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Operation of logic gates (AND, NAND, OR, NOR) with single circuit using BJT (Bipolar Junction Transistor)

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ABSTRACT

In this paper, we have developed a circuit which gives the output for 4-Logic gates of "AND, NAND, OR, NOR" simultaneously by taking only two inputs "A" and "B". I used bipolar junction transistors (BJT) to design this circuit. Previously we have each circuit for each logic gate but now in our new circuit, we developed four logic gates in a single circuit. Thus we can decrease the size of the special circuits. Instead of using four IC's for four logic gates if we use this single IC for all the four logic gates then the space used for the remaining three IC's can be used for other purposes. This circuit is very easy to design because it has only six bipolar junction transistors (BJT's).

Keywords— *Logic gates, Integrated Circuits (IC's), Bipolar Junction Transistors (BJT's)*

1. INTRODUCTION

Logic Gates are important parts of digital electronics. These logic gates are mainly used to perform a logical operation between two or more input functions [1]. Generally, for every logic gate, we have only one output but in case of inputs, it may vary because we have 2-inputs logic gates and some of the logic gates are also available for 3-inputs also. But for logic gate called "NOT" have only a single input and single output. These logic gates only take the binary data as input either "ACTIVE LOW (0)" or "ACTIVE HIGH (1)" by receiving the voltage input [2]. Active low represents "0V" Active high represents "+3V to +7V". To obtain the required circuit we can join any number of logic gates together. We can design many special circuits like FLIPFLOPS, MULTIPLEXERS, LATCHES, REGISTERS, and COUNTERS etc.

2. PROBLEM FORMULATION AND EXPERIMENTAL SETUP

2.1 Active low and active high

Table 1: Active High and Active low

Parameter	Active Low	Active High
Input (for ideal case)	0V to 0.7V	0.7V to 5.0V
Output (for ideal case)	0V to 0.7V	0.7V to 5.0V
Input (for practical case)	0V to 2.0V	2.0V to 5.0V
Output (for practical case)	0V to 2.0V	2.0V to 5.0V

2.2 Types of logic gates in this circuit

- AND
- NAND
- OR
- NOR

2.2.1 Logic gate AND: It takes 2-inputs and gives only a single output. The main operation of this AND gate is Z =A. B, where A and B are 2-inputs and Z, is the output.

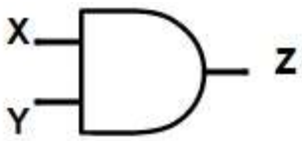

Fig. 1: AND gate symbol

Table 2: Truth table of AND gate

Input-A	Input-B	Output Z = A.B
0	0	0
0	1	0
1	0	0
1	1	1

2.2.2 Logic gate NAND: It takes 2-inputs and gives only a single output. The main operation of this NAND gate is Z =A. B, where A and B are 2-inputs and Z, is the output.

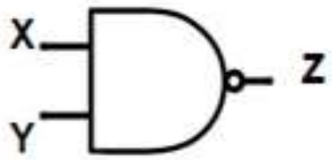

Fig. 2: NAND gate symbol

Table 3: Truth table of the NAND gate

Input-A	Input-B	Output $Z = \overline{A.B}$
0	0	1
0	1	1
1	0	1
1	1	0

2.2.3 Logic gate OR: It takes 2-inputs and gives only a single output. The main operation of this OR gate is Z=A+B where A and B are 2-inputs and Z is the output.

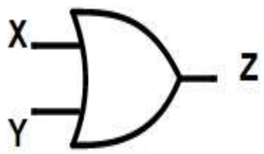

Fig. 3: OR gate symbol

Table 4: Truth table of OR gate

Input-A	Input-B	Output Z = A+B
0	0	0
0	1	1
1	0	1
1	1	1

2.2.4 Logic gate NOR: It takes 2-inputs and gives only single output. The main operation of this NOR gate is Z =A+B where A and B are 2-inputs and Z is the output [3].

