Trinity College Dublin
Coláiste na Tríonóide, Baile Átha Cliath
The University of Dublin

3C2 DIGITAL CIRCUITS ASSIGNMENT

The Transistor level circuit to implement computing functions.

(Multisim Report submission)

Assignment:

A. **Bounded Natural Number Addition Circuit**
B. **An Integer Comparison Circuit**
C. **Natural Number Comparator Circuit**

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Abstract

In this report, I worked on three functions F1, F2 and F3. To perform these functions, I have designed three different circuits which contains gates. Somewhere to perform the logical operations I used BC547A transistors. In these function transistors are performing AND, OR etc operations. To perform the operations, I also used two switches. Our purpose to make these circuits is to perform summation and comparison functions. While on or off the switches different probes glow to represent the different function. Different lights are specific to represent that A>B, A<B and A=B. Values of A and B depends upon the value of voltage across resistors. In our case both A and B have the same value of resistance therefore there is same value of voltage for A and B. We only operate our function by on or off the switches. This can be used to detect the current in a different specific circuit. It can be utilized to add two or more different values. Furthermore, these designs can be used for comparison purpose of different values.

Background Knowledge

These circuits contain BC547A transistor. Which is a Bipolar junction transistor and it is a kind of NPN transistor. BC547 has two operation properties forward bias and reverse bias. In the forward bias, the current can pass when the collector and emitter are connected in the circuit. While in the reverse bias, it acts as a disconnect switch and current cannot pass through it.

We also used 7408N which is actually perform the function of AND Gate. Truth table for the AND Gate is given as

INPUT		OUTPUT
A	B	F
0	0	0
0	1	0
1	0	0
1	1	1

We also used the 7402N which performs the function of NOR Gate. Truth Table of the NOR gate is given as

INPUT		OUTPUT
A	B	F
0	0	1
0	1	0
1	0	0
1	1	0

FUNCTION NO. 01

$$F_1(A,B) = A + B \mod N$$

According to this equation, in our circuit when both switches or one of them is on then Probe will glow otherwise it will remain off.

1.Simulation

This Circuit involve four BC547A Transistors energized by 12V DC Power Supply. Switches S1 and S2 are applied to perform the function F1.

