## Schedule of Homework and Exam Due Dates

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**NOTE:** If special circumstances prevent you from meeting these due dates, please contact the instructor to make an alternate arrangement.
1-1 Do problem 4-21 from text (Liao)
1-2 Do problem 4-23 from text
1-3 Do problem 4-24 from text (read sect. 4-3-3)
1-4 Do problem 4-25 from text
1-5 Do problem 4-31 from text (read sect. 4-5-3)
2-1  Do Problem # 5-7 from Liao

2-2  Do Problem #5-9 from Liao

2-3  Do Prpblem #5-10 from Liao
University of Delaware

ELEG 855
Microwave and Millimeter-Wave Technology

Homework Set #3

3-1 Two n-channel, depletion mode field effect transistors have a source-drain spacing ($L_{SD}$) equal to 4 times the gate length ($L$). They are identical in every respect except that transistor A has its gate equally spaced between source and drain while transistor B has a gate to drain spacing twice as large as its source to gate spacing.

What is the ratio of maximum transconductance of the two FETs,

\[
\frac{g_{m\text{max}}\text{of A}}{g_{m\text{max}}\text{of B}} = ?
\]

if the channel is 0.2 $\mu$m thick, 300 $\mu$m wide, and has a conductivity $\sigma = 100(\Omega.cm)^{-1}$ and a length $L_{SD} = 8\mu$m.

3-2 Do problem 6-8 Text
3-3 Do problem 6-11 Text
3-4 Do problem 6-13 Text
3-5 Do problem 6-14 Text (Note correction $w=140\mu$m)
3-6 Do problem 6-15 Text (Note correction $w = 100\mu$m)
4-1 A simplified equivalent circuit for a varactor diode is shown below.

Using this circuit show that
(a.) The Q of the varactor is given by
\[ Q \simeq \frac{\omega C_j R_p}{(1 + \omega^2 C_j^2 R_p R_s)} \quad \text{for} \quad \frac{R_s}{R_p} << 1 \]

(b.) The frequency at which Q is a maximum is given by
\[ \omega_0 = \frac{1}{C_j \sqrt{R_p R_s}} \]

(begins with the expression for Q in part a)

4-2 We wish to use a shunt p-i-n diode switch to control microwave power in a transmission line of characteristic impedance \( Z_0 = 50\Omega \).

(a.) How many diodes are required to switch an incident power \( P_i = 1\text{KW} \) if the reverse bias resistance of each diode is \( 50\Omega \), the forward bias diode resistance is \( 1\Omega \) and each diode can dissipate 1 Watt?

(b.) What power will leak through the switch and reach the load when
4-3 Do problem 5-12 from the text.
4-4 Do problem 5-13 from the text.
4-5 Do prob. 8-7 in text.
4-6 Do prob. 8-8 in text.
   (Read Section 8-5-3 of text for relevant equations)
4-7 Do prob. 8-9 in text.
   (Read Section 8-5-3 of text for relevant equations)
1. If a silicon p'-n-i-n' Read diode has an n layer doping concentration of $1 \times 10^{16} / \text{cm}^3$, an n layer width of 2 $\mu$m and a total depletion layer width of 10 $\mu$m, what is its reverse breakdown voltage?

2. A GaAs p'-n-i-n' Read diode has a reverse breakdown voltage of 15 volts, a cross-sectional area of 10 mm$^2$, a total depletion width (W) of 8 $\mu$m and an ionization layer thickness ($X_a$) of 0.3 $\mu$m. If it is biased to an operating point at which the reverse current is 100 A, what is the total reverse voltage across the diode?

3. A GaAs Read diode has an avalanche region that is resonant at a frequency of 35 GHz when the diode is biased with a DC current density of 100 A/cm$^2$. What will be its resonant frequency if the bias current density is increased to 200 A/cm$^2$?
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Homework Set #5

5-1 Do Problem 8-1 (Liao)
5-2 Do Problem 8-3 (Liao)
5-3 Data is given below for three Ge IMPATT diodes

<table>
<thead>
<tr>
<th></th>
<th>Diode A</th>
<th>Diode B</th>
<th>Diode C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Width of drift region</td>
<td>5.3(\mu m)</td>
<td>16(\mu m)</td>
<td>25.2(\mu m)</td>
</tr>
<tr>
<td>Area</td>
<td>(10^{-4}\text{cm}^2)</td>
<td>(10^{-4}\text{cm}^2)</td>
<td>(10^{-4}\text{cm}^2)</td>
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a. Which of these diodes could best be used as TRAPATT oscillator to produce microwave power at a frequency of 3 GHz?

b. What is the maximum obtainable output power, assuming all thermal heating problems are negligible and current and electric field are uniformly distributed over area?

c. If the efficiency is 45% and the output power is desired to be 0.5 watt, can you use a bias supply with a maximum current rating of 10 milliamps? (Assume cw operation.)

5-4 Do problem 8-4 (Liao)
5-5 Do problem 8-5 (Liao)
5-6 Do problem 8-6 (Liao)
6-1 Do problem 7-1 (Liao)
6-2 Do problem 7-2 (Liao)
6-3 Do problem 7-4 (Liao)
6-4 Do problem 7-5 (Liao)
6-5 Do problem 7-7 (Liao)

6-6 A Gunn oscillator is fabricated from GaAs with an impurity concentration of \( N_0 = 5 \times 10^{15} / \text{cm}^3 \), and has a length \( L = 0.002 \text{ cm} \), and an area \( A = 10^{-6} \text{ cm}^2 \).

a. In what mode would you expect this device to oscillate if you provide suitable bias and placed it in a cavity resonant at:

(1) 4 GHz
(2) 5 GHz (assume \( v_{\text{dom}} = v_{\text{sl}} \))
(3) 8 GHz

b. If the efficiency at 5 GHz is 6% and the desired power output is 100 milliwatts, what must be the average (DC) bias voltage? (Assume \( v_{\text{dom}} = v_{\text{sl}} = v_r \), carrier velocity outside the domain.)
7-1 Do problem 11-3 (Liao)
7-2 Do problem 11-4 (Liao) assume \( d = 10^{-8} \text{ mhos/m} \) for board
7-3 Do problem 11-5 (Liao) assume \( d = 10^{-10} \text{ mhos/m} \) for board
7-4 Compare and contrast the relative advantages of hybrid microwave integrated circuits vs. monolithic microwave integrated circuits.