

**UNIVERSITY OF CALIFORNIA, BERKELEY**  
**EE40: Introduction to Microelectronic Circuits**

**Digital Logic Gate (I & II)**

**Introduction-1:**

This lab is going to about digital logic circuits. You will use two kinds of integrated circuits: 7404 (4 inverters) and 7400 (4 nand gates). The datasheets for the 7400 and 7404 ICs are provided. In this lab you will build a simple security system for a house.

Security System Specifications:

The security system has three inputs (“Disarm”, “Trip” and “Test”) and two outputs (“All OK” and “Alarm”). The first input is the “Disarm” button which must be set low to arm the security system. The second input is the “Trip” sensor, which is high if one of the security sensors has been tripped. The third input is the “Test” switch, which puts the system in test mode to check for faulty trip sensors.

The “Alarm” signal goes high if the system is armed and a sensor is tripped. The “All OK” signal goes high if the system is armed and no sensor is tripped or if the system is in test mode and no sensor is tripped.

The output signals “Alarm” and “All OK” shall be displayed using 2 LEDs. These LEDs will be driven by the final gate that determines the output signal. Depending on the power supply, choose a resistance  $R$  in series with the LED, in order to have 5mA in the LED when driven high by the output gate.

## Introduction-2:

In this lab you will measure the propagation delay of an inverter. Important timing parameters associated with the speed of digital logic gates are the propagation delay time  $t_{PD}$ , and the output signal rise and fall times,  $t_R$  and  $t_F$ . Propagation delay is a measure of how much time is required for a signal to change state. It is measured as the time from the 50% point of the input to the 50% point of the output (Figure 1). It is often cited as the average of the high-to-low and low-to-high delays (corresponding to the two transitions). The rise and fall times represent the amount of time for a signal to change state. To measure rise and fall times, you should be using the 10% to the 90% point, or vice versa.

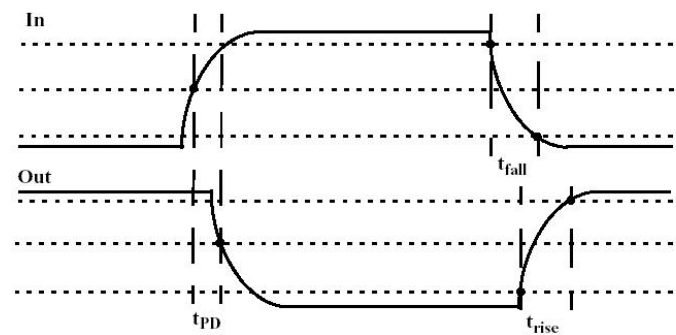


Figure 1

You can measure all these parameters by using a function generator and connecting two inverters in series. A common way used to measure propagation delay is to build a ring oscillator like in figure 2.

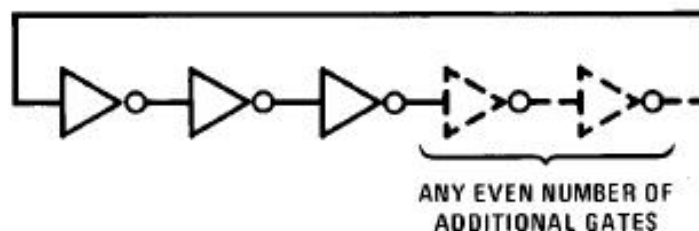


Figure 2

The voltage in this circuit is an (almost) square wave. By measuring the frequency of the oscillation and dividing by the number of inverters, we can get the propagation delay.

Name: \_\_\_\_\_  
Student ID: \_\_\_\_\_  
Section: \_\_\_\_\_  
Date: \_\_\_\_\_

**Prelab-1**

1. Write out the truth table for the security system. This truth table should have 2 output signals.

<b>Disarm</b>	<b>Trip</b>	<b>Test</b>	<b>All OK</b>	<b>Alarm</b>
0	0	0		
0	0	1		
0	1	0		
0	1	1		
1	0	0		
1	0	1		
1	1	0		
1	1	1		

2. For each output signal, write down the k-map and draw a realization of the circuit using AND-OR logic. Be sure to minimize the number of gates since they are in limited supply.

3. We only have access to inverters and nand gates. Using De-Morgan's laws, manipulate the AND-OR logic into NAND-NAND logic.

### **Prelab-2**

Explain why the ring circuit generates oscillation.

### Lab / Lab Report-1

Build the circuit. You need two chips: one 7400 and one 7404. Follow the TA's instruction for connecting power supply etc. Verify it's behavior: verify every entry of the truth table.

Disarm	Trip	Test	All OK (Theoretical)	Alarm (Theoretical)	All OK (Experimental)	Alarm (Experimental)
0	0	0				
0	0	1				
0	1	0				
0	1	1				
1	0	0				
1	0	1				
1	1	0				
1	1	1				

## Lab / Lab Report-2

First, measure the timing properties of an inverter. You should measure propagation delay, rise and fall time as defined in figure 1. In order to do this, connect two inverters in series and use the function generator as input like in figure 3.

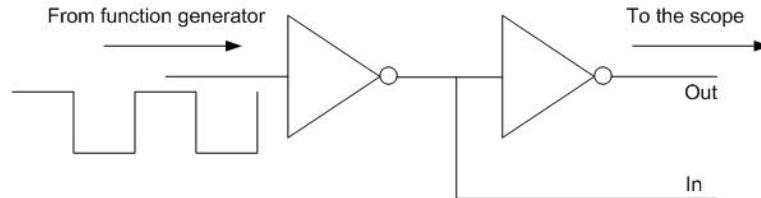


Figure 3

Using the scope, measure propagation time, rise and fall time between the two signals In and Out.

Now build a ring oscillator like in figure 2 and measure the oscillation frequency. Estimate the delay through one inverter. Is this delay the same as the previously measured delay? Why, or why not?