디지털시스템입문(가) Midterm Exam.

Name:_____ **Student#:**_____ [Points Acquired: ( ) /100]

Problem 1: O/X Quiz. [10 points]

① 0.035 μF is equal to 35 nF. (0.035 μF 는 35 nF와 동일하다.) [O / X]

② All circuits must have a complete path for current. (모든 회로는 전류를 위한 완전한 경로를 가져야 한다) [O / X]

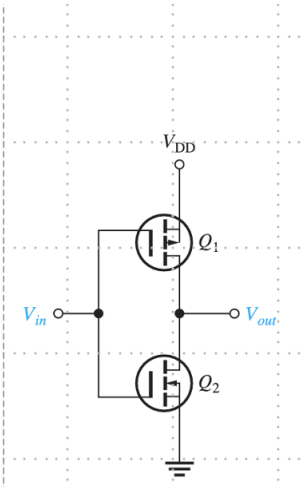
③ Use $R = V / I$ to calculate resistance. (저항을 계산하기 위해 $R = V / I$ 를 이용한다.) [O / X]

④ When a new path is added to a parallel circuit, the total resistance goes up. (병렬회로에 새 통로가 추가될 때 전체 저항은 커진다.) [O / X]

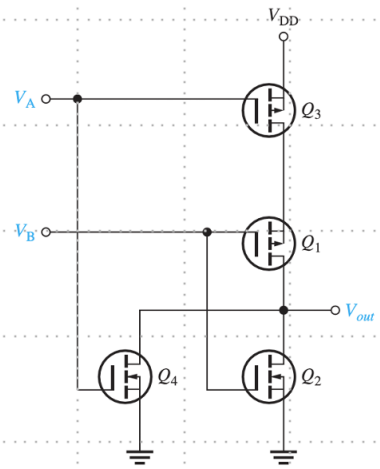
⑤ The simplest way to visualize diode operation is to think of it as a switch. When forward-biased, the diode ideally acts as a closed (on) switch. (다이오드의 동작을 나타내는 가장 간단한 방법은 다이오드를 스위치로 생각하는 것이다. 이상적인 다이오드는 순방향 바이어스일 때 닫힌(On) 스위치로 동작한다.) [O / X]

Problem 2: [10 Points]

Based on the circuit of a CMOS inverter in Figure (a), the circuit of CMOS NOR gate is created as Figure (b). The operation of the CMOS NOR gate is summarized in the table of Figure (c). Fill out the empty boxes to complete the operation table in Figure (c). (Figure(a)의 CMOS Inverter 회로를 기반으로 CMOS NOR gate 회로를 만들 수 있다. CMOS NOR gate의 동작은 Figure(c)의 Table과 같이 요약할 수 있다. Figure (c)에 있는 동작표를 완성하도록 빈 공간을 채워라.



(a) CMOS Inverter



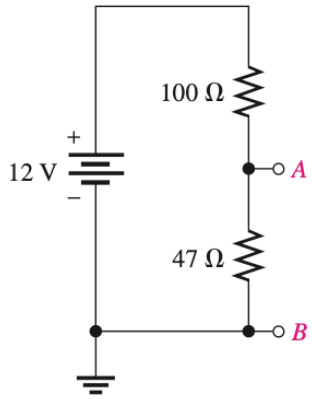
(b) CMOS NOR Gate

V_A	V_B	Q_1	Q_2	Q_3	Q_4	V_{out}
0	0	On	Off	On	Off	V_{DD}
0	V_{DD}					0
V_{DD}	0					0
V_{DD}	V_{DD}	Off	On	Off	On	0

(c) Operation Table of CMOS NOR Gate

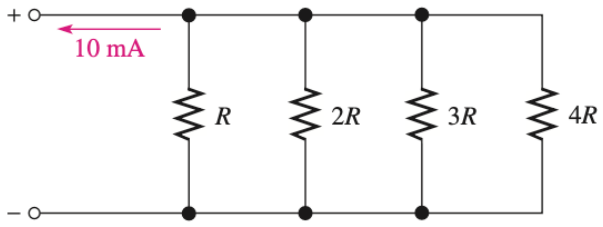
Problem 3: [10 Points]

Find the voltage between *A* and *B* in each voltage divider of Figure. (그림의 전압분배기에서 A와 B사이의 전압을 구하여라.)



