University of Southern California
Ming Hsieh Department of Electrical Engineering
EE 348L - Electronic Circuits
Spring 2016

Homework 1 Solutions

1.1 (a) $I = \dfrac{V}{R} = \dfrac{5\text{ V}}{1\text{ k}\Omega} = 5\text{ mA}$

(b) $R = \dfrac{V}{I} = \dfrac{5\text{ V}}{1\text{ mA}} = 5\text{ k}\Omega$

(c) $V = IR = 0.1\text{ mA} \times 10\text{ k}\Omega = 1\text{ V}$

(d) $I = \dfrac{V}{R} = \dfrac{1\text{ V}}{100\ \Omega} = 0.01\text{ A} = 10\text{ mA}$

Note: Volts, milliamps, and kilohms constitute a consistent set of units.

1.3 (a) $V = IR = 5\text{ mA} \times 1\text{ k}\Omega = 5\text{ V}$

$P = I^2R = (5\text{ mA})^2 \times 1\text{ k}\Omega = 25\text{ mW}$

(b) $R = V/I = 5\text{ V}/1\text{ mA} = 5\text{ k}\Omega$

$P = VI = 5\text{ V} \times 1\text{ mA} = 5\text{ mW}$

(c) $I = P/V = 100\text{ mW}/10\text{ V} = 10\text{ mA}$

$R = V/I = 10\text{ V}/10\text{ mA} = 1\text{ k}\Omega$

(d) $V = P/I = 1\text{ mW}/0.1\text{ mA}$

$= 10\text{ V}$

$R = V/I = 10\text{ V}/0.1\text{ mA} = 100\text{ k}\Omega$

(e) $P = I^2R \Rightarrow I = \sqrt{P/R}$

$I = \sqrt{1000\text{ mW}/1\text{ k}\Omega} = 31.6\text{ mA}$

$V = IR = 31.6\text{ mA} \times 1\text{ k}\Omega = 31.6\text{ V}$

Note: V, mA, kΩ, and mW constitute a consistent set of units.

Done

1.7 Use voltage divider to find V_O

$$V_O = 5\frac{2}{2+3} = 2\ \text{V}$$

Equivalent output resistance R_O is

$$R_O = (2\ \text{k}\Omega \parallel 3\ \text{k}\Omega) = 1.2\ \text{k}\Omega$$

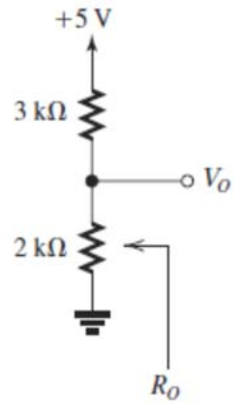
The extreme values of V_O for $\pm 5\%$ tolerance resistor are

$$V_{O\min} = 5\frac{2(1-0.05)}{2(1-0.05)+3(1+0.05)}$$

$$= 1.88\ \text{V}$$

$$V_{O\max} = 5\frac{2(1+0.05)}{2(1+0.05)+3(1-0.05)}$$

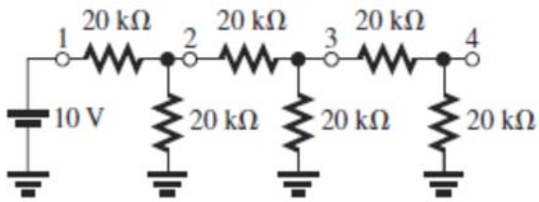
$$= 2.12\ \text{V}$$



The extreme values of R_O for $\pm 5\%$ tolerance resistors are $1.2 \times 1.05 = 1.26\ \text{k}\Omega$ and $1.2 \times 0.95 = 1.14\ \text{k}\Omega$.

Done

1.15



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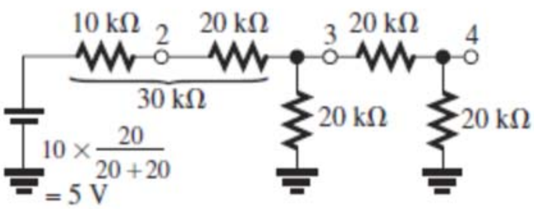

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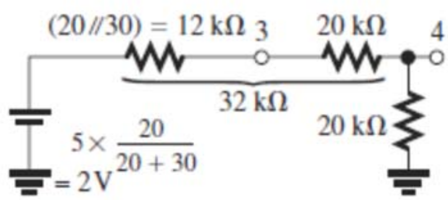

