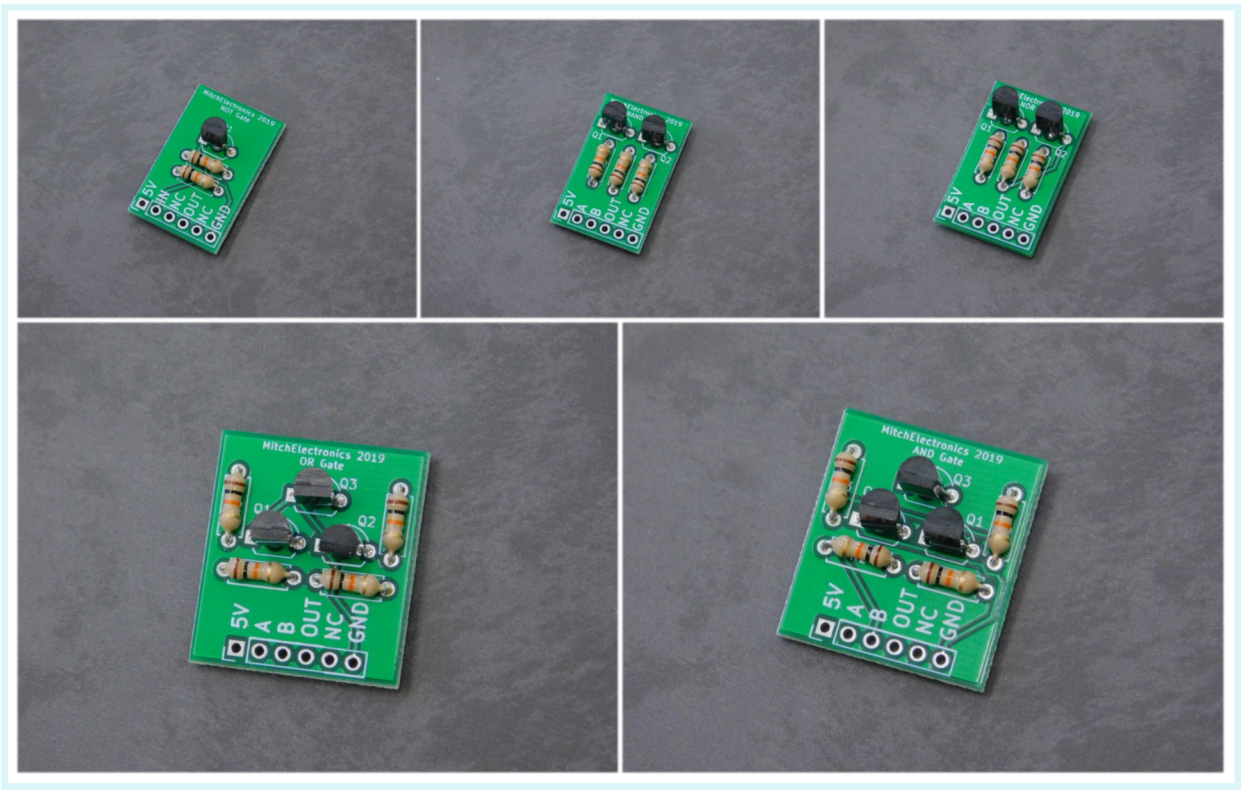
RTL Gate Range

MitchElectronics 2019



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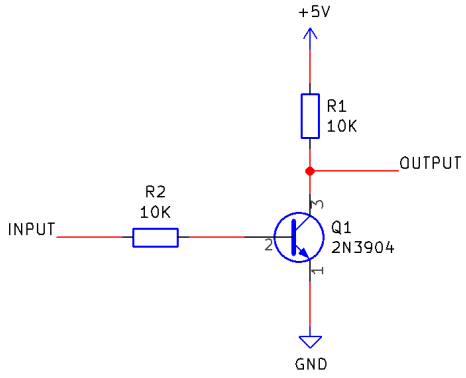
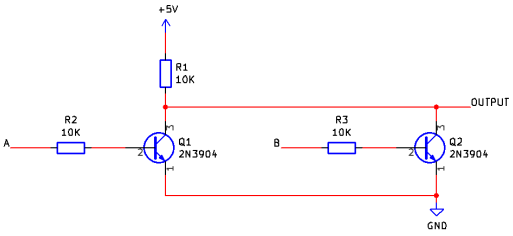
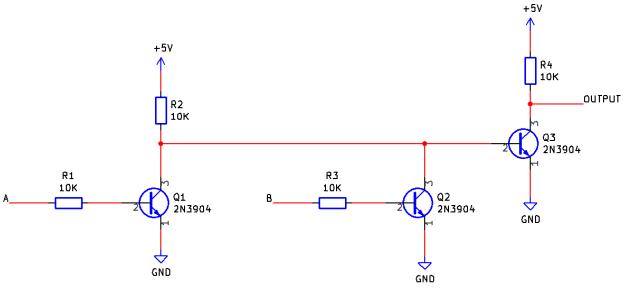