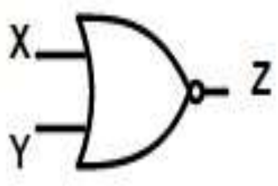

Fig. 4: NOR gate symbol

Table 5: Truth table of NOR gate

Input-A	Input-B	Output $Z = \overline{A + B}$
0	0	1
0	1	0
1	0	0
1	1	0

3. BIPOLAR JUNCTION TRANSISTOR (BJT)

A BJT is a semiconductor solid state 3 terminal device. In BJT's current flows through two terminals called "EMITTER" and "COLLECTOR". And the amount of current is controlled by the third terminal called "BASE" [4].

3.1 Working principle of BJT

Generally, a BJT consists of three junctions

(a) Base-emitter junction
(b) Collector base junction
(c) Emitter collector junction

When the transistor is biased in the active region. Then the base-emitter region is in forward biased and collector-base junction is in reverse biased. The width of the depletion layer of base-emitter junction smaller than that of a depletion layer of collector-base junction. Where BE junction is in forwarding bias it reduces the barrier potential and allows the electrons to flow from emitter to base. As the base region is lightly doped only a few holes. So only some electrons (2%) of emitter region recombine with holes in the base region and flows out of the base terminal. This forms the base current which is formed due to recombination of electrons and holes. The remaining large number of electrons will pass the collector junction to form large collector current. The base current is very smaller than the collector current [5].

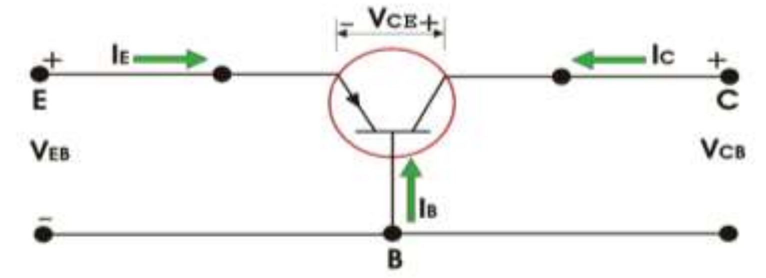

Fig. 5: BJT Circuit

From Kirchhoff's current law: IB = IE + IC

3.2 BJT as a switch

This bipolar transistor can be used switches for a LED. Because LED needs a small voltage at logical DC level. The areas of operation of transistors as a switch require two modes of SATURATION REGION and CUT-OFF region. When the voltage of the BJT is in "cut-off region" the transistor acts as "closed switch". When the voltage of the BJT is in "saturation region" the transistor acts as "open switch" [6].