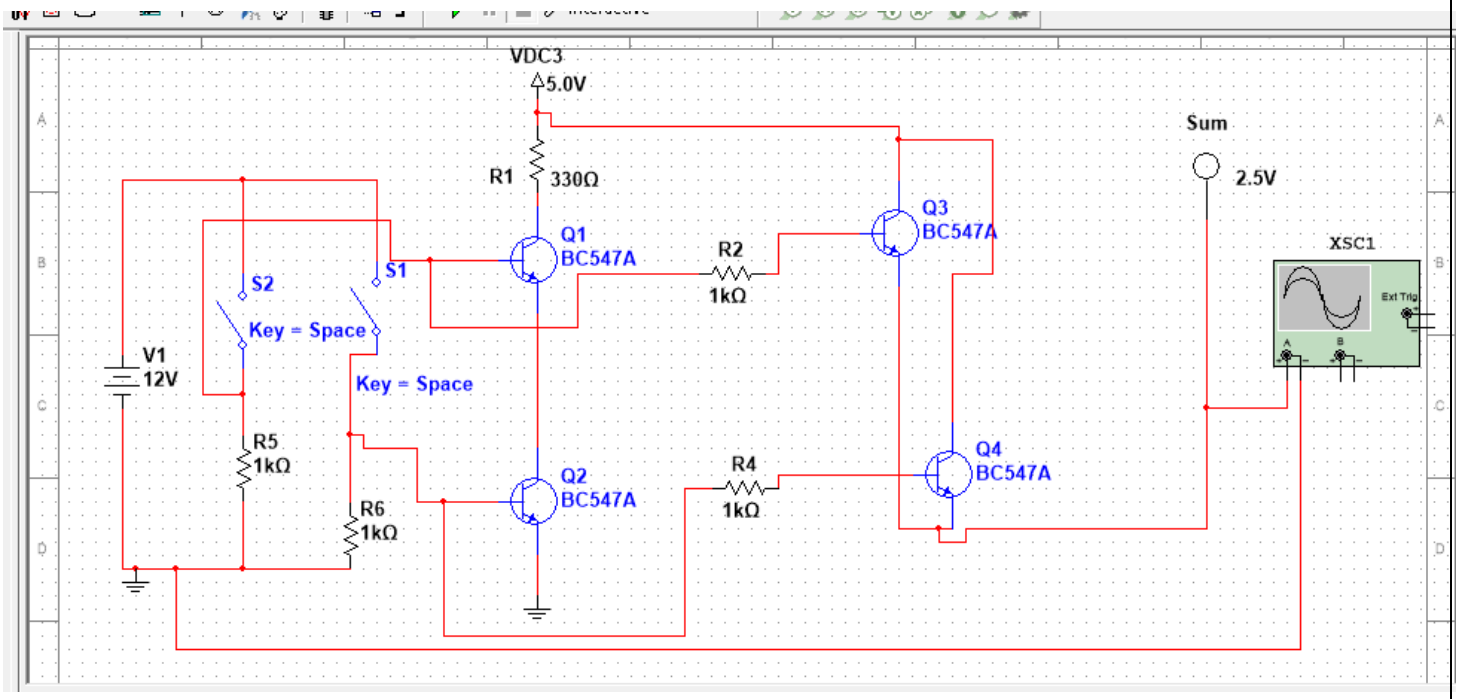


Fig 1.1 Function no. 01 Circuit

There are some Electrical Properties of the Transistor BC547A.

Symbol	Parameter		Conditions	Min.	Typ.	Max.	Unit
I_{CBO}	Collector Cut-Off Current		V_{CB} = 30 V, I_E = 0			15	nA
h_{FE}	DC Current Gain		V_{CE} = 5 V, I_C = 2 mA	110		800	
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage		I_C = 10 mA, I_B = 0.5 mA		90	250	mV
			I_C = 100 mA, I_B = 5 mA		250	600	
$V_{BE(sat)}$	Collector-Base Saturation Voltage		I_C = 10 mA, I_B = 0.5 mA		700		mV
			I_C = 100 mA, I_B = 5 mA		900		
$V_{BE(on)}$	Base-Emitter On Voltage		V_{CE} = 5 V, I_C = 2 mA	580	660	700	mV
			V_{CE} = 5 V, I_C = 10 mA			720	
f_T	Current Gain Bandwidth Product		V_{CE} = 5 V, I_C = 10 mA, f = 100 MHz		300		MHz
C_{ob}	Output Capacitance		V_{CB} = 10 V, I_E = 0, f = 1 MHz		3.5	6.0	pF
C_{ib}	Input Capacitance		V_{EB} = 0.5 V, I_C = 0, f = 1 MHz		9		pF
NF	Noise Figure	BC546 / BC547 / BC548 V	CE = 5 V, I_C = 200 µA, f = 1 kHz, R_G = 2 kΩ		2 1	0	dB
		BC549 / BC550			1.2	4.0	
		BC549	V_{CE} = 5 V, I_C = 200 µA, R_G = 2 kΩ, f = 30 to 15000 MHz		1.4	4.0	
		BC550			1.4	3.0	

