Implementation of Discrete Mathematics in Logic Gates for Electronic Circuit

Umair Khalid Qureshi, Shahzad Ali Khaskheli, Manzar Bashir Arain, Lata Bai and Syed Hasnain Ali Shah

Abstract: This research has implementation of discrete mathematics in logic gates for electronic circuit. The idea of research comes from De-Morgan law in discrete mathematics. The proposed logic gates developed with the help of Not Gate, AND Gate, OR Gate, Exclusive OR Gate, conditional OR Gate and Exclusive OR Not Gate. The proposed logic gates give interesting results, such as same truth values and equal truth values of two compound logic gates. The purpose of this research work is to understand the importance of discrete mathematics in logic gates and electronic circuit. This research covers the operation of the logic gates, which are relevant for digital electronic circuit. From result it has been concluded that the proposed logic gates are good achievement in the field of digital logic design for the electronic circuit.

Keywords: logic gates, digital electronic circuit, truth table, logic gates symbols.

1. INTRODUCTION

The foundation of the logic gates was laid down by a British mathematician Boole in the middle of the 19th century. Logic gate is a part of for Digital logics Design in the field of electronic that can be used to implement the most elementary logic gate expressions, and it is the most basic building block of combinational logic gates. Logic gates can be defined as simple physical devices used to implement the Boolean function. Logic gates are used to perform a logic gate operation with one or more inputs and generates a logical output. These digital logic circuits are formed by connecting one or more logic gates together (Ragini et al, 2010). There are many researchers and scientists have been worked in logic gates, here we are discussing some references for understanding logic gates. A universal gate is a gate which can implement any Boolean function without need to use any other gate type. Usually universal gate is used to derive basic three gates namely, AND, OR and inverter whereas other gates are the derivation of these three basic gates (reference 2). Reversible logic has various applications in various field like in nanotechnology, quantum computing, Low power CMOS, Optical computing and DNA computing. The reversible logic is design, main purposes are - decrease quantum cost, depth of the circuits & the number of garbage output. This paper provides the basics of reversible logic gates & its implementation in Qca. Basic Reversible Logic Gates and It's Qca Implementation (Biswas *et al*, 2014). To develop a three terminal device architecture, termed the transcript or, that uses bacteriophage serine integrases to control the flow of RNA polymerase along DNA, from this is to realized permanent amplifying AND, NAND, OR, XOR, NOR, and XNOR gates actuated across common control signal ranges and sequential logic supporting autonomous cell-cell communication of DNA encoding distinct logic-gate states (Bonnet *et al*, 2013). To demonstrated two-input microdroplet-based universal logic gates using a liquid-electronic hybrid divider with the help of Boolean logic functions, microfluidic chip, chemical analysis and IF logic function, which have been realized by manipulating the applied voltages. The presence or absence of microdroplets at the detector translates into the binary signal 1 or 0 (Zhou *et al*, 2012). The continuous improvement to increase the processing performance of electronic components has been achieved by a constant reduction of the transistor size in met- al-oxide semiconductor (MOS) technology. The increased performance of integrated circuits (ICs) is also associated with increase in packing density. Design of Logic Gates using Laterally Actuated Double-Gate NEMS (Pandiyan *et al*, 2016). To study and understand the basic logic gates, implement the basic logic gate and the study the specifications of every logic gates when connected it with one input constant and the

- *Corresponding Author: Umair Khalid Qureshi, Department of Business Administration, Shaheed Benazir Bhutto University, Sanghar, Sindh, Pakistan*
  E-mail: umair.khalid_sng@sbbusba.edu.pk
- *Co-Author: Shahzad Ali Khaskheli, Manzar Bashir Arain, Lata Bai and Syed Hasnain Ali Shah, Department of Information Technology, Shaheed Benazir Bhutto University, Sanghar, Sindh, Pakistan*

other is variable (Taha *et al*, 2019) and (Zhou *et al*, 2009). Similarly, this research focused on logic gates in digital logic design for electronic circuit. This article is using logic gates symbols to represent the proposed compound logic gates. From truth table and logigates shows the important of proposed work in the field of digital logic design for electronic circuit.