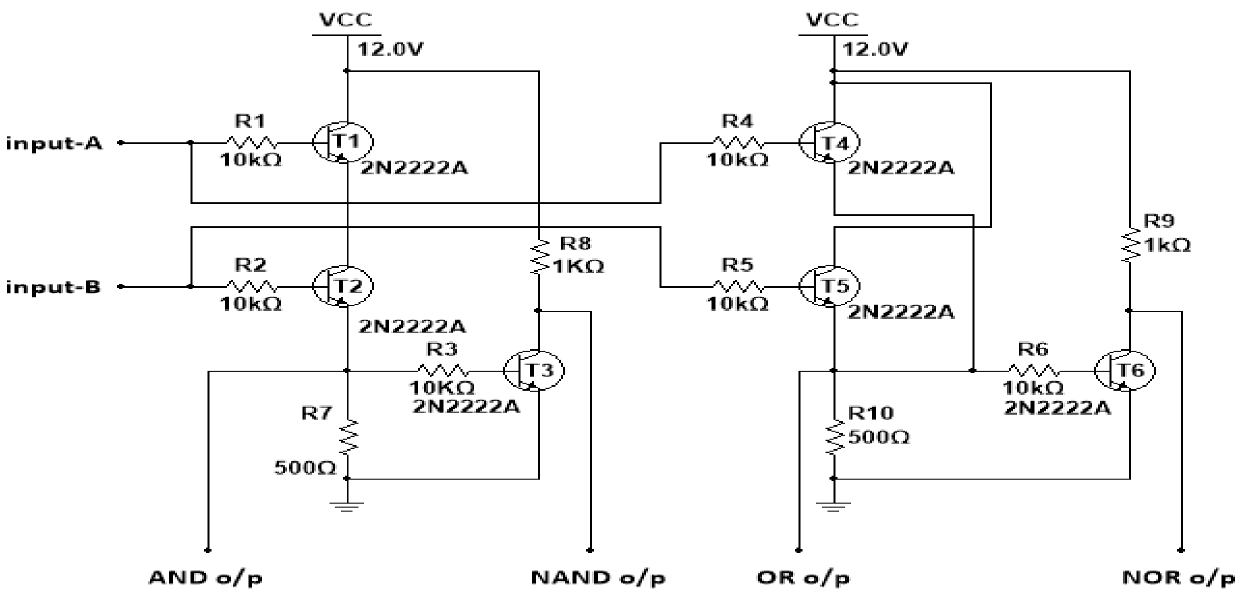

Fig. 6: Circuit diagram

Table 6: Truth table

Input-A	Input-B	AND o/p	NAND o/p	OR o/p	NOR o/p
LOW	LOW	LOW	HIGH	LOW	HIGH
LOW	HIGH	LOW	HIGH	HIGH	LOW
HIGH	LOW	LOW	HIGH	HIGH	LOW
HIGH	HIGH	HIGH	LOW	HIGH	LOW

3.3 Cases

1) For A=LOW and B=LOW
2) For A=LOW and B=HIGH
3) For A=HIGH and B=LOW
4) For A=HIGH and B=HIGH

