Implementation of 3 Stage Ring Oscillator Using CMOS

Ratul Chakraborty, University of Calcutta

June 29, 2021

Abstract

A ring oscillator is a device composed of an odd number of NOT gates in a ring, whose output oscillates between two voltage levels, representing true and false. The NOT gates, or inverters, are attached in a chain and the output of the last inverter is fed back into the first. Because a single inverter computes the logical NOT of its input, it can be shown that the last output of a chain of an odd number of inverters is the logical NOT of the first input. The final output is asserted a finite amount of time after the first input is asserted and the feedback of the last output to the input causes oscillation. We use this logic to implement a 3 Stage Ring Oscillator using CMOS.

1 Circuit Details

The schematic for a 3 stage ring oscillator is shown. 3 inverters using CMOS are connected in series to form this Ring Oscillator. The inverters are connected to a voltage source and capacitors in between. The ring oscillator uses an odd number of inverters to give the effect of a single inverting amplifier with a gain of greater than one. Rather than having a single delay element, each inverter contributes to the delay of the signal around the ring of inverters, hence the name ring oscillator. Adding pairs of inverters to the ring increases the total delay and thereby decreases the oscillator frequency. Changing the supply voltage changes the delay through each inverter, with higher voltages typically decreasing the delay and increasing the oscillator frequency. If t represents the time delay for a single inverter and n represents the number of inverters in the inverter chain, then the frequency of oscillation is given by: f = 1/2tn. The period of a ring oscillator varies in a random manner as T+T where T is a random value. In high-quality circuits, the range of T is relatively small compared to the average period T. This variation in the oscillator period is called jitter. Local temperature effects cause the period of a ring oscillator to wander above and below the long-term average period. So, the frequency of a silicon ring oscillator will generally be stable, when the ambient temperature is constant and factors of heat transfer from the device to the ambient environment do not vary.

2 Implemented Circuit

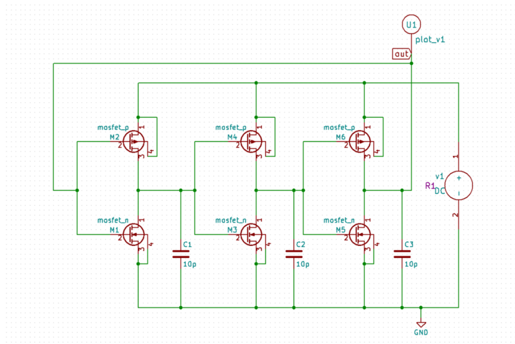

Figure 1: Implemented circuit diagram.

3 Implemented Waveforms

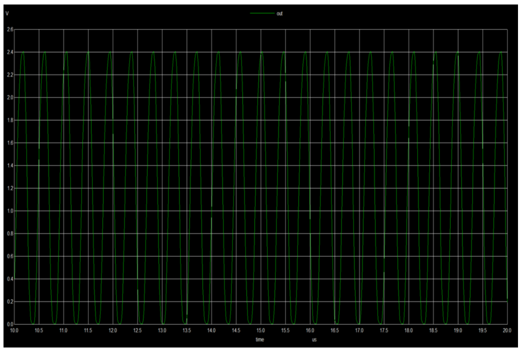

Figure 2: Implemented waveform.

References

[1] S. U. Rafiul Islam, Ahmad Nafis Khan Suprotik and M. Amin. Design and analysis of 3 stage ring oscillator based on mos capacitance for wireless applications. https://www.researchgate.net/publication/316908267_Design_and_an

[2] Wikipidia. Rong oscillator. https://en.wikipedia.org/wiki/Ring_oscillator.