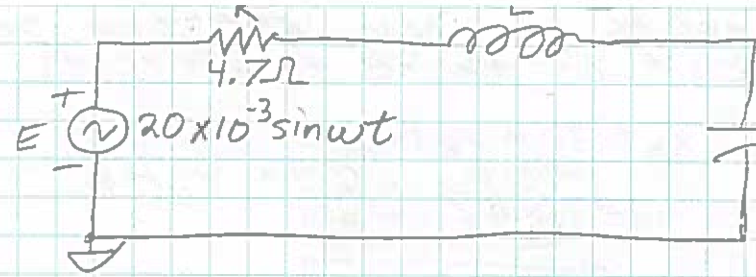
21-4



a) Find the value of L in millihenries if the resonant frequency is 1800 Hz.

$$f_s = \frac{1}{2\pi\sqrt{LC}} \Rightarrow L = \frac{1}{(2\pi f_s)^2 \cdot C} = \frac{1}{2\pi \cdot 1.8kHz \cdot 2uF}$$

$$= \boxed{3.91\ mH}$$

b) Calculate and compare X_C + X_L

$$X_C = \frac{1}{2\pi \cdot 1.8kHz \cdot 2uF} = \boxed{44.2\Omega}$$

$$X_L = 2\pi \cdot 1.8kHz \cdot 3.91mH = \boxed{44.2\Omega}$$ Same

c) $E_{RMS} = .707 \cdot 20\times10^{-3}\ V = 14.14 mV_{RMS} \angle 0^\circ$

$$I_{RMS} = \frac{14.14 mV_{RMS} \angle 0}{4.7\Omega + j44.2 - j44.2} = \boxed{3.009\ mA_{RMS} \angle 0^\circ}$$

d) Find the power dissipated by the circuit at resonance

$$P = I^2R = (3.009mA)^2 \cdot 4.7\Omega = \boxed{42.54\ uW}$$

e) What is the apparent power delivered to the system at resonance?

$$S_T = P_T = \boxed{42.54\ uVA}$$

f) What is the power factor of the circuit at resonance?

$$F_P = \frac{P_T}{S_T} = \frac{42.54\ uW}{42.54\ VA} = \boxed{1}$$

g) Calculate the Q of the circuit and the resulting bandwidth

$$Q = \frac{X_L}{R} = \frac{44.2\Omega}{4.7\Omega} = \boxed{9.4} \quad BW = \frac{f_s}{Q_s} = \frac{1800Hz}{9.4} = \boxed{191.49\ Hz}$$

h) Find the cutoff frequencies, and calculate the power dissipated by the circuit at these frequencies

$f_1 = f_s - 1/2\,BW$
$= 1800Hz - .5 \cdot 191.49Hz$
$\boxed{= 1.7\ KHz}$

$f_2 = f_s + 1/2\,BW$
$= 1800Hz + .5 \cdot 191.49Hz$
$\boxed{= 1.896\ kHz}$

$P_{HPF} = \frac{1}{2} P_{MAX} = \frac{1}{2} \cdot 42.54\,\mu W = \boxed{21.27\,\mu W}$

5 a) Find the bandwidth of a series resonant circuit having a resonant frequency of 6000 Hz and a Q_s of 15.

$$BW = \frac{f_r}{Q_s} = \frac{6000}{15} = \boxed{400\text{ Hz}}$$

b) Find the cutoff frequencies

$$f_1 = f_r - \frac{BW}{2} = 6000\text{ Hz} - \frac{400\text{ Hz}}{2} = \boxed{5800\text{ Hz}}$$

$$f_2 = f_r + \frac{BW}{2} = 6000\text{ Hz} + \frac{400\text{ Hz}}{2} = \boxed{6200\text{ Hz}}$$

c) If the resistance of the circuit at resonance is 3Ω, what are the values of X_L and X_C in ohms?

