American International University- Bangladesh

Department of Electrical and Electronic Engineering

EEE2104: Electrical Devices Laboratory

Title: Study of Inverter Circuits using MOSFET and BJT

Abstract:

This experiment gives an excellent practical realization of the RTL inverter, NMOS inverter, and CMOS inverter. At first a CMOS inverter will be designed, simulated, and understood in the pre-lab section. Then all kind of inverter circuits mentioned above will be designed on the project board in the laboratory and analyzed the theoretical concepts and the practical results.

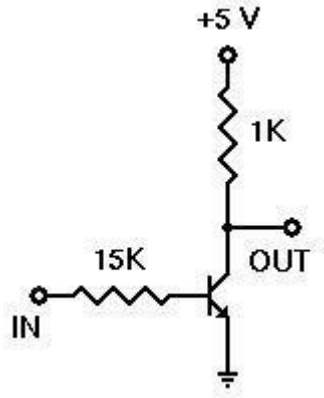
Introduction:

The objective of this experiment is to observe- RTL inverter, NMOS inverter and CMOS inverter

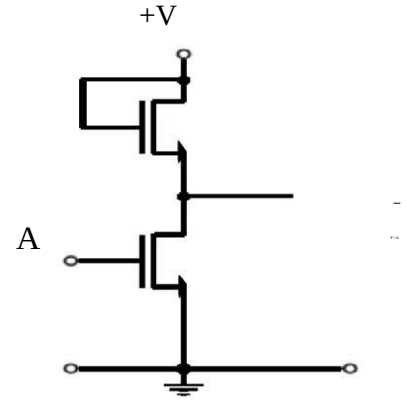
Theory and Methodology:

RTL Inverter:

Resistor-Transistor Logic (RTL) is a large step beyond Diode Logic (DL). Basically, RTL replaces the diode switch with a transistor switch. If a +5V signal (logic 1) is applied to the base of the transistor (through an appropriate resistor to limit base-emitter forward voltage and current), the transistor turns fully on and grounds the output signal. If the input is grounded (logic 0), the transistor turns off and the output signal rises to +5 volts. In this way, the transistor inverts the logic sense of the signal, but it also ensures that the output voltage will always be a valid logic level under all circumstances. Because of this, RTL circuits can be cascaded indefinitely, where DL circuits cannot be cascaded reliably at all.



NMOS Inverter:



An inverter can be designed with a single NMOS and a resistor. In case of NMOS inverter two NMOS are used where one is used as a load and another one is used for inverting the input. The load transistor must have a high and the switching transistor have a low resistance.

CMOS INVERTER:

The two MOSFETs are designed to have matching characteristics. Thus, they are complementary to each other. When off, their resistance is effectively infinite; when on, their channel resistance is about 200 Ohm . Since the gate is essentially an open circuit it draws no current, and the output voltage will be equal to either ground or to the power supply voltage, depending on which transistor is conducting.

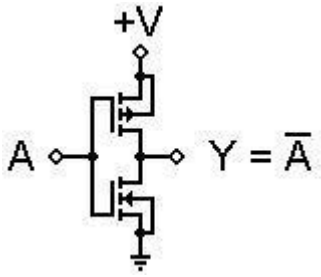


Fig: A CMOS inverter

When input A is grounded (logic 0), the N-channel MOSFET is unbiased, and therefore has no channel enhanced within itself. It is an open circuit, and therefore leaves the output line disconnected from ground. At the same time, the P-channel MOSFET is forward biased, so it has a channel enhanced within itself. This channel has a resistance of about 200 ohm, connecting the output line to the +V supply. This pulls the output up to +V (logic 1). When input A is at +V (logic 1), the P-channel MOSFET is off and the N-channel MOSFET is on, thus pulling the output down to ground (logic 0). Thus, this circuit correctly performs logic inversion, and at the same time provides active pull-up and pull-down, according to the output state.

Pre-Lab Homework:

Simulate the above-mentioned inverter using PSPICE_9.1_STUDENT_VERSION. Complete table 1, table 2 & table 3 using PSPICE_9.1_STUDENT_VERSION.