3.3.1 For A=LOW and B=LOW

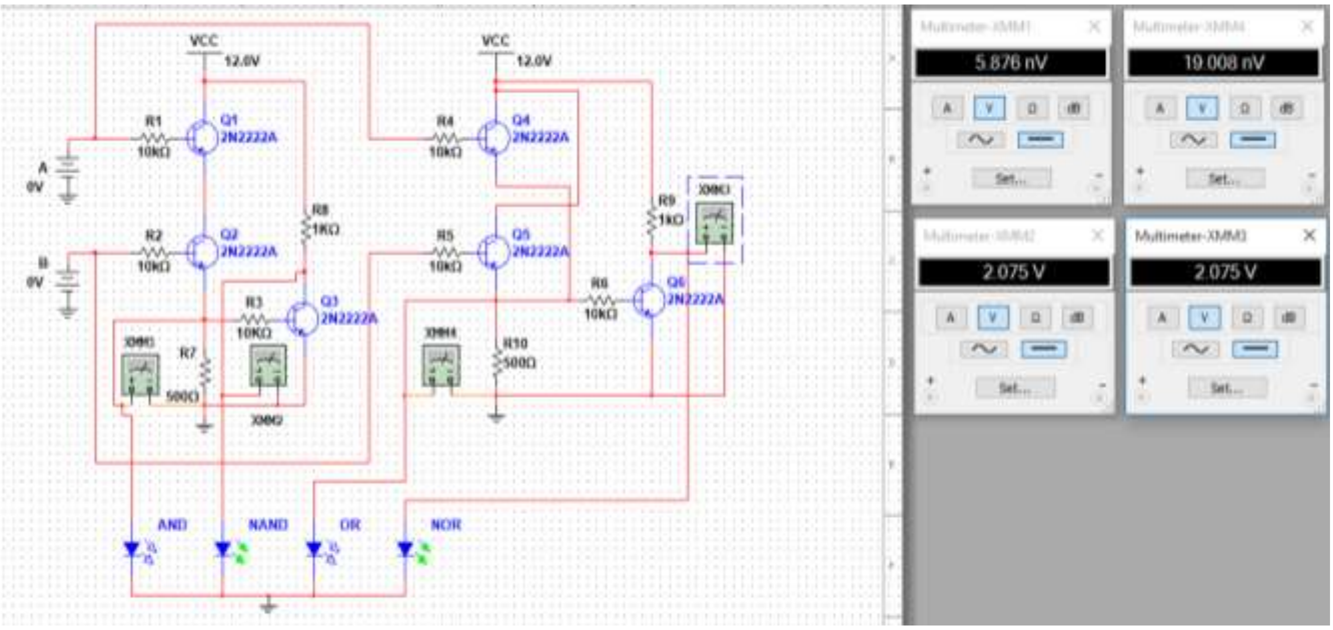

Fig. 7: Case 1 circuit

Table 7: Output and readings

Multimeter Number	XMM1	XMM2	XMM4	XMM3
Logic gate	AND	NAND	OR	NOR
Readings	5.876nV(OFF)	2.075V(ON)	19.009nv(OFF)	2.075V(ON)
LED position	OFF	ON	OFF	ON