$$Q_s = \frac{X_L}{R} \rightarrow X_L = Q_s R = (15)(3\Omega) = \boxed{45\Omega}$$

$$X_L = X_C \text{ @ } f = f_r, \text{ so } X_C = \boxed{45\Omega}$$

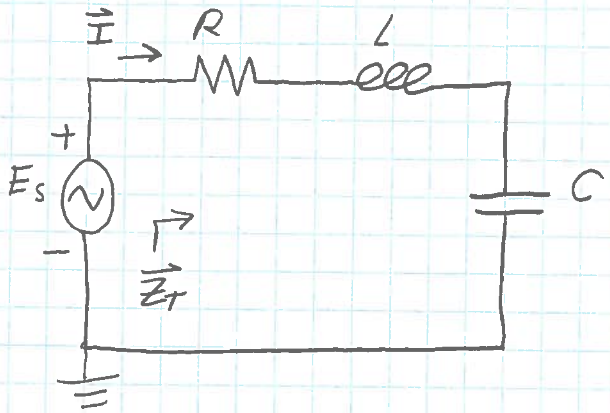
d) What is the power dissipated at the half-power frequencies if the maximum current flowing through the circuit is 0.5 A?

* assumed to mean 0.5 A_p

$$P_{max} = I^2 R = (0.5\, A_p)^2 (3\Omega) = 750\text{ mW}$$

$$P_{HPF} = \frac{1}{2} P_{max} = \frac{1}{2}(750\text{ mW}) = \boxed{375\text{ mW}}$$

P21.9



$\vec{E}_s = 5V_{pk}\angle 0°$

$I_{PEAK} = 500mA$ (@ f_s)

$BW = 120Hz$

$f_s = 8400\,Hz$

FIND

(a) R, L, C

$$I_{PEAK} = \frac{E_S}{R} = \frac{5V_{pk}\angle 0°}{R} = 500\,mA$$

$$\therefore R = \frac{5V_{pk}\angle 0°}{500\,mA\ pk} = \boxed{10\Omega}$$

$$BW = \frac{f_s}{Q_s} \quad \therefore \quad Q_s = \frac{f_s}{BW} = \frac{8400Hz}{120Hz}$$

$$\underline{Q_s = 70}$$

But $Q_s = \frac{X_L}{R}$

$$\therefore X_L = (Q_s)(R) = (70)(10\Omega) = \underline{700\Omega}$$

$X_L = 2\pi f L$

$$\therefore L = \frac{X_L}{2\pi f} = \frac{700\Omega}{(2\pi)(8400Hz)}$$

$$\boxed{L = 13.3\,mH}$$

$X_C = \frac{1}{2\pi f C}$

$$\therefore C = \frac{1}{2\pi f X_C} = \frac{1}{(2\pi)(8400Hz)(700\Omega)}$$

$$\boxed{C = 27.1nF}$$

(b) f_1, f_2

$$f_2 = \frac{1}{2\pi}\left[\frac{R}{2L} + \frac{1}{2}\sqrt{\left(\frac{R}{L}\right)^2 + \frac{4}{LC}}\right]$$

$$\boxed{f_2 = 8.44\ kHz}$$

$$f_1 = \frac{1}{2\pi}\left[-\frac{R}{2L} + \frac{1}{2}\sqrt{\left(\frac{R}{L}\right)^2 + \frac{4}{LC}}\right]$$

$$\boxed{f_1 = 8.32\ kHz}$$

OR

$$f_2 = f_s + \frac{BW}{2} = 8400\ Hz + \frac{120\ Hz}{2}$$

$$\boxed{f_2 = 8.46\ kHz}$$

& $$f_1 = f_s - \frac{BW}{2} = 8400\ Hz - \frac{120\ Hz}{2}$$

$$\boxed{f_1 = 8,34\ kHz}$$

Problem 21-14. For the parallel resonant network in Fig. 21.55:

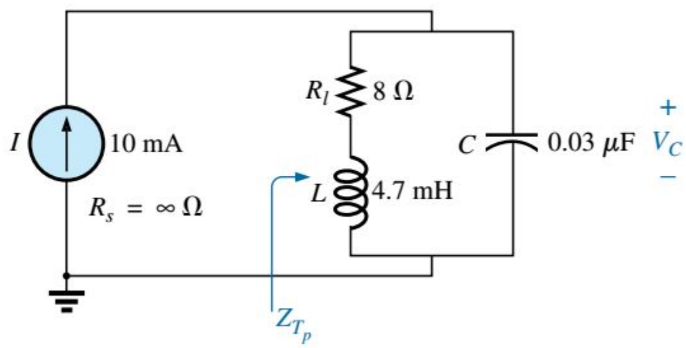


FIG. 21.55
Problem 14.

