EE 3 Final Exam W '13 Solutions

1. a) series resistors ⇒ $20\,\Omega$

20 parallel to 20 : $10\,\Omega$

2 $10\,\Omega + 10\,\Omega = 20\,\Omega$

b) parallel impedances $j\omega L$ and $\left(R + \frac{1}{j\omega C}\right)$

$$\Rightarrow \frac{j\omega L\left(R + 1/j\omega C\right)}{R + j\left(\omega L - 1/\omega C\right)} = \frac{1 + j10\omega}{10 + j\left(\omega - 1/\omega\right)}$$

2 $$\therefore Z_{eq} = 10 + \frac{1 + j10\omega}{10 + j\left(\omega - 1/\omega\right)}$$

c) For the second part, $R_{eq} = 20\,\Omega$

1 $\therefore v_2 = 20 i_2$

since $v_1 = v_2 \frac{N_1}{N_2}$, $v_1 = \frac{1}{2} 20 i_2 = 10 i_2$

1 $\frac{i_2}{i_1} = \frac{1}{2}$; $i_2 = \frac{i_1}{2}$; $v_1 = 10 i_1/2 = 5 i_1$

1 By KVL $1 = 20 i_1 + 5 i_1$; $i_1 = 1/25$; $v_1 = 1/5$

1 Thus $i_2 = 1/50$; $v_2 = 2/5$

The parallel resistors equally divide the current

1 $i_3 = i_4 = 1/100$

d) ~~Power~~ Voltage is stepped up to reduce resistive

1 losses in transmission lines and then stepped down for safety in local distribution.

2. a) 10 Ω resistor prevents damaging currents
1 through motor + 1kΩ prevents large currents through base

We require $V_{BE} > V_{th}$ for current to
1 flow from C → E.

b) A DC motor would change directions with the current changing directions. But in any case the
1 transistor would only be active in positive phases.

1 we want $e^{-T/RC}$ to be ~ 1 for $T = 1/f_c = 10^{-3}$

1 so $RC \lesssim 10^{-4}$ would work (value = .9)
$C = .1 \mu F$

c) wavefront spreading, transducer losses,
2 obstructions

need $\frac{R_f}{R_1} = 10$. Given other resistor
1 values, $R_1 = 1k\Omega$, $R_f = 10k\Omega$ would be good

d) Basis for most digital logic (Computers)
most amplifiers use them
2 (could name particular classes of consumer products → radio, TV, etc.)

3. a) $L = 100^2 = 10^4$

2 Thus $G = 10^4$

b) Always put the lowest noise figure amplifiers first

1 Start with gains 10 + 10:

1 $F = 8 + \frac{8-1}{10} = 8.7$

Then add gain 100

1 $F = 8.7 + \frac{10-1}{100} = 8.7 + .09 = 8.79$

c) Then noise figure for one link is

1 $F = 10^4 + \frac{8.79-1}{10^4} = 10^4 + 7.79\times10^4 = 8.79\times10^4$

For the second link

1 $F = 8.79\times10^4 + \frac{8.79\times10^4 - 1}{1} \simeq 2\times 8.79\times10^4$

Thus 10 links are needed for a degradation by

1 a factor of 10.

d) Digital repeaters increase error rate linearly with the number of links, rather than

1 decreasing SNR. This is far more favorable when the error rate per link is low. (We can additionally use multiple modulation formats) Analog systems were used until relatively recently due to cost; Moore's Law has

1 pushed it down.

[If in (c) amplifier is first, $F_1 = 8.79 + \frac{10^4-1}{10^4} = 9.79$

$F_2 = 9.79 + \frac{9.79-1}{1} = 9.79 + 8.79$; $F_n = 9.79 + (n-1)8.7$

$n \simeq 11$.]