2. Graph

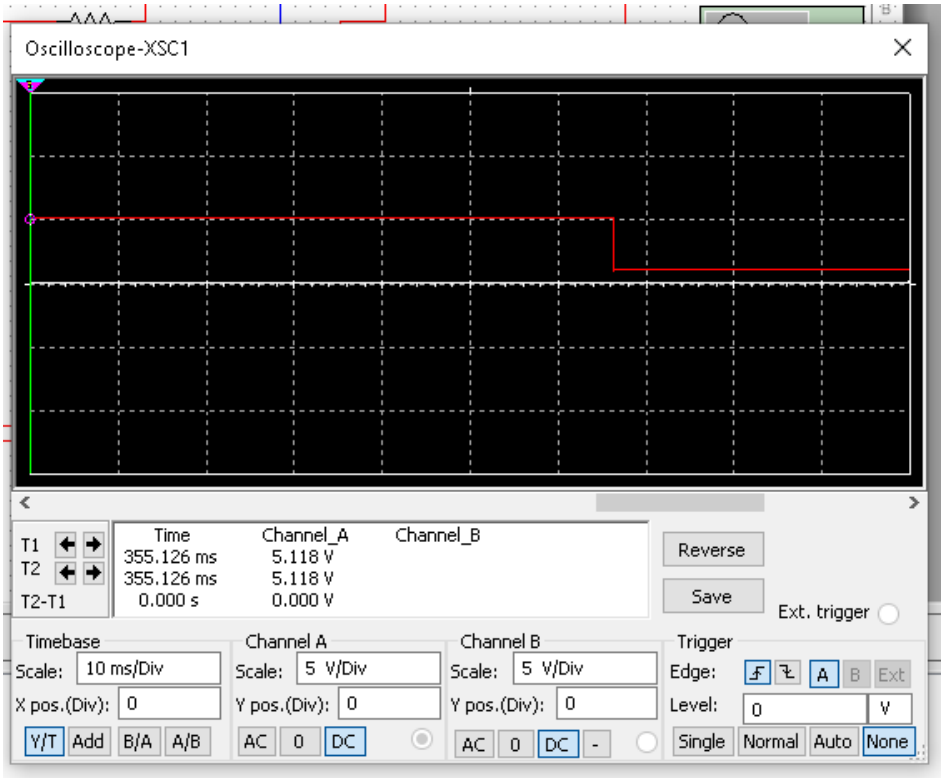


Fig 1.2 Graph of Function no. 01 Circuit

The Graph has taken from the output of the circuit through Channel A. Channel is set for 5V/Div scale range.

3. Explanation

In this circuit we get the value of function elements A and B natural numbers by voltage across the resistors R5 and R6. Then through the transistors installed we perform the function of summation. When both switches are on and one of them is on then probe will glow otherwise it will not glow and show that there is no summation is performing. It's A or B value can be altered by changing the voltage across resistance and this can be done by changing the value of the resistance. It's A or B value can be altered by changing the voltage across resistance and this can be done by changing the value of the resistance. Input and Output voltages can be interrupted by changing the value of the resistances.

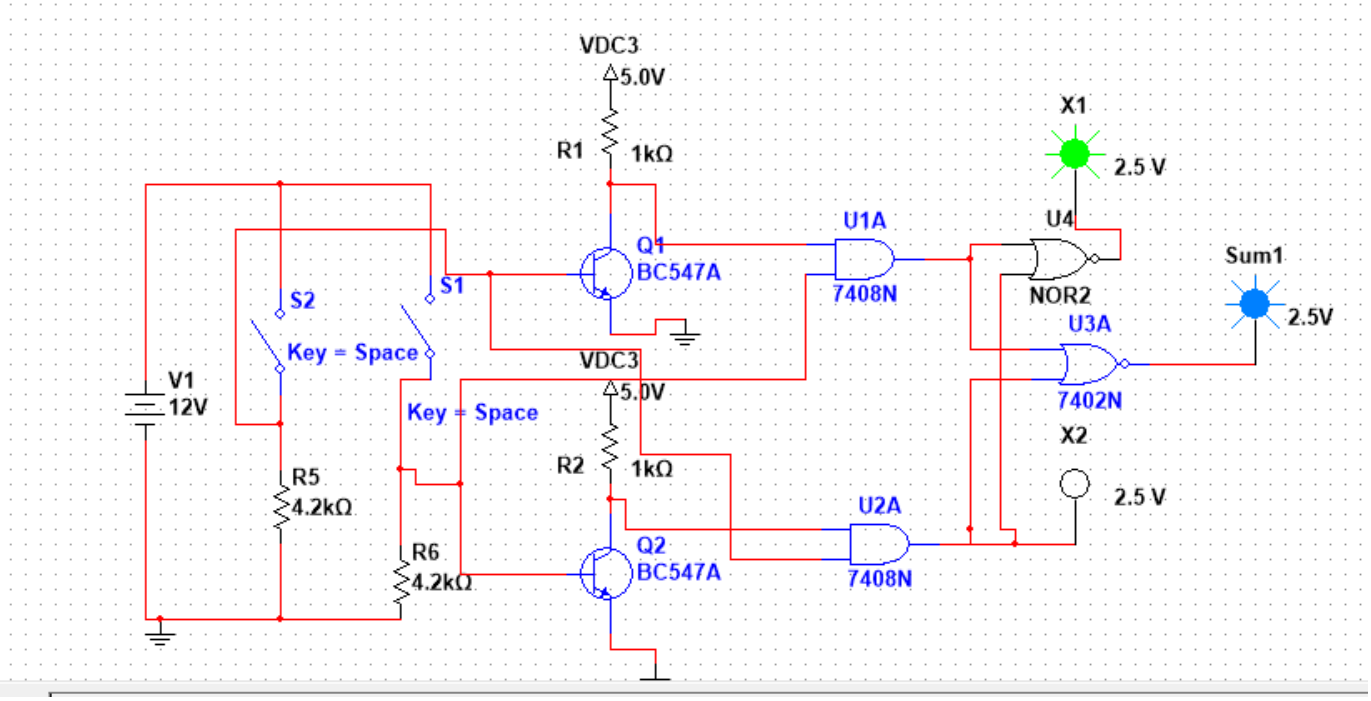
Different voltages can be applied to the circuit for example 9V, 10V and 12V DC. As for BC547 it is designed upto the level of 300mA collector current and its maximum input voltage is 65DC. It require from power off to power on time is almost 10 and onward.