(a) Calculate f_s.

$$\begin{aligned} f_s &= \frac{1}{2\cdot\pi\cdot\sqrt{LC}} \\ &= \boxed{13.4\,\text{kHz}} \end{aligned}$$

(b) Determine Q_l using $f = f_s$. Can the approximate approach be applied?

$$\begin{aligned} Q_l &= \frac{X_L}{R_l} \\ &= \frac{2\cdot\pi\cdot f_s\cdot L}{R_l} = \frac{2\cdot\pi\cdot 13.4\,\text{kHz}\cdot 4.7\cdot 10^{-3}}{8} \\ &= \boxed{49.5} \end{aligned}$$

(c) Determine f_p and f_m Given that $Q_l > 10$,

$$f_p = f_s = f_m = \boxed{13.4\,\text{kHz}}$$

(d) Calculate X_L and X_C using f_p. How do they compare?

$$\begin{aligned} X_L &= 2\cdot\pi\cdot f_s\cdot L \\ &= 2\cdot\pi\cdot 13.4\,\text{kHz}\cdot 4.7\cdot 10^{-3} \\ &= \boxed{398.8\,\Omega} \end{aligned}$$

$$\begin{aligned} X_C &= \frac{1}{2\cdot\pi\cdot f_s\cdot C} \\ &= \frac{1}{2\cdot\pi\cdot 13.4\,\text{kHz}\cdot 0.03\cdot 10^{-6}} \\ &= \boxed{398.8\,\Omega} \end{aligned}$$

X_L is equal to X_C

(e) Find the total impedance at resonance (f_p).

$$Z_{T_P} = R_S || {Q_l}^2 R_l$$

where: $R_s = \infty\Omega$. Therefore

$$\begin{aligned} Z_{T_P} &= {Q_l}^2 \cdot R_l \\ &= 49.5^2 \cdot 8\,\Omega \\ &= \boxed{19.58\,\mathrm{k\Omega}} \end{aligned}$$

(f) Calculate V_C at resonance (f_p).

$$\begin{aligned} V_C &= I \cdot Z_{T_P} \\ &= 10\,\mathrm{mA} \cdot 19.58\,\mathrm{k\Omega} \\ &= \boxed{195.8\,\mathrm{V}} \end{aligned}$$

(g) Determine Q_p and the BW using

$$\begin{aligned} Q_p &= \frac{Z_{T_P}}{X_L} = \frac{Z_{T_P}}{X_C} \\ &= \frac{19.58\,\mathrm{k\Omega}}{398.8\,\Omega} \\ &= \boxed{49.48} \end{aligned}$$

$$\begin{aligned} BW &= \frac{f_p}{Q_p} = \frac{f_s}{Q_p} \\ &= \frac{f_p}{Q_p} = \frac{13.4\,\mathrm{kHz}}{49.48} \\ &= \boxed{270.9\,\mathrm{Hz}} \end{aligned}$$

(h) Calculate I_L and I_C at f_p.

$$\begin{aligned} I_L &= I_C = Q_l \cdot I_T \\ I_L &= 49.5 \cdot 10\,\mathrm{mA} \\ I_L &= \boxed{494.8\,\mathrm{mA}} \end{aligned}$$

Problem 21-18. For the network in Fig. 21.59:

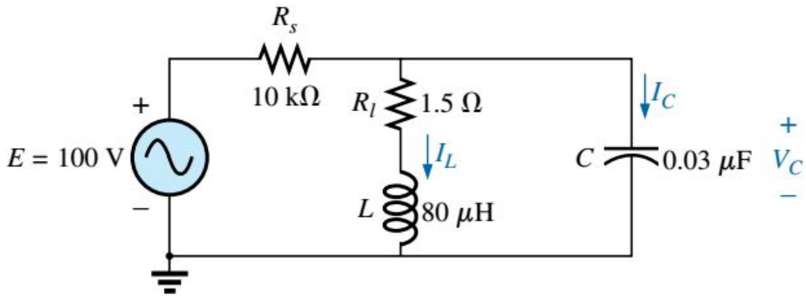


FIG. 21.59
Problem 18.