3.3.2 For A=LOW and B=HIGH

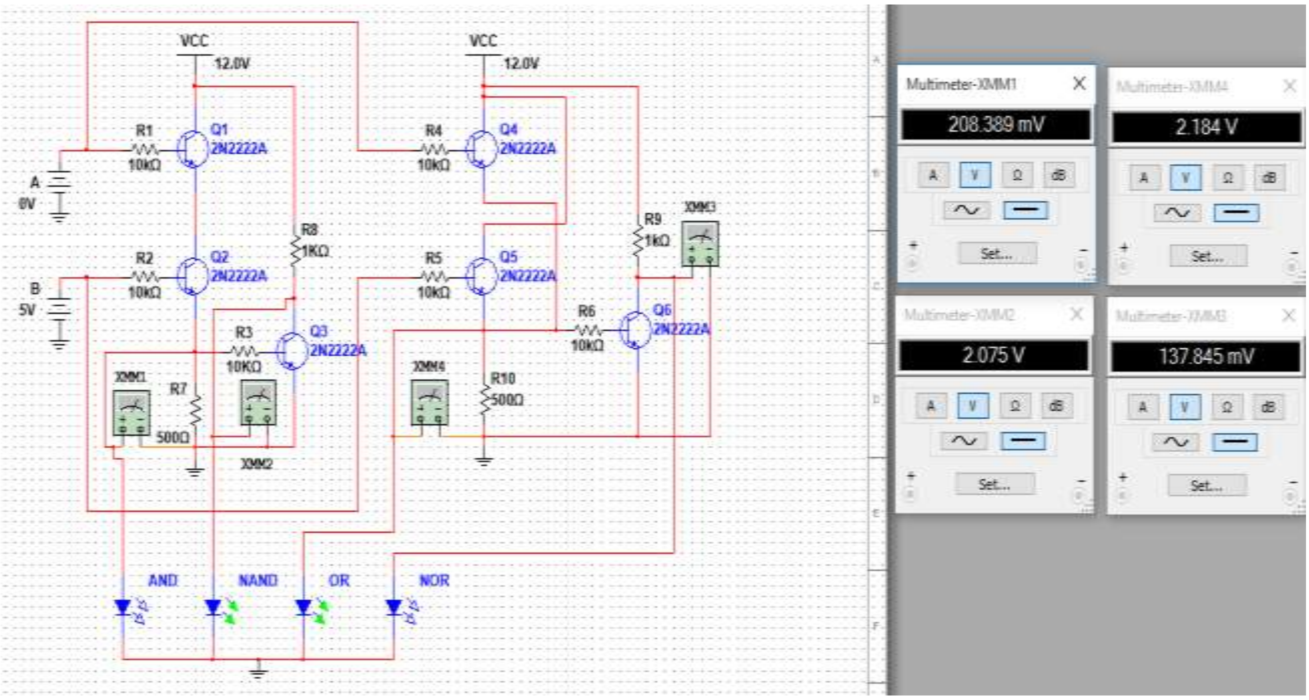

Fig. 8: Case 2 circuit

Table 8: Output and readings

Multimeter Number	XMM1	XMM2	XMM4	XMM3
Logic gate	AND	NAND	OR	NOR
Readings	208.38mV(OFF)	2.075V(ON)	2.184V(ON)	137.84mV(OFF)
LED position	OFF	ON	ON	OFF

3.3.3 For A=HIGH and B=LOW

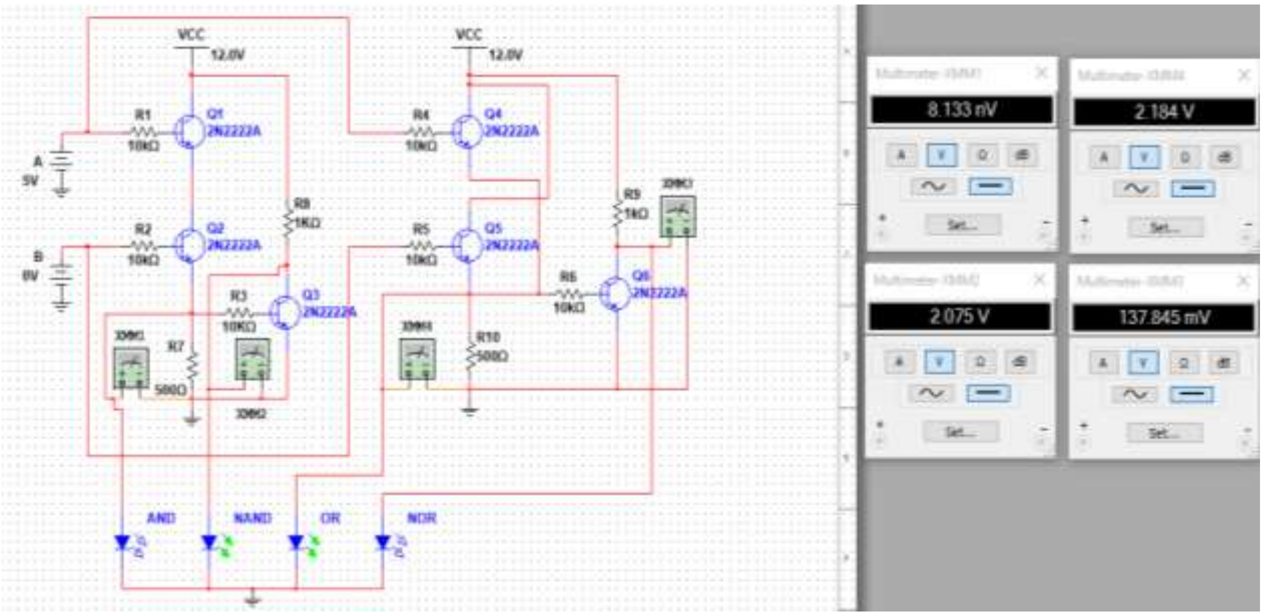

Fig. 9: Case 3 circuit

Table 9: Output and readings

Multimeter Number	XMM1	XMM2	XMM4	XMM3
Logic gate	AND	NAND	OR	NOR
Readings	8.133nV(OFF)	2.075V(ON)	2.184V(ON)	137.84mV(OFF)
LED position	OFF	ON	ON	OFF