FUNCTION NO 02

$$F_2(A,B) = \begin{cases} \top, & A > B \\ \bot, & A \leq B \end{cases}$$

1. Simulation Circuit Diagram

Its circuit contain two BC547 Transistors, two 7408N Gates, one NOR Gate and one 7402N gate. Transistors are powered up by 5.0 V DC Supply. This Circuit is designed for the function of Comparison of Natural numbers. Natural numbers are gained by the voltage across the resistors R5 and R6.



2.1 Function no. 02 Circuit

Different Gates and their function are given as:

Gate	Function
7408N	And Operation
7402N	NOR Operation
U4	NOR Operation

2. Graph

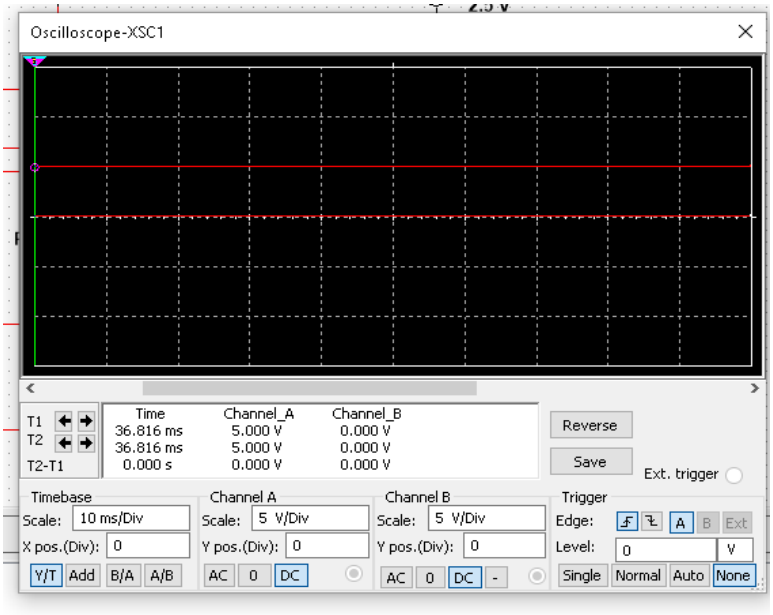


Fig 2.2 Graph of Function no. 02 Circuit

This graph is for the outputs of the NOR and AND Gate.

3. Explanation

BC547 installed in the circuit perform the function of NOT Gate. We have two NOT gate in the circuit. Inputs A and B in injected to the Circuit by switches installed and it get the values of A and B through the voltage across the resistors. Then 7408N Gate perform the function of AND gate. When any one or both of the input get 1 input then it gives signal 1 towards the output and probe glows and show that in this Case A≤B. Then 7402N performs the function of NOR it will only glow when both switches are on or off (mean A=B). U1 also perform the function of NOR Gate and it will only give output 1 when both inputs are zero. It's A or B value can be altered by changing the voltage across resistance and this can be done by changing the value of the resistance. Input and Output voltages can be interrupted by changing the value of the resistances.