(a) Find the resonant frequencies f_s, f_p and f_m. What do the results suggest about the Q_p of the network?

$$\begin{aligned} f_s &= \frac{1}{2 \cdot \pi \cdot \sqrt{LC}} \\ &= \frac{1}{2 \cdot \pi \cdot \sqrt{(80\,\mu\text{H})(0.03\,\mu\text{F})}} \\ &= \boxed{102.73\,\text{kHz}} \end{aligned}$$

$$\begin{aligned} f_p &= f_s\sqrt{1 - \frac{{R_l}^2 C}{L}} \\ &= 102.7\,\text{kHz}\sqrt{1 - \frac{1.5^2(0.03\,\mu\text{F})}{(80\,\mu\text{H})}} \\ &= \boxed{102.71\,\text{kHz}} \end{aligned}$$

$$\begin{aligned} f_m &= f_s\sqrt{1 - \frac{1}{4}\left[\frac{{R_l}^2 C}{L}\right]} \\ &= 102.7\,\text{kHz}\sqrt{1 - \frac{1}{4}\left[\frac{1.5^2(0.03\,\mu\text{F})}{(80\,\mu\text{H})}\right]} \\ &= \boxed{102.73\,\text{kHz}} \end{aligned}$$

Given that $f_s \approx f_p \approx f_m$, Q_l of the network is greater than or equal to 10.

(b) Find the values of X_L and X_C at resonance (f_p). How do they compare?

$$\begin{aligned} X_L &= 2 \cdot \pi \cdot f_s \cdot L \\ &= 2 \cdot \pi \cdot 102.73\,\text{kHz} \cdot 80 \cdot 10^{-6} \\ &= \boxed{51.64\,\Omega} \end{aligned}$$

$$
\begin{aligned}
X_C &= \frac{1}{2 \cdot \pi \cdot f_s \cdot C} \\
&= \frac{1}{2 \cdot \pi \cdot 102.73\,\text{kHz} \cdot 0.03 \cdot 10^{-6}} \\
&= \boxed{51.64\,\Omega}
\end{aligned}
$$

$X_L \approx X_C$ at resonance (f_p)

(c) Find the impedance Z_{T_P} at resonance (f_p).

$$
\begin{aligned}
Z_{T_P} &= R_s \mid\mid {Q_l}^2 \cdot R_l \\
&= 10\,\text{k}\Omega \mid\mid 34.4^2 \cdot 1.5\,\Omega \\
&= \frac{10\,\text{k}\Omega \cdot \left[34.4^2 \cdot 1.5\,\Omega\right]}{10\,\text{k}\Omega + \left[34.4^2 \cdot 1.5\,\Omega\right]} \\
&= \boxed{1.51\,\text{k}\Omega}
\end{aligned}
$$

where

$$
\begin{aligned}
Q_l &= \frac{X_L}{R_l} = \frac{51.64\,\Omega}{1.5\,\Omega} \\
&= \boxed{34.4}
\end{aligned}
$$

(d) Calculate Q_P and the BW.

$$
\begin{aligned}
Q_p &= \frac{Z_{T_P}}{X_L} = \frac{Z_{T_P}}{X_C} \\
&= \frac{1.51\,\text{k}\Omega}{51.64\,\Omega} \\
&= \boxed{29.2}
\end{aligned}
$$

$$
\begin{aligned}
BW &= \frac{f_p}{Q_p} = \frac{f_s}{Q_p} \\
&= \frac{f_p}{Q_p} = \frac{102.73\,\text{kHz}}{29.2} \\
&= \boxed{3.52\,\text{kHz}}
\end{aligned}
$$

