EECS 210 Sec 2 – W’01 Midterm 1 – 2/9/01

50 minutes, closed book, one 8.5”x11” crib sheet, calculator, no scratch sheets

I have neither given nor received aid on this exam, nor have I concealed any violation of the Honor Code.

Name: ____________________________

Solution Set

v(t)\text{in} is periodic in time T_{in}, exhibits odd symmetry, and is comprised of a fundamental frequency and two harmonics whose Fourier coefficients are positive and have amplitudes shown in the frequency domain representation:

\[ \text{Amplitude} \]
\[ \text{Volts} \]

\[ 0 \quad 1 \quad 2 \quad 3 \quad 4 \quad \omega \]

1.a (5%) What is the period, T_{in}, of v(t)\text{in} (in seconds)?

\[ \omega = \frac{2\pi}{T_{in}} = 1 \Rightarrow T_{in} = \frac{2\pi}{1} = 6.28 \text{ s} \]

F(\omega) is a high pass filter with a cutoff at \( f_{c} = 0.25 \text{ Hz} \) so that all frequencies below 0.25 Hz are blocked. Frequencies above 0.25 Hz are passed without a delay in phase but with a transfer function that looks like \( F(\omega) = 1 - e^{-\omega} \)

1.b (15%) If v(t)\text{in} is passed through filter F(\omega) and v(t)\text{out} is the output, write v(t)\text{out} as a sinusoidal series (in Volts).

\[ \omega = 1 \Rightarrow f = \frac{\omega}{2\pi} = 0.16 \text{ Hz} \] fundamental is blocked
\[ \omega = 2 \Rightarrow f = \frac{2\omega}{2\pi} = 0.32 \text{ Hz} \] 2nd harmonic is passed
\[ F(1) = 1 - e^{-1} = 0.63 \] \[ F(2) = 1 - e^{-2} = 0.95 \]

\[ v(t)\text{out} = 0.86 \sin 2t + 0.95 \sin 3t \text{ V} \]

1.c (5%) Considering v(t)\text{out} as a new signal, what is its fundamental frequency (in Hz)?

My error here. I had meant to show the 3rd component at \( \omega = 4 \text{ rad/s} \) rather than at \( \omega = 2 \text{ rad/s} \). Then, for the new signal, the fundamental would have been \( \omega = 2 \text{ rad/s} \), and the 2nd harmonic would have been \( \omega = 4 \text{ rad/s} \). For this case the fundamental frequency would have been \( f = \frac{2}{2\pi} = 0.32 \text{ Hz} \).

The way I drew the problem, the fundamental is \( f = 0.16 \text{ Hz} \), but it is absent in the signal. I will accept either answer.
2. (10%) Find $R_{eq}$ in the equivalent circuit (in ohms).

\[ R_{eq} = ((6 \parallel 6) + 3) \parallel 6 + 9 = (3+3) \parallel 6 + 9 = 6 \parallel 6 + 9 \]

\[ = 3 + 9 = 12 \Omega \]

2. (10%) What is the power dissipated/produced (+/-) by the current source (in Watts)?

We need $\mathbb{V}_{AB}$ ± model analysis at a

\[ i_1 + 2 - i_2 = 0 \]

\[ \frac{24 - V}{12} + 2 - \frac{V}{12} = 0 \]

\[ \Rightarrow 24 - 2V + 2V = 0 \]

\[ V = 24 V \]

\[ P_{2A} = (\text{voltage drop in direction of current}) \times \text{current} \]

\[ = -24 \times 2 = -48 \text{ W} \]

For the circuit:

3. (15%) Use mesh-current for loop $i_1$ to find $i_2$ (in Amps).

\[ -4(i_2 - i_1) - 9 - 5i_2 = 0 \quad \text{but} \quad i_1 = -\frac{3V}{4} \]

\[ \therefore -4(i_2 + \frac{3}{4}) - 9 - 5i_2 = 0 \]

\[ -9i_2 - 12 = 0 \]

\[ i_2 = -\frac{4}{3} A \]
4 (15%) Use KVL around the outer loop to find current i (in Amps):

\[
24 - 3i - 2(i_2) - 3i = 0
\]

\[
24 - 3i - 2(i + 7) - 3i = 0
\]

\[
8i = 24 - 14
\]

\[
i = \frac{10}{4} A
\]

Use any method you like to solve the following circuit:

5.a (10%) What is the voltage \( v_a \) (in Volts)?

By observation, \( v_a = v_{\text{ref}} = 0 \) V

5.b (15%) What is the voltage \( v_b \) (in Volts)?

Try nodal analysis: at a) \( i_1 - i - 5i = 0 \)

But \( i_1 = \frac{v_a - v_b}{10} = \frac{6 - 0}{10} = \frac{3}{5} A \)

\[
i = \frac{3}{5} - i - 5i = 0
\]

\( \Rightarrow i = \frac{1}{10} A \)

Also \( 5i = \frac{v_a - v_b}{20} = \frac{0 - v_b}{20} \)

\( \Rightarrow v_b = -100i = -100 \left( \frac{1}{10} \right) \)

\( v_b = -10 V \)