2. Proposed Compound Propositional Law

This segment has presented a compound logic gates for electronic circuit, which is based on Not Gate, AND Gate, OR Gate, Exclusive OR Gate, conditional statement and Exclusive OR Not Gate. The proposed compound logic gates can be defined as:

a) $B \oplus \bar{B}$
b) $A + (A \rightarrow B)$
c) $A + (\bar{B} + B)$
d) $(\overline{A \oplus \bar{B}}).(\overline{A + B})$
e) $(\overline{A + B}) \rightarrow \left(\overline{\bar{A} \overline{\oplus} \bar{B}}\right)$
f) $(\bar{A} \rightarrow B) + (B \oplus \bar{B})$
g) $(A \oplus B) \overline{\oplus} (\bar{A} \oplus \bar{B})$
h) $(A \overline{\&} B) + (\bar{A} \oplus \bar{B})$
i) $A \overline{\oplus} B \equiv \bar{A} \overline{\oplus} \bar{B}$
j) $(A \overline{\oplus} B) + (\bar{A} \overline{\oplus} \bar{B})$
k) $A + (\bar{B} + B)$
l) $\left(A \overline{\oplus} B\right) + \left(\bar{A} \overline{\oplus} \bar{B}\right)$
m) $(A \overline{\oplus} B).(\bar{A} \overline{\oplus} \bar{B})$
n) $\left(\bar{A} \overline{\oplus} \bar{B}\right) + (\bar{A} \rightarrow B)$
o) $(\overline{A + B}) \rightarrow \left(\bar{A} \overline{\oplus} \bar{B}\right)$

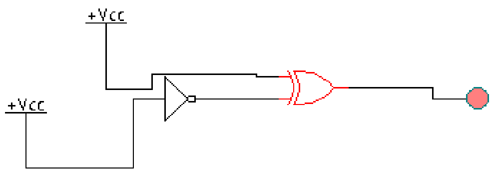
Hence these are the compound logic gates for electronics circuit. Proposed compound logigates are used all the symbol of logic gates same as de-Morgan law. From these logic gates it can be observed that this research is a good achievement in electronic field, and it is also used in further research purpose. In below segment, we have produced the results of proposed Compound logic gates.

3. Results and Discussions

Logic gates operations are used to connect a compound statement and this process is called as logigates operations. There are six major logic gates operations performed, which is based on respective symbols, such as Not Gate, AND Gate, OR Gate, Exclusive OR Gate, conditional OR Gate and Exclusive OR Not Gate. In this section, we have produced the results of proposed compound logic gates with the help logigates operations. The results created by a truth table for better understanding to check the proposed logic gates for electronics circuit. Let us perform one by one all the compound logic gates with their logic gates operation, such as

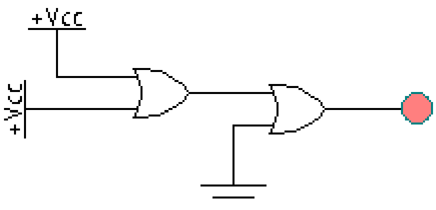
i. $B \oplus \bar{B}$

B	$\bar{B}$	$B \oplus \bar{B}$
1	0	1
0	1	1



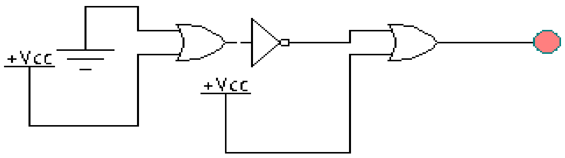
ii. $A + (A \rightarrow B)$

A	B	$A \rightarrow B$	$A + (A \rightarrow B)$
1	1	1	1
1	0	0	1
0	1	1	1
0	0	1	1



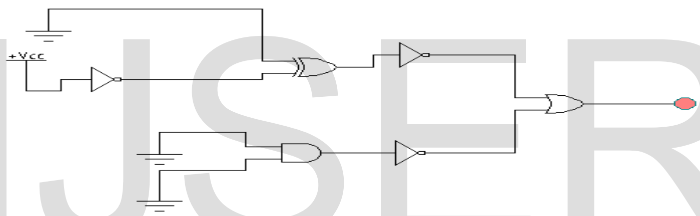
iii. $A + (\bar{B} + B)$

A	B	$\neg B$	$(\bar{B} + B)$	$A + (\bar{B} + B)$
1	1	0	1	1
1	0	1	1	1
0	1	0	1	1
0	0	1	1	1



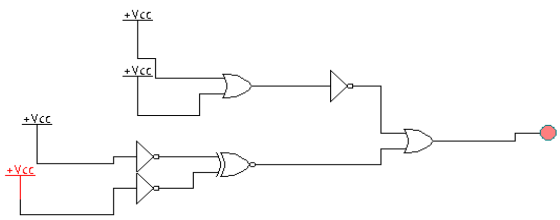
iv. $(\overline{A \oplus \bar{B}}).(\overline{A + B})$

A	B	$\neg B$	$A \oplus \bar{B}$	$\overline{A \oplus \bar{B}}$	$A + B$	$(\overline{A + B})$	$(\overline{A \oplus \bar{B}}).(\overline{A + B})$
1	1	0	0	1	1	0	1
1	0	1	1	0	0	1	1
0	1	0	1	0	0	1	1
0	0	1	0	1	0	1	1



