0.1 Exercise 1: Design and Implementation of NOT Gates Using Transistors

High-Level and Low-Level Input Voltages

The high-level input voltage (V_{IH}) is the minimum input voltage that is considered as high, while the low-level input voltage (V_{IL}) is the maximum input voltage that is considered as low.

High-Level and Low-Level Output Voltages

The high-level output voltage (V_{OH}) is the minimum output voltage that the circuit provides as a high, while the low-level output voltage (V_{OL}) is the maximum output voltage that the circuit provides as a low.

Noise Margin

The high noise margin (NM_H) is the gap between the high-level input voltage and the high-level output voltage, while the low noise margin (NM_L) is the gap between the low-level output voltage and the low-level input voltage.

$$NM_H = V_{OH} - V_{IH}$$

$$NM_L = V_{IL} - V_{OL}$$

Propagation Delays

For this assignment's meassures, when the input changes from low to hight and the output from high to low, the high-to-low propagation delay is considered as the time between the moment in which the input voltage reaches the 90% of its maximum high value, until the moment in which the output voltage reaches the 10% of its maximum high value.

$$t_{pHL} = t_{10\%V_{maxO}} - t_{90\%V_{maxI}}$$

In the case in which the input goes from high to low and the output from low to high, the low-to-high propagation delay is considered as the time between the moment in which the input voltage reaches the 10% of its maximum high value, until the moment in which the output voltage reaches the 90% of its maximum high value.

$$t_{pLH} = t_{90\%V_{maxO}} - t_{10\%V_{maxI}}$$

The high-to-low transition time or fall time (t_f) is the time that it takes the output voltage to go from its high maximum value to its low minimum value, while the low-to-high transition time or rise time (t_r) is the time that it takes for it to change from its low minimum value to tis high maximum value.

Maximum Output Current

0.1.1 Measurements

0.1.2 Using a BJT NPN 337 Transistor

Without Load Connected to the Output

With a $1nF$ Capacitor Connected to the Output

0.1.3 Using a BJT PNP 327 Transistor

Without Load Connected to the Output

	NPN	NPN with capacitor	PNP	PNP with capacitor
$V_{IH}(V)$	0,9	0,9	4,5	4,6
$V_{IL}(V)$	0,5V	0,6	4,2	4,3
$V_{OH}(V)$	4,96V	4,56	4,77	5
$V_{OL}(V)$	0,1	0,12	0,05	0,45
$NM_H(V)$	4,06	3,66	0,27	0,4
$NM_L(V)$	0,4	0,48	4,15	3,85
t_{pHL}	87ns	$2,7\mu s$	$2,72\mu s$	101ns
t_{pLH}	$2,94\mu s$	104ns	73ns	$2,23\mu s$
t_f	69,5ns	84ns	575ns	770ns
t_r	505ns	520ns	83ns	86 ns
I_{OutMax}				