

**Department of Electrical and Computer Engineering
UNIVERSITY OF BRITISH COLUMBIA**

ELEC 480 SEMICONDUCTOR DEVICES

FINAL EXAM, April 22, 1999

Time: 2.5 hours

Answer all four questions.

No books or notes or calculators allowed.

This exam consists of two typed pages, one SPICE listing and one sheet of equations.

1. (15 marks) ...

The attached SPICE input listing is intended to perform a simulation of the read operation, using a 250 MHz clock, of a RAM cell at which a zero is stored. Besides the six transistors of the memory cell, the listing refers to two n-channel pull-ups and represents the complementary bit lines of a column of 1024 cells by capacitors.

- (a) There are 14 erroneous entries in the input listing. Circle these on the listing and, nearby, suggest the correct values.

Detach the page of the input listing, add your name and number as requested, and insert the page into your exam booklet.

- (b) For the corrected listing: sketch the circuit and label all nodes; also, sketch the voltage signals during one clock cycle at the nodes indicated in the plot statement.

2. (15 marks) ...

- (a) The company FASTBJT is designing homojunction bipolar-junction transistors for high-frequency power amplifiers. Its transistor fabrication technology allows designers to vary only the basewidth and the base doping density.

Two designers, Fred and Martha, present their designs for the company's new transistor to their manager.

Martha's design uses a quasi-neutral basewidth of W_B and a base doping density of N_B . Fred's design uses $W_B/5$ and $5N_B$, respectively.

The manager is smart; which design does she choose, and why?

- (b) Fred and Martha decide to quit FASTBJT and start a new company making HBTs. Should their old company be concerned about this new rival?

3. (13 marks) ...

(a) Consider two n-channel FETs which are identical apart from their gate length, L . OLD FET has $L = 1.0 \mu\text{m}$, whereas NEW FET has $L = 0.1 \mu\text{m}$.

Explain how and why the devices would differ as regards: (i) threshold voltage, (ii) output conductance, (iii) punchthrough voltage.

(b) Consider a n^+pn BJT operating in the active mode. Explain how and why the common-emitter current gain, and the common-emitter, short-circuit, unity-gain, cut-off frequency change with collector current.

4. (12 marks) ...

(a) EE480 Inc. manufactures n-channel enhancement FETs with gates made from very highly doped n-type polysilicon.

One day, a drowsy process engineer mistakenly fabricates the gates from highly doped p-type polysilicon.

(i) Draw equilibrium energy band diagrams for the n-gate and p-gate transistors.

(ii) Estimate the difference in threshold voltage between the two devices.

(b) After the above disaster, EE480 Inc. decides to switch to manufacturing BJTs.

The FET-trained personnel need to be re-educated as to the meaning and significance of "saturation". Why?