Apparatus:

1)	DC Power Supply	[1]
2)	Power Supply Cable	[2]
3)	Multimeter	[1]
4)	Project Board	[1]
	For RTL Inverter	
5)	1K and 15kResistance	[1 for each]
6)	2N4124 NPN silicon transistor, or equivalent	[1]
7)	DMM	[1]
	For NMOS Inverter with Ohmic Load	[1]
8)	10k Resistance	[1]
9)	Depletion type n- channel MOSFET	[1]
	For CMOS Inverter	
10)	IRF 9540 : enhancement type p- channel MOSFET	[1]
11)	IRF 540 :enhancement type n- channel MOSFET	[1]

Precautions:

Have your instructor check all your connections after you are done setting up the circuit and make sure that you apply only enough voltage to turn on the chip, otherwise it may get damaged.

Experimental Procedure:

1) Construct the circuit as shown in Figures.
2) Use Multi-meter to take the readings and fill the following table.

Circuit Diagrams:

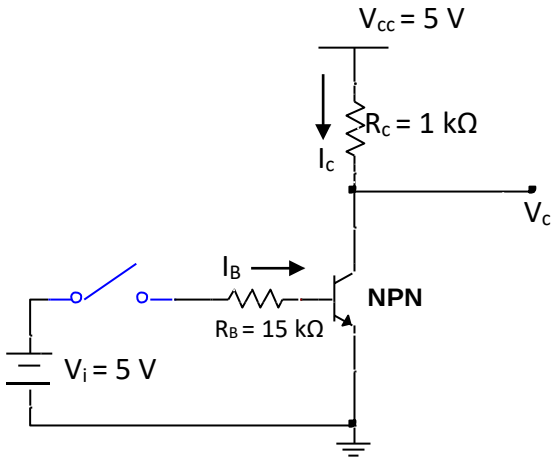


Fig. BJT inverter.

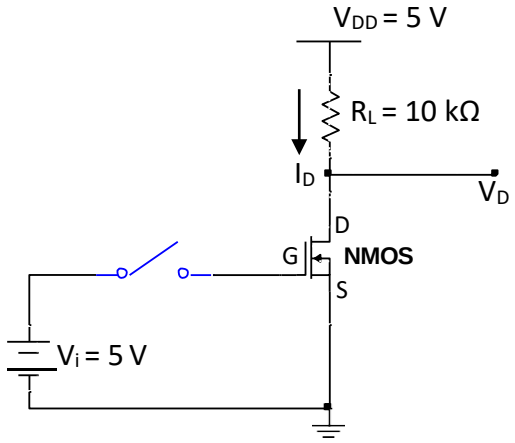


Fig. NMOS inverter.

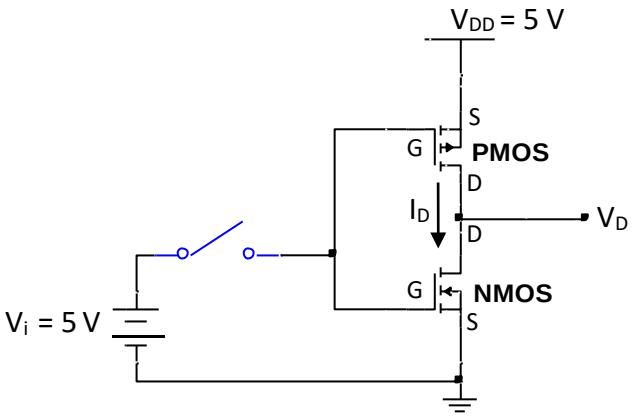


Fig. CMOS inverter.

Table 1: RTL inverter circuit parameters

RTL Inverter	Vin	V_C	V_{BE}	I_B	I_C
A=0					
A=1					

Table 2: NMOS inverter circuit parameters

NMOS Inverter	Vin	V_D	V_{DS}	I_D
A=0				
A=1				

Table 3: CMOS inverter circuit parameters

CMOS Inverter	MOSFET Type	Vin	V_D	V_{DS}	I_D
A=0	P MOS				
	N MOS				
A=1	P MOS				
	N MOS				

Simulation and Measurement:

Compare the simulation results with your experimental data comment on the differences (if any).

Questions for report writing:

1. Compare the inverter circuits and discuss the advantages or disadvantages of one over the other.
2. Design an inverter circuit using diode logic.

Discussion and Conclusion:

Interpret the data/findings and determine the extent to which the experiment was successful in complying with the goal that was initially set.

Reference(s):

[1] American International University–Bangladesh (AIUB) Electronic Devices Lab Manual.
[2] A.S. Sedra, K.C. Smith, Microelectronic Circuits, Oxford University Press (1998)
[3] J. Keown, ORCAD PSpice and Circuit Analysis, Prentice Hall Press (2001)
[4] P. Horowitz, W. Hill, The Art of Electronics, Cambridge University Press (1989).