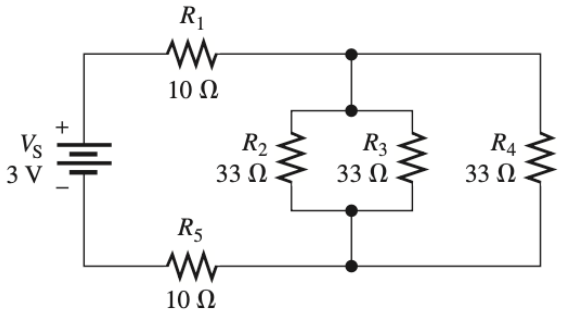
Problem 4: [20 Points]

What is the current through each resistor in Figure? *R* is the lowest-value resistor, and all others are multiples of that value as indicated. (그림에서 각 저항을 지나는 전류는 얼마인가? R이 가장 작은 저항이고 다른 저항들은 R의 곱 형태로 표시되어 있다.)



Problem 5: [10 Points]

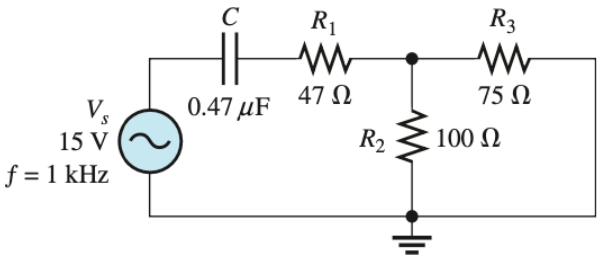
Identify the series and parallel relationships of the resistors in Figure as seen from the source terminals. (그림에서 전원 단자에서 보는 저항들의 직렬-병렬 관계를 설명하여라.)



Problem 6: [20 Points]

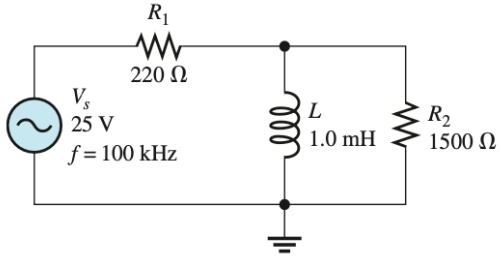
For the circuit in Figure, determine the following. (그림의 회로에서 다음 값들을 결정하여라.)

(a) I_{tot} **(b)** θ **(c)** V_{R1} **(d)** V_{R2} **(e)** V_{R3} **(f)** V_C



Problem 7: [20 Points]

Determine the voltage (V_{R1}, V_{R2} , V_L) across each element in Figure. (각 소자 양단의 전압을 구하여라.)



Formulas for Reference:

Voltage-divider $V_x = \left(\frac{R_x}{R_T}\right)V_S$

Current divider $I_x = \left(\frac{R_T}{R_x}\right)I_T$

Kirchhoff's current law

$$I_{IN(1)} + I_{IN(2)} + I_{IN(3)} + \cdots + I_{IN(n)} = I_{OUT(1)} + I_{OUT(2)} + I_{OUT(3)} + \cdots + I_{OUT(m)}$$

Total parallel resistance $R_T = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \cdots + \frac{1}{R_n}}$

Capacitive reactance $X_C = \frac{1}{2\pi fC}$

Ohm's law $V = IZ$, $I = \frac{V}{Z}$, $Z = \frac{V}{I}$

Phase angle of lead circuit $\phi = \tan^{-1}\left(\frac{X_C}{R}\right)$

Inductive reactance $X_L = 2\pi fL$

Parallel RL impedance $Z = \frac{RX_L}{\sqrt{R^2 + X_L^2}}$

Parallel RL phase angle $\theta = \tan^{-1}\left(\frac{R}{X_L}\right)$

$$R_{eq} = Z_2 \cos\theta_p$$
$$X_{L(eq)} = Z_2 \sin\theta_p$$

Solutions

Problem 1:

(1) O, (2) O, (3) O, (4) X, (5) O

Problem 2:

V_A	V_B	Q_1	Q_2	Q_3	Q_4	V_{out}
0	0	On	Off	On	Off	V_{DD}
0	V_{DD}	Off	On	On	Off	0
V_{DD}	0	On	Off	Off	On	0
V_{DD}	V_{DD}	Off	On	Off	On	0

Problem 3:

$$V_{AB} = \left(\frac{47\ \Omega}{147\ \Omega}\right)12\ \text{V} = \mathbf{3.84\ V}$$

Problem 4:

In the equations below, please read **A** as **mA**.