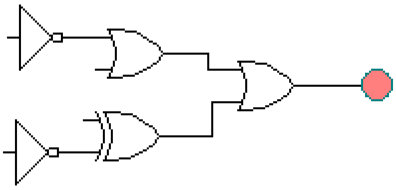
v. $(\overline{A + B}) \rightarrow \left(\overline{\bar{A} \oplus \bar{B}}\right)$

A	B	$A + B$	$(\overline{A + B})$	$\bar{A}$	$\bar{B}$	$\bar{A} \overline{\oplus} \bar{B}$	$(\overline{A + B}) \rightarrow \left(\overline{\bar{A} \oplus \bar{B}}\right)$
1	1	1	0	0	0	1	1
1	0	1	0	0	1	0	1
0	1	1	0	1	0	0	1
0	0	0	1	1	1	1	1



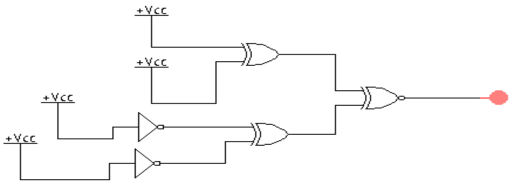
vi. $(\bar{A} \rightarrow B) + (B \oplus \bar{B})$

A	B	$\bar{A}$	$\bar{B}$	$\bar{A} \rightarrow B$	$B \oplus \bar{B}$	$(\bar{A} \rightarrow B) + (B \oplus \bar{B})$
1	1	0	0	1	1	1
1	0	0	1	1	1	1
0	*1*	1	0	1	1	1
0	0	1	1	0	1	1



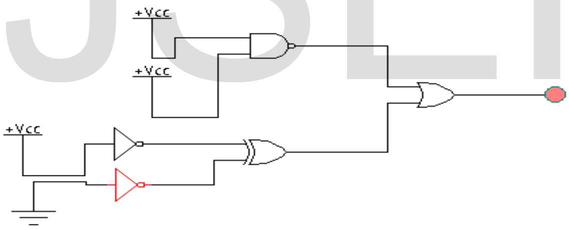
vii. $(A \oplus B)\ \overline{\oplus}\ (\bar{A} \oplus \bar{B})$

A	B	$A \oplus B$	$\bar{A}$	$\bar{B}$	$\bar{A} \oplus \bar{B}$	$(A \oplus B)\ \overline{\oplus}\ (\bar{A} \oplus \bar{B})$
1	1	0	0	0	0	1
1	0	1	0	1	1	1
0	1	1	1	0	1	1
0	0	0	1	1	0	1



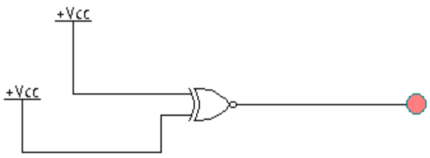
viii. $(\overline{A\&B}) + (\bar{A} \oplus \bar{B})$

A	B	$\bar{A}$	$\bar{B}$	$A\&B$	$\overline{A\&B}$	$\bar{A} \oplus \bar{B}$	$(\overline{A\&B}) + (\bar{A} \oplus \bar{B})$
1	1	0	0	1	0	0	0
1	0	0	1	0	1	1	1
0	1	1	0	0	1	1	1
0	0	1	1	0	1	0	1



ix. $A\ \overline{\oplus}\ B \equiv \bar{A}\ \overline{\oplus}\ \bar{B}$

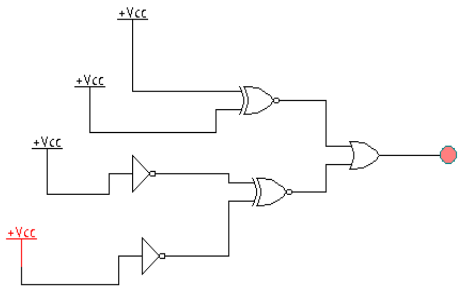
A	B	$\bar{A}$	$\bar{B}$	$A\ \overline{\oplus}\ B$	$\bar{A}\ \overline{\oplus}\ \bar{B}$
1	1	0	0	1	1
1	0	0	1	0	0
0	1	1	0	0	0
0	0	1	1	1	1



x. $(A\overline{\oplus}B)+(\bar{A}\ \overline{\oplus}\ \bar{B})$

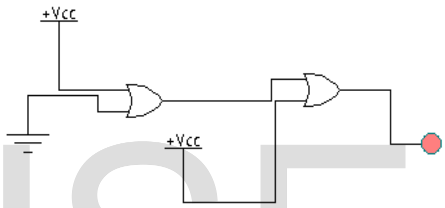
A	B	$\bar{A}$	$\bar{B}$	$A\overline{\oplus}B$	$\bar{A}\ \overline{\oplus}\ \bar{B}$	$(A\overline{\oplus}B)+(\bar{A}\ \overline{\oplus}\ \bar{B})$
1	1	0	0	1	0	1
1	0	0	1	0	1	1
0	1	1	0	0	1	1

