# EE331, Spring 2014 Design Project

## **Project Description**

Design two XOR gates using only individual transistors, diodes, and resistors. The first XOR gate should use standard CMOS technology. The second XOR gate should use transmission gates to accomplish the XOR function. This second implementation should use ONLY transmission gates and INVERTERs ... no additional logic should be necessary.

Each XOR gate implementation should drive an LED driver circuit, appropriately designed to turn LED lights on in different colors to indicate "on" and "off." When the XOR output is "high," the dual LED (red/green) should indicate the "high" by turning green. When the XOR output is "low," the dual LED should indicate the "low" by turning red. The dual LED is simply two diodes in parallel (but with opposite polarity), so in one direction, when the applied voltage to the LED exceeds the turn-on voltage, the diode turns green and when applied voltage in the other direction exceeds the turn-on voltage, the diode turns red.

Your project has three sub-components to it: (a) a CMOS XOR gate; (b) a transmission gate implementation of an XOR gate; and (c) the LED driver. In your project, you should perform (a) initial calculations and models "on paper" that demonstrate the basic operation of each of these three sub-components; (b) simulation of each of these three sub-components; (b) simulation of each of these three sub-components parameters (like worst case rise time, voltage transfer curves, basic operation of the LED circuit, etc.); and (c) two working systems of each of the XOR gates (one using the CMOS implementation and one the transmission gate implementation of the XOR gate) driving the LED as described above.

Your grade will be based on having accurately completed each of these segments of the design project:

## **Simulation Components (30 points)**

- Transient and DC simulation OR High quality on-paper calculations of XOR gate (CMOS implementation)
- Transient and DC simulation OR High quality on-paper calculations of XOR gate (transmission gate implementation)
- Transient and DC simulation OR High quality on-paper calculations of LED driver circuit.

## Working Circuits (50 points)

(40 points) Demonstrate the two full systems working accurately.

(10 points) Characterize and demonstrate how fast each circuit can operate (propagation delays, rise and fall times).

#### **Evaluation (10 points)**

Evaluate and compare your two designs regarding performance, reliability, cost, and power dissipation. Discuss the extent to which these factors could be improved or traded-off in a final product.

### **Questions (15 points)**

Answer questions regarding circuit AC and/or DC characteristics posed by your TA. Demonstrate facility with the operation of lab equipment as directed by your TA.

#### **Bells and Whistles (10 points)**

Demonstrate an aspect or multiple aspects of your working circuits (XOR CMOS and XOR transmission gate systems) that are exemplary. Some ideas include: (a) Fabulously neat and well labelled wiring that an eight year old could use to troubleshoot or modify your circuit; (b) An interesting output indicator (beyond the single LED indicator of "high" and "low" described in the basic project description) or something else creative in your final implementation.

Prizes will be given for Tues/Wed Lab Sections and Thursday Lab Section for the best in the categories of exemplary execution (e.g., (a) above) and augmentation (e.g., (b) above) in addition to the up to 10 points of credit in your design project.