3.3.4 For A=HIGH and B=HIGH

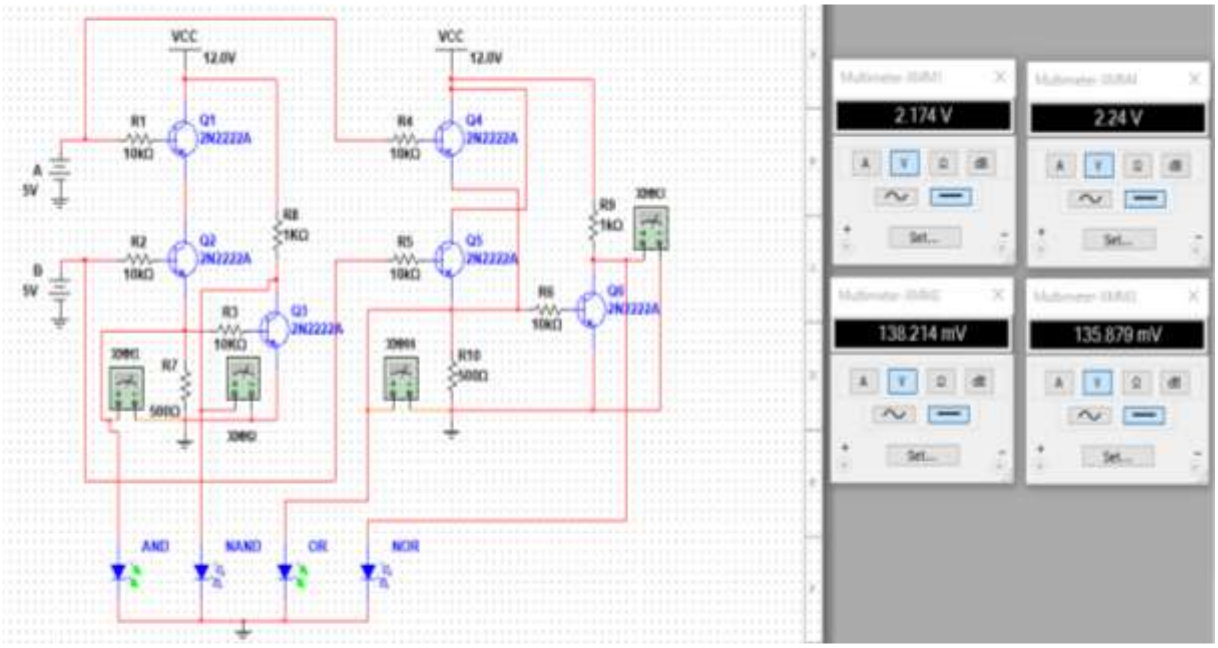

Fig. 10: Case 4 circuit

Table 10: Output and readings

Multimeter Number	XMM1	XMM2	XMM4	XMM3
Logic gate	AND	NAND	OR	NOR
Readings	2.174V(ON)	138.21mV(OFF)	2.24V(ON)	135.87mV(OFF)
LED position	ON	OFF	ON	OFF

4. CONCLUSION

From this article, we can conclude that this circuit is very useful. Because in some special circuits it is necessary that we have to use all the logic gates at a time. So, it is difficult to connect 4-IC's for 4-logic gates. At that time by using this circuit we can get the outputs of all the logic gates at a time by giving only 2-inputs. We can also design an Integrated Circuit (IC) very easily with this circuit because it has only 6-BJT's. It reduces the complexity of the logic gate circuits which we had seen before.

5. ACKNOWLEDGMENT

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6. REFERENCES

[1] Logic gate, Wikipedia.
[2] Introduction to logic gates, electronics hub.
[3] M. Morris Mano, Michael D. Ciletti. Digital Design, 5th edition, section 2.8.
[4] Bipolar Junction Transistors Working Principle and Applications, elprocus.
[5] Bipolar Junction Transistor or BJT, electrical4u
[6] Ali Habeb Aseeri, Fouzeyah Rajab Ali. Bipolar junction transistor as a switch, IOSR Journal of Electrical and Electronics Engineering (IOSR-JEEE), volume 13, PP 54-57