(e) Find the magnitude of current I_L and I_C at resonance (f_p).
Use source conversion to convert the voltage source "E" to current source "I"

$$
\begin{aligned}
I &= \frac{E}{R_s} = \frac{100}{10\,\text{k}\Omega} \\
&= 10\,\text{mA}
\end{aligned}
$$

And the parallel resistance $R_s = R_p = 10\,\text{k}\Omega$. Using current devider

$$
\begin{aligned}
I_T &= I \cdot \frac{R_s}{R_s + {Q_l}^2 \cdot R_l} \\
&= 10\,\mathrm{mA} \cdot \frac{10\,\mathrm{k\Omega}}{10\,\mathrm{k\Omega} + 34.4^2 \cdot 1.5} \\
&= 8.49\,\mathrm{mA}
\end{aligned}
$$

$$
\begin{aligned}
I_L = I_C &= Q_L \cdot I_T \\
&= 34.4 \cdot 8.49\,\mathrm{mA} \\
&= \boxed{292.3\,\mathrm{mA}}
\end{aligned}
$$

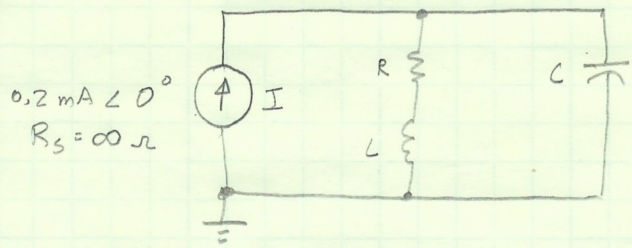
(f) Calculate the voltage V_C at resonance (f_p)

$$
\begin{aligned}
V_C &= I_C \cdot Z_{T_P} \\
&= 292.3\,\mathrm{mA} \cdot 1.51\,\mathrm{k\Omega} \\
&= \boxed{15.1\,\mathrm{V}}
\end{aligned}
$$

(26) Design the network below to have the following characteristics:

$BW = 500\ Hz$ $\quad Q_p = 30$ $\quad V_{C_{max}} = 1.8\ V$

* Voltages and currents are in peak *



$$Z_{T_p} = \frac{V_{C_{max}}}{I} = \frac{1.8\ V}{0.2\ mA} = 9\ k\Omega$$

$$Q_p = \frac{R}{X_L} = \frac{R_p}{X_L} \longrightarrow X_L = \frac{R_p}{Q_p} = \frac{Z_{T_p}}{Q_p} = \frac{9\ k\Omega}{30} = 300\ \Omega = X_C$$

$$BW = \frac{f_p}{Q_p} \longrightarrow f_p = (BW)(Q_p) = (500\ Hz)(30) = \boxed{15\ kHz}$$

$$L = \frac{X_L}{2\pi f} = \frac{300\ \Omega}{2\pi(15\ kHz)} = \boxed{3.18\ mH}$$

$$C = \frac{1}{2\pi f X_C} = \frac{1}{2\pi(15\ kHz)(300\ \Omega)} = \boxed{35.37\ nF}$$

$$Q_p = \frac{X_L}{R_L} \longrightarrow R_L = \frac{X_L}{Q_p} = \frac{300\ \Omega}{30} = \boxed{10\ \Omega}$$

Problem 21-28.

Verify the results in Example 21.8. That is, show that the resonant frequency is 40 kHz, the cutoff frequencies are as calculated, and the bandwidth is 1.85 kHz.

The circuit simulated in Multisim,the resulting magnitude and phase response curves are shown below. The resonant frequency from Multisim is in agreement with the resonant frequency from Example 21.8 in the text. Where