Different voltages can be applied to the circuit for example 9V, 10V and 12V DC. As for BC547 it is designed upto the level of 300mA collector current and its maximum input voltage is 65DC. It requires from power off to power on time is almost 10 and onward.

Function no 03

$$F_3(A,B) = \begin{cases} -1, & A < B \\ 0, & A = B \\ 1, & A > B \end{cases}$$

1. Simulation

Its circuit contain 2 BC547A Transistors, two 7408N Gates, one 7402N Gate and 12V battery. 7408N performs the function of AND Gate while 7402N performs the function of NOR Gate.

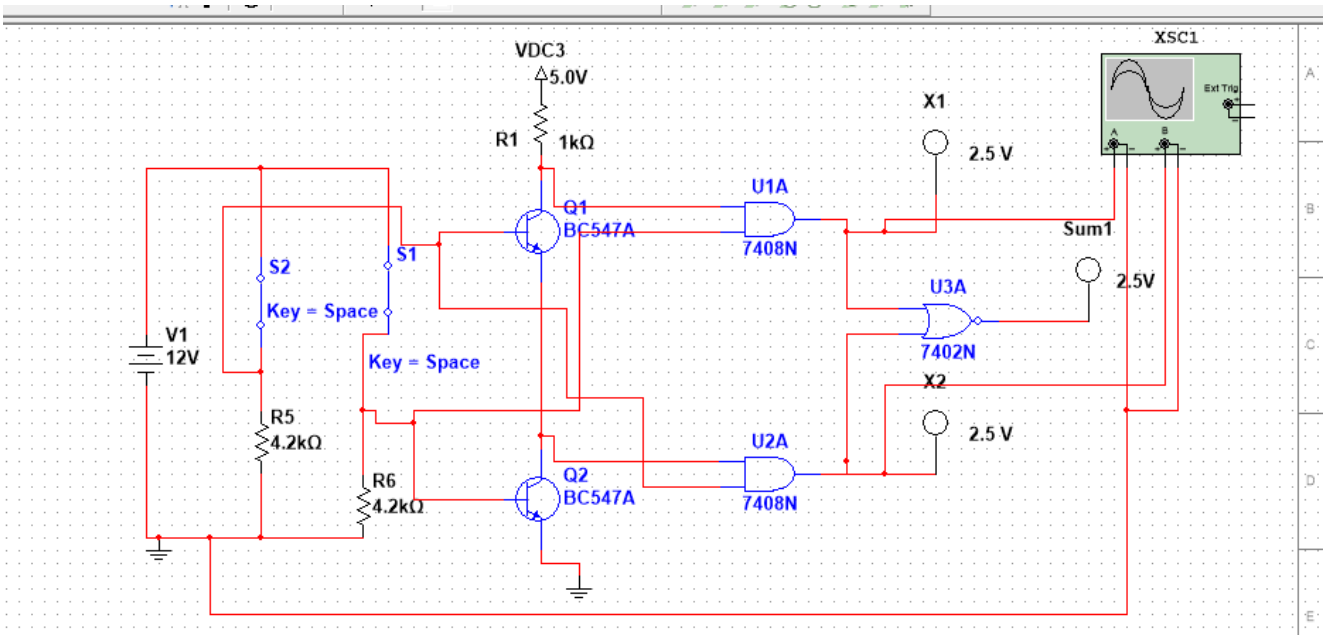


Fig 3.1 Function no. 03 Circuit

Different Gates and their function are given as:

