/30

ELEC 4705 - Quiz 3

Thurs. Nov. 9th 2017

Name:
Student Number:

1. Optical Systems

   (a) (3 points) What are three benefits of using photons for data transmission over electrons? Using photonics for communication provide resistance against electromagnetic interference (EMI), has higher bandwidth $10^{14}Hz$ over electronics $10^{8}Hz$, the material is cheaper and lighter (glass over copper), much lower attenuation so easier for long distance transmission.

   (b) (3 points) How is the optical beam confined to the fiber? Does the fiber itself limit the allowed modes? An optical beam is confined in a fiber by was of index variation between the core (where the beam propagates) and the cladding (where the beam is confined). In order to have confinement $n_1 > n_2$ where n_1 is the index of refraction of the core and n_2 is the index of refraction of the cladding. This also defines the allowable modes in the core. a very narrow region of n_1 (on the order of microns) surrounded by a much thicker n_2 will allow the transmission of a single mode, a fiber where there is a smooth transition between n_1 and n_2 will support multiple modes, and a large core surrounded by a thin cladding will undergo total internal reflection and support many modes.

(c) (2 points) Aside from data transmission, what can a fiber be used for? What properties of a fiber make it a good candidate for these uses? A fiber can be used as a sensor for temperature, pressure, detection of other forms of mechanical stress, detection of chemicals, and as biosensor by implementing grating structures, appropriate coatings, etc. Fibers are ideal for all these uses because of their immunity to EMI, their being chemically inert, their small size, and their long lifespan making them perfect as passive or active sensors.

(d) (2 points) What is a microring resonator and what can it be used for? A microring resonator is a photonic structure (it is a ring shape) that can serve many purposes. It can be used for filtering, multiplexing, as well as used in electro-optic, thermo-optic, operations leading to all optical swithching and signal modulation.

2. MOSFET

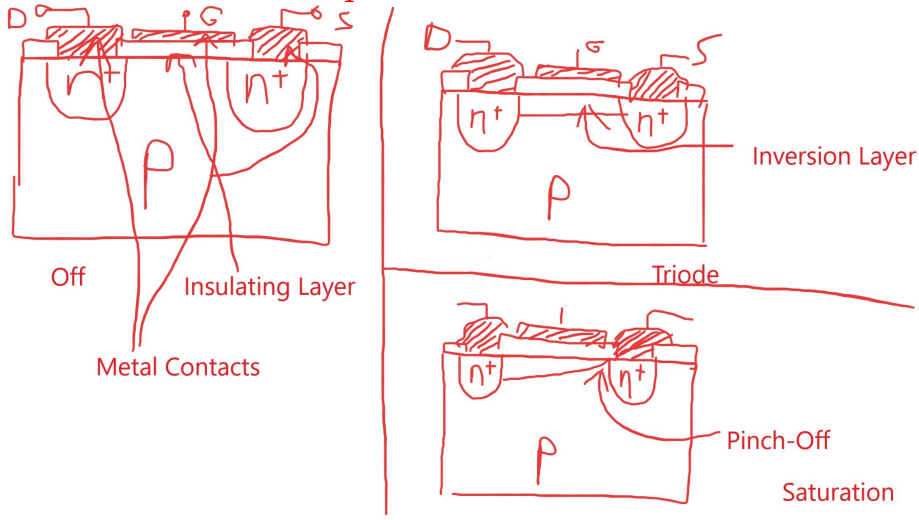
(a) (2 points) Why is a MOSFET a nonlinear device and what is the ideal model for its behaviour and what is an example of a more advanced model? A MOSFET is a nonlinear device because the current through it is controlled by the voltage applied to the gate, and rolls off to a max value for a given gate voltage. Past the threshold voltage, the only way to increase current is to increase the gate voltage. This is modeled ideally by the square law model, and more accurately by a variety of more complex models such as the simple charge control model, the meyer model, the velocity saturation model, or capacitance models like the meyer capacitance model or the ward dutton charge based model.

(b) Describe and explain the physical process that allows current to flow between the terminals by way of the following steps:

i. (2 points) Name two major regions or modes of operation. Off, triode, saturation

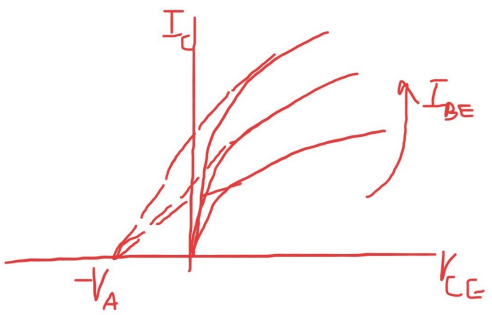
ii. (6 points) Draw a cross-section of a MOSFET in the two regions you listed previously and explain what is happening in each region, and how it affects current flow. See figure ii The current is allowed to flow between the terminals of a FET when an inversion layer is formed underneath the gate between the two heavily doped wells. This is created by attracting charge towards the insulating layer underneath the gate, which effectively creates an n-doped channel that the current can flow through. An increase in the voltage between the source and drain starts to warp the shape of the

bridge causing pinchoff to occur, thus limiting the current flow. A higher gate voltage means a higher V_{DS} is needed to reach pinch-off and the saturation region.

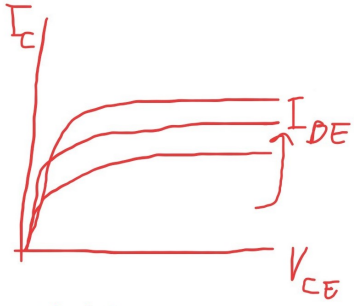


3. BJT

(a) (6 points) Draw both the ideal and the realistic I-V (collector current vs base voltage) plots and label the regions. Explain the difference between the two and the primary source of this difference. Make sure to show the effect of different values of I_B. The source of the difference is the Early effect (voltage). This is caused by changes in the depletion region width (between the n and p regions) which occur due to the applied voltage.



Realistic IV Curve



Ideal Curve

(b) (3 points) How is a BJT used as an amplifier? very simply, the base voltage directly controls the collector-emitter current, and so an AC signal is seen by the base and a duplicate signal is formed byt the current flowing between the collector and the emitter. This duplicate signal is thus an amplified version of the original.

(c) (1 point) What is another use for a BJT? BJTs can also be used as gates (switches) for binary operations.