$$R_T = \frac{1}{\frac{1}{R}+\frac{1}{2R}+\frac{1}{3R}+\frac{1}{4R}} = \frac{R}{1+\frac{1}{2}+\frac{1}{3}+\frac{1}{4}} = 0.48R$$

$$I_R = \left(\frac{R_T}{R}\right)10\ \text{A} = \left(\frac{0.48R}{R}\right)10\ \text{A} = \mathbf{4.8\ A}$$

$$I_{2R} = \left(\frac{R_T}{2R}\right)10\ \text{A} = \left(\frac{0.48R}{2R}\right)10\ \text{A} = \mathbf{2.4\ A}$$

$$I_{3R} = \left(\frac{R_T}{3R}\right)10\ \text{A} = \left(\frac{0.48R}{3R}\right)10\ \text{A} = \mathbf{1.6\ A}$$

$$I_{4R} = \left(\frac{R_T}{4R}\right)10\ \text{A} = \left(\frac{0.48R}{4R}\right)10\ \text{A} = \mathbf{1.2\ A}$$

Problem 5:

R_2, R_3, and R_4 are in parallel and this parallel combination is in series with both R_1 and R_5. Therefore, the total resistance can be expressed as $R_T = (R_2 \parallel R_3 \parallel R_4) + R_1 + R_5$.

Problem 6:

$$R_{tot} = R_1 + R_2 \parallel R_3 = 89.9\ \Omega$$

$$X_C = \frac{1}{2\pi(1\,\text{kHz})(0.47\ \mu\text{F})} = 339\ \Omega$$

$$Z_{tot} = \sqrt{R_{tot}^2 + X_C^2} = \sqrt{(89.9\ \Omega)^2 + (339\ \Omega)^2} = 351\ \Omega$$

(a) $$I_{tot} = \frac{V_s}{Z_{tot}} = \frac{15\ \text{V}}{351\ \Omega} = \mathbf{42.7\ mA}$$

(b) $$\theta = \tan^{-1}\left(\frac{X_C}{R_{tot}}\right) = \tan^{-1}\left(\frac{339\ \Omega}{89.9\ \Omega}\right) = \mathbf{75.1°}$$ (I_{tot} leads V_s)

(c) $$V_{R1} = \left(\frac{R_1}{Z_{tot}}\right)V_s = \left(\frac{47\ \Omega}{351\ \Omega}\right)15\ \text{V} = \mathbf{2.01\ V}$$

(d) $$V_{R2} = \left(\frac{R_2 \parallel R_3}{Z_{tot}}\right)V_s = \left(\frac{42.9\ \Omega}{351\ \Omega}\right)15\ \text{V} = \mathbf{1.83\ V}$$

(e) $V_{R3} = V_{R2} = \mathbf{1.83\ V}$

(f) $$V_C = \left(\frac{X_C}{Z_{tot}}\right)V_s = \left(\frac{339\ \Omega}{351\ \Omega}\right)15\ \text{V} = \mathbf{14.5\ V}$$

Problem 7:

$$X_L = 2\pi(100\ \text{kHz})(1.0\ \text{mH}) = 628\ \Omega$$

$$Z_p = \frac{R_2 X_L}{\sqrt{R_2^2 + X_L^2}} = \frac{(1500\ \Omega)(628\ \Omega)}{\sqrt{(1500\ \Omega)^2 + (628\ \Omega)^2}} = 579\ \Omega$$

$$\theta = \tan^{-1}\left(\frac{R_2}{X_L}\right) = \tan^{-1}\left(\frac{1500\ \Omega}{628\ \Omega}\right) = 67.3°$$

$$R_{\text{eq}} = Z_p \cos\theta = (579\ \Omega)\cos 67.3° = 224\ \Omega$$

$$X_{L(\text{eq})} = Z_p \sin\theta = (579\ \Omega)\sin 67.3° = 534\ \Omega$$

$$Z_{tot} = \sqrt{(R_1 + R_{\text{eq}})^2 + X_{L(\text{eq})}^2} = \sqrt{(444\ \Omega)^2 + (534\ \Omega)^2} = 694\ \Omega$$

$$I_{tot} = \frac{25\ \text{V}}{694\ \Omega} = 36\ \text{mA}$$

$$V_{R1} = I_{tot}R_1 = (36\ \text{mA})(220\ \Omega) = \mathbf{7.92\ V}$$

$$V_{R2} = V_L = I_{tot}Z_p = (36\ \text{mA})(579\ \Omega) = \mathbf{20.8\ V}$$