Gate	Function
7408N	And Operation
7402N	NOR Operation

2. Graph

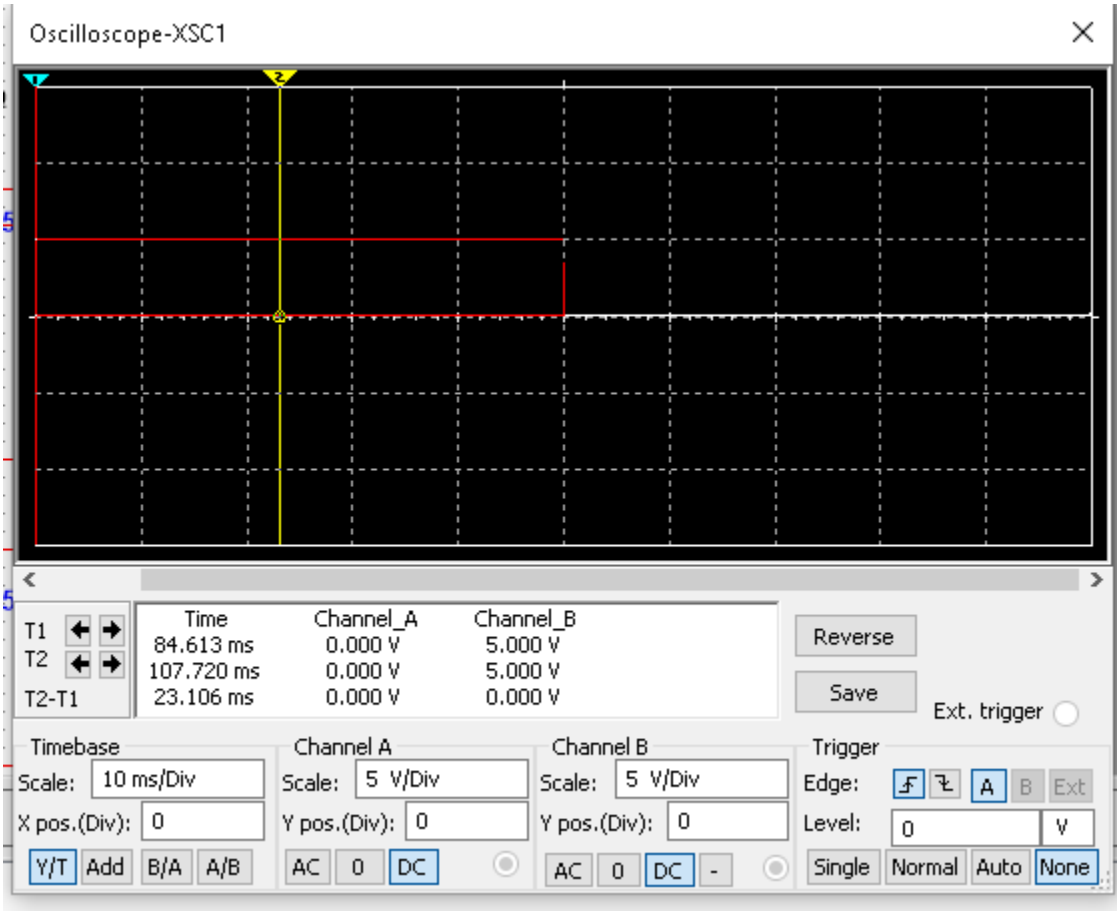


Fig 3.2Graph of Function no. 03 Circuit

3. Explanation

BC547 installed in the circuit perform the function of NOT Gate. We have two NOT gate in the circuit. Inputs A and B in injected to the Circuit by switches installed and it get the values of A and B through the voltage across the resistors. Then 7408N Gate perform the function of AND gate. When any one or both of the input get 1 input then it gives signal 1 towards the output and probe glows and show that in this Case A<B or A>B. Then 7402N performs the function of NOT it will only glow when both switches are on or off (mean A=B). It's A or B value can be altered by changing the voltage across resistance and this can be done by changing the value of the resistance. It's A or B value can be altered by changing the voltage across resistance and this can be done by changing the value of the resistance. Input and Output voltages can be interrupted by changing the value of the resistances.

Different voltages can be applied to the circuit for example 9V, 10V and 12V DC. As for BC547 it is designed upto the level of 300mA collector current and its maximum input voltage is 65DC. It require from power off to power on time is almost 10 and onward.

Material List:

Component	Quantity
Transistor (BC547)	08
12V DC Supply	03
Resistors 1 Ohm	07
Resistors	04
7408N Gate	04
7402N Gate	03
Switches	06

Conclusion:

All designs performing two different function one is summation and second is comparison. We utilized each probe to represent the specific condition for example A>B, A<B and A=B at different values of the function. All the circuits depend upon the value of A and B which can be a natural number or integer depends upon the condition. This circuit can be used to check that two different values are adding or not. It can be utilized for comparison between two quantities. It is easy to use but it can only give signs by glowing li8 or by switching off the light. It cannot give a specific value in the forms of digits.