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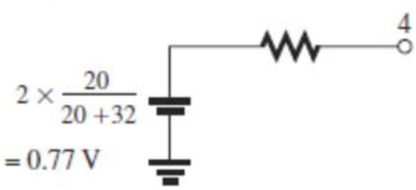
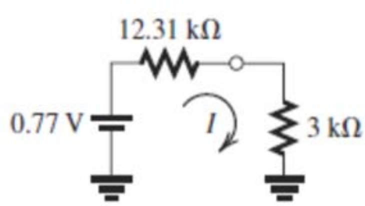
Thévenin equivalent: (20//32) = 12.31 kΩ





Now, when a resistance of 3 kΩ is connected between node 4 and ground,

$$I = \frac{0.77}{12.31 + 3}$$

$$= 0.05 \text{ mA}$$

Done

1.19 Refer to Fig. P1.19. Using the voltage divider rule at the input side, we obtain

$$\frac{v_\pi}{v_s} = \frac{r_\pi}{r_\pi + R_s} \tag{1}$$

At the output side, we find v_o by multiplying the current $g_m v_\pi$ by the parallel equivalent of r_o and R_L,

$$v_o = -g_m v_\pi (r_o \parallel R_L) \tag{2}$$

Finally, v_o/v_s can be obtained by combining Eqs. (1) and (2) as

$$\frac{v_o}{v_s} = -\frac{r_\pi}{r_\pi + R_s} g_m (r_o \parallel R_L)$$

Done

1.28

Case	ω (rad/s)	f (Hz)	T (s)
a	3.14×10^{10}	5×10^9	0.2×10^{-9}
b	2×10^9	3.18×10^8	3.14×10^{-9}
c	6.28×10^{10}	1×10^{10}	1×10^{-10}
d	3.77×10^2	60	1.67×10^{-2}
e	6.28×10^4	1×10^4	1×10^{-4}
f	6.28×10^5	1×10^5	1×10^{-5}

Done

1.39 (a) $A_v = \dfrac{v_O}{v_I} = \dfrac{10\text{ V}}{100\text{ mV}} = 100\text{ V/V}$

or $20 \log 100 = 40$ dB

$A_i = \dfrac{i_O}{i_I} = \dfrac{v_O/R_L}{i_I} = \dfrac{10\text{ V}/100\ \Omega}{100\ \mu\text{A}} = \dfrac{0.1\text{ A}}{100\ \mu\text{A}}$

$= 1000\text{ A/A}$

or $20 \log 1000 = 60$ dB

$A_p = \dfrac{v_O i_O}{v_I i_I} = \dfrac{v_O}{v_I} \times \dfrac{i_O}{i_I} = 100 \times 1000$

$= 10^5\text{ W/W}$

or $10 \log 10^5 = 50$ dB

(b) $A_v = \dfrac{v_O}{v_I} = \dfrac{1\text{ V}}{10\ \mu\text{V}} = 1 \times 10^5\text{ V/V}$

or $20 \log 1 \times 10^5 = 100$ dB

$A_i = \dfrac{i_O}{i_I} = \dfrac{v_O/R_L}{i_I} = \dfrac{1\text{ V}/10\text{ k}\Omega}{100\text{ nA}}$

$= \dfrac{0.1\text{ mA}}{100\text{ nA}} = \dfrac{0.1 \times 10^{-3}}{100 \times 10^{-9}} = 1000\text{ A/A}$

or $20 \log A_i = 60$ dB

$A_p = \dfrac{v_O i_O}{v_I i_I} = \dfrac{v_O}{v_I} \times \dfrac{i_O}{i_I}$

$= 1 \times 10^5 \times 1000$

$= 1 \times 10^8\text{ W/W}$

or $10 \log A_P = 80$ dB

(c) $A_v = \dfrac{v_O}{v_i} = \dfrac{5\text{ V}}{1\text{ V}} = 5\text{ V/V}$

or $20 \log 5 = 14$ dB

$$A_i = \frac{i_O}{i_I} = \frac{v_O/R_L}{i_I} = \frac{5\text{ V}/10\ \Omega}{1\text{ mA}}$$