0	0	1	1	1	0	1



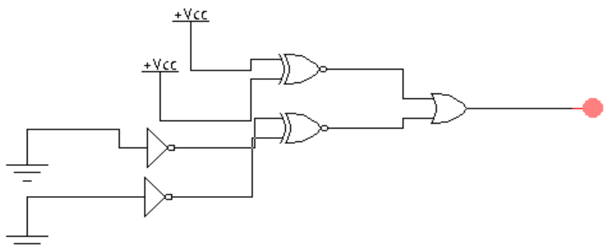
xi. $A + (\bar{B} + B)$

A	B	$\bar{B}$	$\bar{B} + B$	$A + (\bar{B} + B)$
1	1	0	1	1
1	0	1	1	1
0	1	0	1	1
0	0	1	1	1



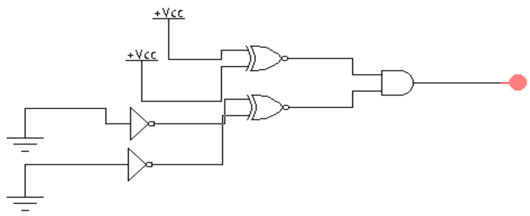
xii. $(A \overline{\oplus} B) + (\bar{A} \overline{\oplus} \bar{B})$

A	B	$\bar{A}$	$\bar{B}$	$(A \leftrightarrow B)$	$(A \overline{\oplus} B)$	$(A \overline{\oplus} B) + (\bar{A} \overline{\oplus} \bar{B})$
1	1	0	0	1	0	1
1	0	0	1	0	1	1
0	1	1	0	0	1	1
0	0	1	1	1	0	1



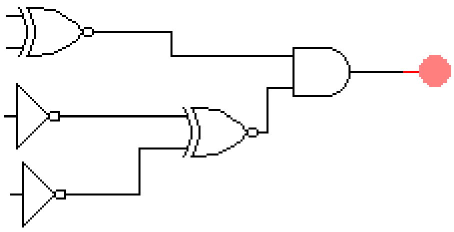
xiii. $(A \overline{\oplus} B).(\bar{A} \oplus \bar{B})$

A	B	$\bar{A}$	$\bar{B}$	$A \overline{\oplus} B$	$\bar{A} \oplus \bar{B}$	$(A \overline{\oplus} B).(\bar{A} \oplus \bar{B})$
1	1	0	0	1	0	0
1	0	0	1	0	1	0
0	1	1	0	0	1	0
0	0	1	1	1	1	1



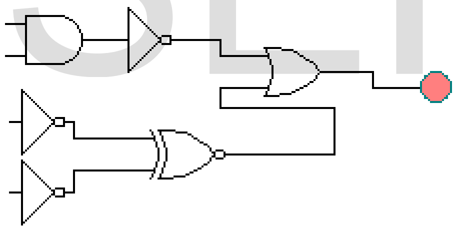
xiv. $(\bar{A} \overline{\oplus} \bar{B}) + (\bar{A} \rightarrow B)$

A	$\bar{A}$	B	$\bar{B}$	$(\bar{A} \overline{\oplus} \bar{B})$	$\bar{A} \rightarrow B$	$(\bar{A} \overline{\oplus} \bar{B}) + (\bar{A} \rightarrow B)$
1	0	1	0	1	1	1
1	0	0	1	0	1	1
0	1	1	0	0	1	1
0	1	0	1	1	0	1



xv. $(\overline{A + B}) \rightarrow (\bar{A} \overline{\oplus} \bar{B})$

A	B	$\bar{A}$	$\bar{B}$	$\overline{A + B}$	$\bar{A} \overline{\oplus} \bar{B}$	$(\overline{A + B}) \rightarrow (\bar{A} \overline{\oplus} \bar{B})$
1	1	0	0	0	1	1
1	0	0	1	0	0	1
0	1	1	0	0	0	1
0	0	1	1	1	1	1



From the results which shows in truth table it has been clarified that the proposed compound logic gates are useful and very important for Digital logics Design. Throughout the results and discussions, it can be detected that the compound logic gates are decent attainment for logical circuit, and it is good for further research purpose in Digital logics Design.

4. Conclusion

This article a compound logic gates have been proposed for Digital logics Design in the field of electronic. This idea of research comes from a De-Morgan law and discrete mathematics. This research has been discussed some useful topics — i.e. Not Gate, AND Gate, OR Gate, Exclusive OR Gate, conditional statement and Exclusive OR Not Gate. The results and discussions appear to show the support of compound logic gates and warrant further research in the area of Digital logics Design. From truth tables of logic gates is justify the validity of proposed logic gates. Throughout the article it can be observed that the compound logic gates are good achievement for Digital logics Design in the field of electronic.

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