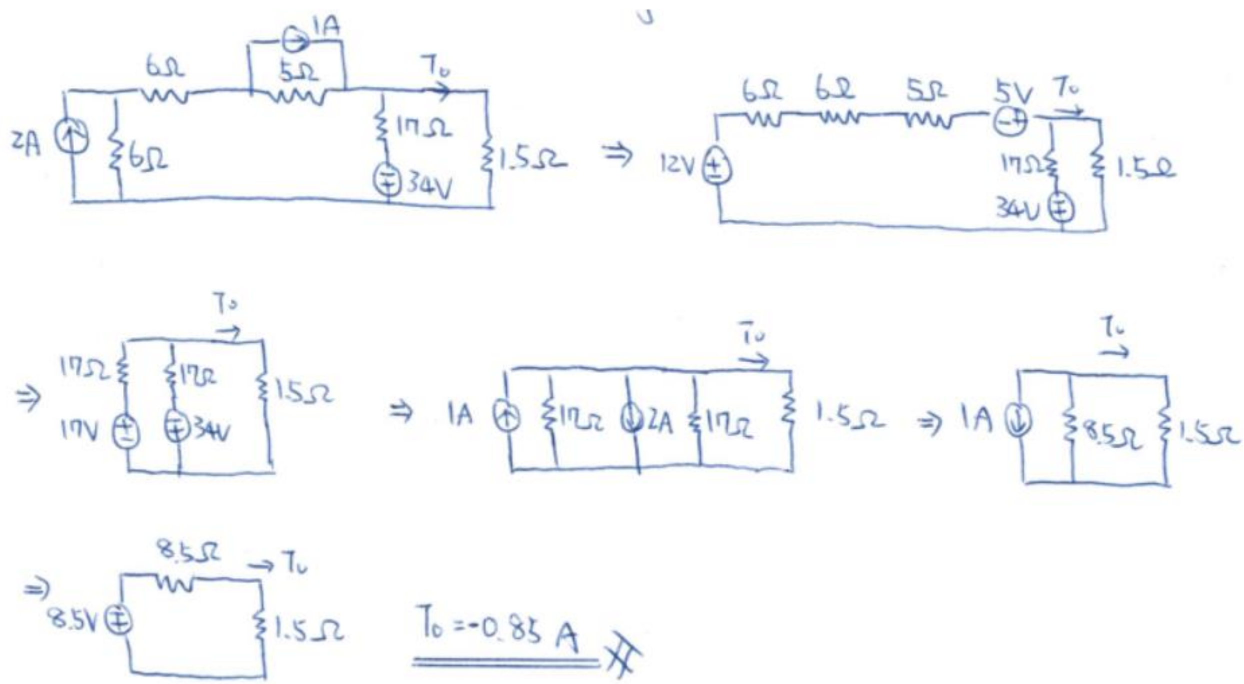
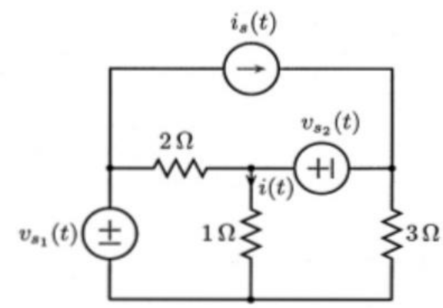


Figure 2

We can eliminate the resistor in series with 2A current source and the resistor in parallel with the 34V voltage source. After three times of voltage/current conversion, we have $I_o = -0.85A$

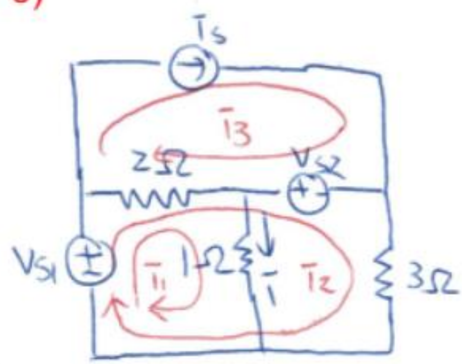


Q3. Refer circuit below. Find i(t) (current flowing through the 1 ohm resistor) in terms of $i_s(t)$, $v_{S1}(t)$, $v_{S2}(t)$.



Use mesh current analysis, we have three loops of current I_1, I_2, I_3

3)



Apply KVL to I_1 and I_2 loop.

$I_3 = I_s$

$-V_{s1} + (I_1 + I_2 - I_3)\,2 + I_1 = 0$

$-V_{s1} + (I_1 + I_2 - I_3)\cdot 2 + V_{s2} + I_2 \cdot 3 = 0$

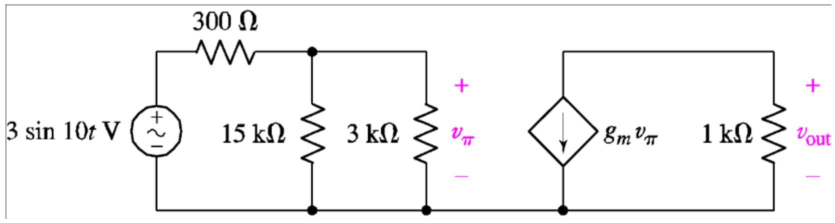
$$\Rightarrow \begin{cases} 3I_1 + 2I_2 - 2I_3 = V_{s1} & \text{— ①} \\ 2I_1 + 5I_2 - 2I_3 = V_{s1} - V_{s2} & \text{— ②} \end{cases}$$

① × 5 − ② × 2

$\Rightarrow 11 I_1 - 6 I_3 = 3V_{s1} + 2V_{s2}$

$$I_1 = \frac{3V_{s1} + 2V_{s2} + 6I_s}{11}$$

Q4. The circuit below is a commonly used equivalent circuit used to model the ac behavior of a bipolar junction transistor amplifier circuit. If g_m = 38 m, compute v_{out}.



First, we consider the left circuit.

The euivalent parallel resistance is $3K\Omega \,||\, 15K\Omega = 2.5K\Omega$

Use voltage divider, we got $V_\pi = 3sin10t * \frac{2.5K\Omega}{2.5K\Omega+300\Omega} = 2.68sin10t$

Hence, the dependent source $g_m V_\pi = 0.038 * 2.68sin10t = 0.1018sin10t\ A$

$V_{out} = -(g_m V_\pi * 1K\Omega) = -101.8sin10t\ V$