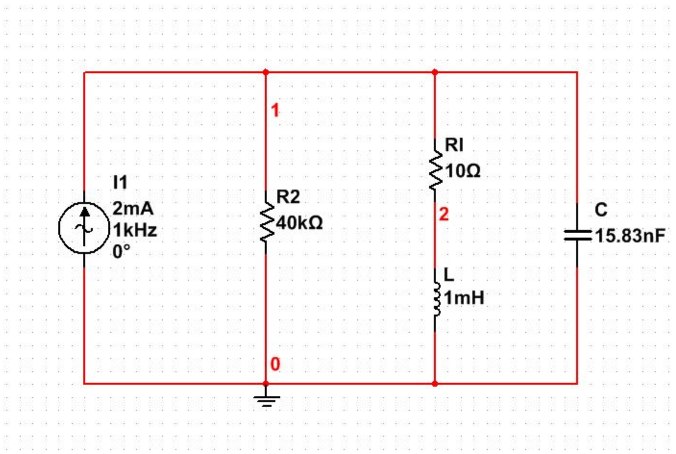
$$f_{p_{Multisim}} = 40.01\,\text{kHz}$$

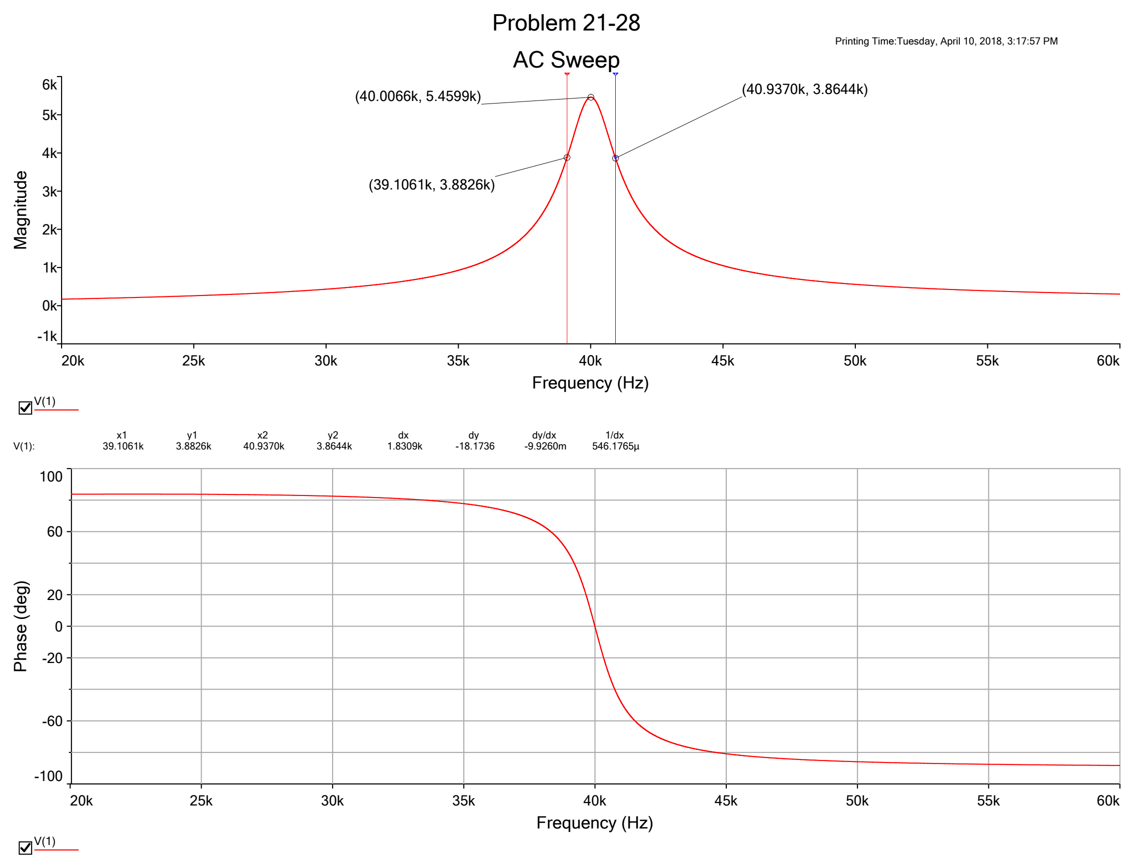
$$f_{p_{Text}} = 40.01\,\text{kHz}$$

Similarly the bandwidth from Multisim is in agreement with the bandwidth from the text. Where