$$= \frac{0.5\text{ A}}{1\text{ mA}} = 500\text{ A/A}$$

or $20 \log 500 = 54$ dB

$$A_p = \frac{v_O i_O}{v_I i_I} = \frac{v_O}{v_I} \times \frac{i_O}{i_I}$$

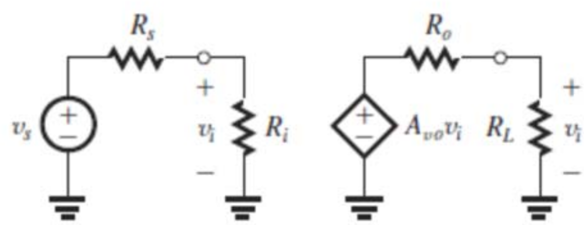
$$= 5 \times 500 = 2500\text{ W/W}$$

or $10 \log A_p = 34$ dB

Done

1.43 $v_o = A_{vo} v_i \dfrac{R_L}{R_L + R_o}$

$$= A_{vo}\left(v_s \frac{R_i}{R_i + R_s}\right) \frac{R_L}{R_L + R_o}$$



Thus,

$$\frac{v_o}{v_s} = A_{vo} \frac{R_i}{R_i + R_s} \frac{R_L}{R_L + R_o}$$

(a) $A_{vo} = 100, R_i = 10R_s, R_L = 10R_o$:

$$\frac{v_o}{v_s} = 100 \times \frac{10R_s}{10R_s + R_s} \times \frac{10R_o}{10R_o + R_o}$$

$= 82.6$ V/V or $20 \log 82.6 = 38.3$ dB

(b) $A_{vo} = 100, R_i = R_s, R_L = R_o$:

$\dfrac{v_o}{v_s} = 100 \times \dfrac{1}{2} \times \dfrac{1}{2} = 25$ V/V or $20 \log 25 = 28$ dB

(c) $A_{vo} = 100$ V/V, $R_i = R_s/10, R_L = R_o/10$:

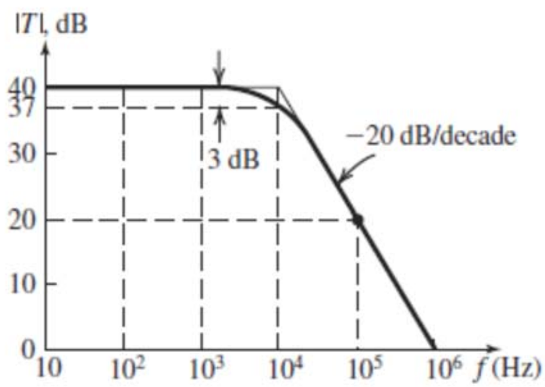
$$\frac{v_o}{v_s} = 100 \frac{R_s/10}{(R_s/10) + R_s} \frac{R_o/10}{(R_o/10) + R_o}$$

$= 0.826$ V/V or $20 \log 0.826 = -1.7$ dB

Done

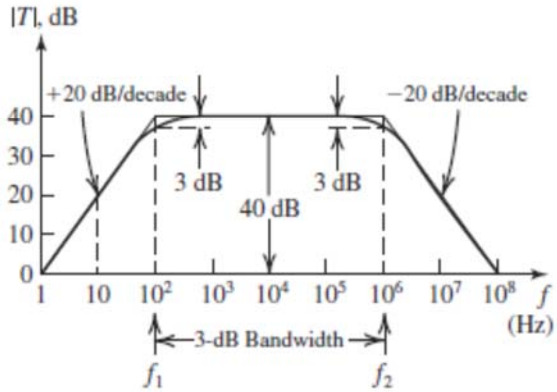
1.71 The given measured data indicate that this amplifier has a low-pass STC frequency response with a low-frequency gain of 40 dB, and a 3-dB frequency of 10^4 Hz. From our knowledge of the Bode plots for low-pass STC networks [Fig. 1.23(a)], we can complete the table entries and sketch the amplifier frequency response.

f (Hz)	$\|T\|$ (dB)	$\angle T$ (°)
0	40	0
100	40	0
1000	40	0
10^4	37	−45°
10^5	20	−90°
10^6	0	−90°



Done

1.72 From our knowledge of the Bode plots of STC low-pass and high-pass networks, we see that this amplifier has a midband gain of 40 dB, a low-frequency response of the high-pass STC type with $f_{3dB} = 10^2$ Hz, and a high-frequency response of the low-pass STC type with $f_{3dB} = 10^6$ Hz. We thus can sketch the amplifier frequency response and complete the table entries as follows.



f (Hz)	1	10	10^2	10^3	10^4	10^5	10^6	10^7	10^8
$\|T\|$(dB)	0	20	37	40	40	40	37	20	0