FALL 2004 **Name _____**
ELEN 665 (ESS)

EXAM #1

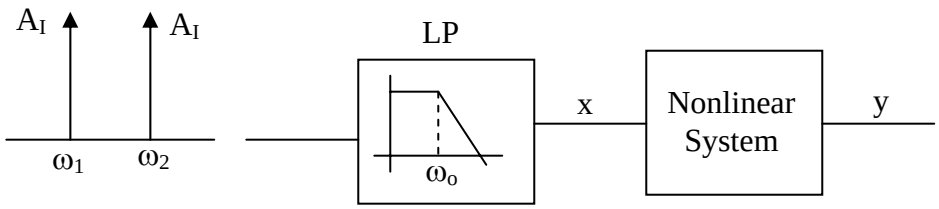
This is a closed book and notes exam. One information page is allowed for the exam. This exam is worth 18% of your total grade.

Prob.	Maximum	Yours
1	4	
2	3	
3	5	
4	3	
5	3	
Extra Credit	2	
Total	20	

Prob. 1 Assume m-identical BP filters in cascade. Determine the effective half-power bandwidth, and also the effective quality factor. Find an approximate expression for $\left|H_{BP}\left(j\omega_o\right)/H_{BP}\left(jn\omega_o\right)\right|$.

$$H_{BP}(s)=\frac{\left(K\frac{\omega_o}{Q}s\right)^m}{\left(s^2+\frac{\omega_o}{Q}s+\omega_o^2\right)^m}$$

Prob. 2. Assume that a cascade of Low-pass and nonlinear system are connected. The LP filter is characterized by:



$$H_{LP}(s) = \frac{\omega_o}{s + \omega_o} \quad ; \quad \omega_o = 1 Gr/s$$

The nonlinear system has an IIP_3 of –15dBm and it is characterized by $y = \alpha_1 x + \alpha_2 x^2 + \alpha_3 x^3$. The two tones are placed at:

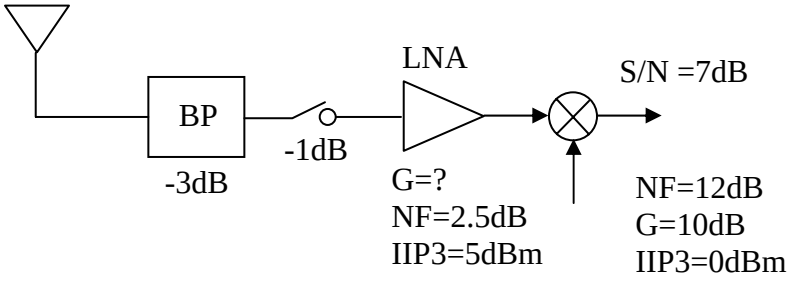
$a)$ $\omega_1 = 0.3 Gr/s$, $\omega_2 = 0.9 Gr/s$

$b)$ $\omega_1 = 0.9 Gr/s$, $\omega_2 = 3^{1/2} Gr/s$

$c)$ $\omega_1 = 3^{1/2} Gr/s$, $\omega_2 = 8^{1/2} Gr/s$

Determine the overall IIP_3 for the above three cases.

Problem 3. The receiver topology shown below has a sensitivity of –106dBm. The system consists of a filter with 3dB loss, followed by a switch with 1dB loss, and LNA, and a mixer. Assume that the system bandwidth is 200 kHz, and a SNR of 7dB is required for a bit error rate of 10^{-3}. What is power gain of the LNA to yield –106 dBm of sensitivity?



Prob. 4. A nonlinear system is characterized by $v_o = k_o + k_1 v_{in} + k_2 v_{in}^2 + k_3 v_{in}^3$
If one applies an input consisting of two sine waves, i.e.,

$$v_{in} = v_1 \cos \omega_1 t + v_2 \cos \omega_2 t$$

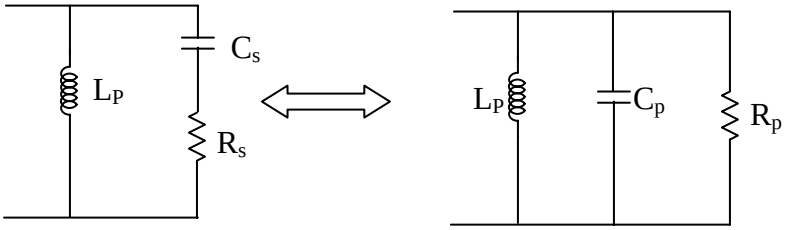
The following table summarize the distortion components.

Frequency	**Component Amplitude**
DC	$k_o + \frac{k_2}{2}\left(v_1^2 + v_2^2\right)$
ω_1	$k_1 v_1 + k_3 v_1 \left(\frac{3}{4} v_1^2 + \frac{3}{2} v_2^2\right)$
ω_2	$k_1 v_2 + k_3 v_2 \left(\frac{3}{4} v_2^2 + \frac{3}{2} v_1^2\right)$
$2\omega_1$	$\frac{k_2 v_1^2}{2}$
$2\omega_2$	$\frac{k_2 v_2^2}{2}$
$\omega_1 \pm \omega_2$	$k_2 v_1 v_2$
$\omega_2 \pm \omega_1$	$\frac{3}{4} k_3 v_1^2 v_2$
$2\omega_1 \pm \omega_2$	$\frac{3}{4} k_3 v_1 v_2^2$
$2\omega_2 \pm \omega_1$	$\frac{k_3 v_{1,2}^3}{4}$
$3\omega_{1,2}$	$\frac{k_3 v_{1,2}^3}{4}$

a) Obtain the input third-order intercept point for the 3rd harmonic. Note that this point is different from the 3rd.-order intermodulation input intercept point.

b) Determine in dB the relation between the input intercept points for the 3rd harmonic and the 3rd-order intermodulation.

Prob. 5. Obtain the expression for L_P, C_P and R_P from the series circuit, use $Q = \omega R_s C_s$ in your expressions.



EXTRA CREDIT. (no partial credit)A nonlinear system characterized by

$$y = a_o + a_1 v_{in} + a_2 v_{in}^2 + a_3 v_{in}^3 + a_4 v_{in}^4 + a_5 v_{in}^5$$

if a two-tone input signal at ω_1 and ω_2 are applied to this system, list the possible frequencies due to the 5th-order intermodulation terms.