$$BW_{Multisim} = 40.94\,\text{kHz} - 39.11\,\text{kHz} = 1.83\,\text{kHz}$$

$$BW_{Text} = 1.85\,\text{kHz}$$





Problem 21-28
AC Sweep
Printing Time:Tuesday, April 10, 2018, 3:17:57 PM
(40.0066k, 5.4599k)
(40.9370k, 3.8644k)
(39.1061k, 3.8826k)
Magnitude
6k
5k
4k
3k
2k
1k
0k
-1k
20k
25k
30k
35k
40k
45k
50k
55k
60k
Frequency (Hz)
V(1)
x1 39.1061k
y1 3.8826k
x2 40.9370k
y2 3.8644k
dx 1.8309k
dy -18.1736
dy/dx -9.9260m
1/dx 546.1765µ
V(1):
Phase (deg)
100
60
20
0
-20
-60
-100
20k
25k
30k
35k
40k
45k
50k
55k
60k
Frequency (Hz)
V(1)

22-5 Given $N = \log_{10} X$, determine x for each value of N.

$x = 10^N$

a) $N = 3$ $x = 1000$

b) $N = 12$ $x = 10^{12}$

c) $N = 0.2$ $x = 1.585$

d) $N = 0.04$ $x = 1.096$

e) $N = 10$ $x = 10^{10}$

f) $N = 3.18$ $x = 1.51 \times 10^3$

g) $N = 1.001$ $x = 10.023$

h) $N = 6.1$ $x = 1.259 \times 10^6$

⑧ Find $\log_{10}(3)^3$ and compare with $3\log_{10}3$.

Assumption: $\log_{10}(3)^3 = \log_{10}(3^3)$ and $\log_{10}(3)^3 \neq [\log_{10}(3)]^3$

$\log_{10}(3^3) = \log_{10}(27) = \boxed{1.43}$

$\qquad\qquad\qquad\qquad\qquad\qquad \parallel$

$3\log_{10}3 = 3(0.4771) = \boxed{1.43}$

∴ They are equal, as expected.

Problem 22-10.

A power level of 100 W is 6 dB above what power level?

$$
\begin{aligned}
dB &= 10 \cdot \log\ \frac{P_o}{P_i} \\
6\ dB &= 10 \cdot \log\ \frac{100\,\mathrm{W}}{P_i} \\
\frac{6}{10} &= \log\ \frac{100\,\mathrm{W}}{P_i} \\
10^{\frac{6}{10}} &= \frac{100\,\mathrm{W}}{P_i} \\
P_i &= \frac{100\,\mathrm{W}}{10^{\frac{6}{10}}} \\
&= \boxed{25.12\,\mathrm{mW}}
\end{aligned}
$$

(12) Determine the dB_m level for an output power of 120 mW.

$$10\log_{10}\left(\frac{120\,mW}{1\,mW}\right) = \boxed{20.8\ dB_m}$$

Problem 22-13.

Find the dB_v gain of an amplifier that raises the voltage level from $0.1\,\mathrm{mV}$ to $8.4\,\mathrm{mV}$.

$$\begin{aligned}
dB_v &= 20 \cdot \frac{8.4\,\mathrm{mV}}{0.1\,\mathrm{mV}} \\
&= 20 \cdot 84 \\
&= 20 \cdot 1.92 \\
&= \boxed{38.49}
\end{aligned}$$

Problem 22-14.

Find the output voltage of an amplifier if the applied voltage is 20 mV and a dB_v gain of 22 dB is attained.

$$\begin{aligned}
dB_v &= 20 \cdot \log \frac{V_o}{V_i} \\
22\ dB_v &= 20 \cdot \log \frac{V_o}{20\,\mathrm{mV}} \\
\frac{22}{20} &= \log \frac{V_o}{20\,\mathrm{mV}} \\
10^{\frac{22}{20}} &= \frac{V_o}{20\,\mathrm{mV}} \\
V_o &= 20\,\mathrm{mV} \cdot 10^{\frac{22}{20}} \\
&= \boxed{251.8\,\mathrm{mV}}
\end{aligned}$$