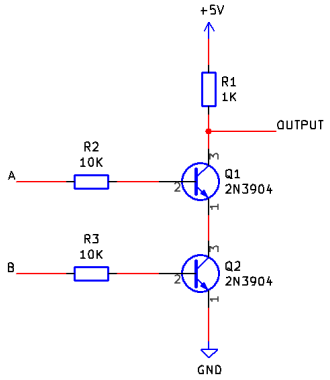
NOT Gate



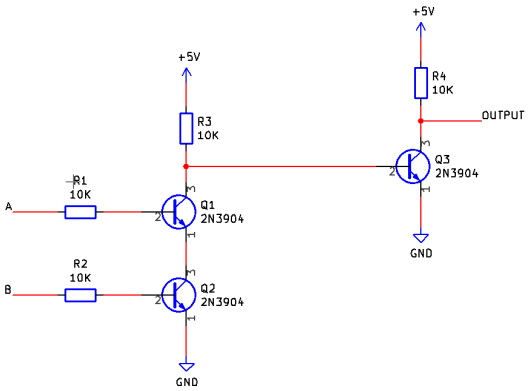
NOR Gate



OR Gate



NAND Gate



AND Gate

Supply voltage shown as 5V but RTL gates can operate on voltages as low as 1V and as high as 12V

SCHEMATIC EXPLANATION

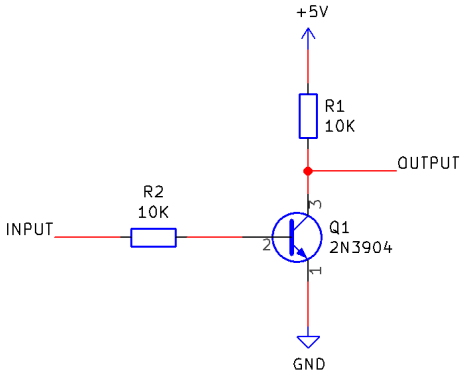
Digital electronics are what allows modern life to function as it does; online banking, the Internet, computer games, simulations, and much more are all possible thanks to digital circuits. Digital systems are made up of individual logic blocks called logic gates and it is these gates that process binary data but how do these gates function?

Before we learn about how RTL gates work it is required that the following is understood before hand

- Logic gates (NAND, NOR, NOT, AND, and OR)
- Simple transistor operation
- Basic level of circuit understanding

Logic gates can be constructed using many different technologies with one of the most famous ones being called CMOS which stands for Complementary Metal Oxide Semiconductor. However, while this technology is employed in almost all electronic circuits it was not always the popular choice. Back in the 80s, TTL (Transistor-Transistor logic) was the popular choice for logic components but again this too was not the only option available for logic gates. During the days of the Apollo moon missions there existed a logic family called RTL which stands for Resistor-Transistor Logic and as the name suggests logic gates built using this method rely on resistors and transistors for enabling their logic function.

The RTL NOT Gate



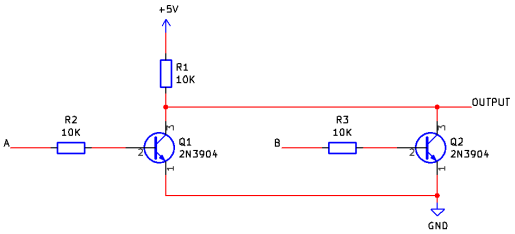
Input	Output
1 (VDD)	0 (GND)
0 (GND)	1 (VDD)

Supply voltage shown as 5V but RTL gates can operate on voltages as low as 1V and as high as 12V

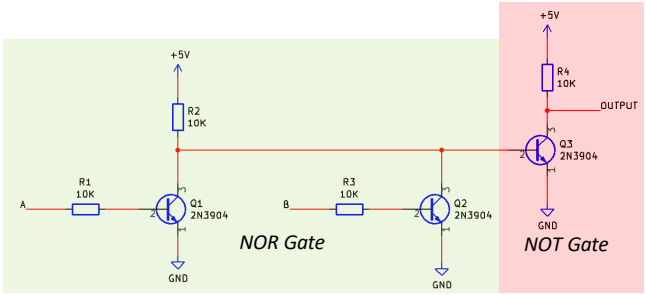
The RTL NOT Gate is the simplest RTL logic gate and consists of only two resistors and a transistor. When the input is off (Input = 0V) the transistor Q1 is turned off and therefore cannot conduct any current. This means that the output is connected to 5V via the 10K resistor and therefore the output is on (5V). When the input is on (Input = V_{Supply}) the transistor Q1 fully turns on and therefore connects the output to ground through the transistor. Therefore, the output switches to 0V and therefore the NOT Gate function is realised.

SCHEMATIC EXPLANATION

The RTL NOR / OR Gate



NOR Gate



OR Gate

Supply voltage shown as 5V but RTL gates can operate on voltages as low as 1V and as high as 12V

NOR gate truth table

Input (A)	Input (B)	Output
0 (GND)	0 (GND)	1 (VDD)
0 (GND)	1 (VDD)	0 (GND)
1 (VDD)	0 (GND)	0 (GND)
1 (VDD)	1 (VDD)	0 (GND)

OR gate truth table

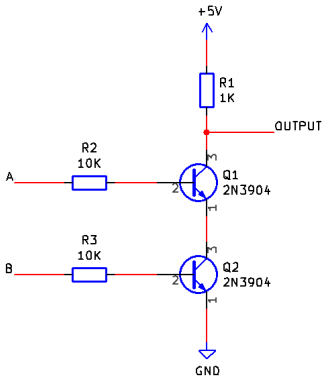
Input (A)	Input (B)	Output
0 (GND)	0 (GND)	0 (GND)
0 (GND)	1 (VDD)	1 (VDD)
1 (VDD)	0 (GND)	1 (VDD)
1 (VDD)	1 (VDD)	1 (VDD)

The RTL NOR Gate is made up of two transistors whose collectors are connected in parallel. When both inputs are off (0V) both transistors are switched off which means the output is connected to 5V through the resistor R1. If either input is on (A or B) then the associated transistor is switched on and this connects the output to ground through that transistor therefore the output switches off (0V). The same occurs if both inputs are on as both transistors are conducting.

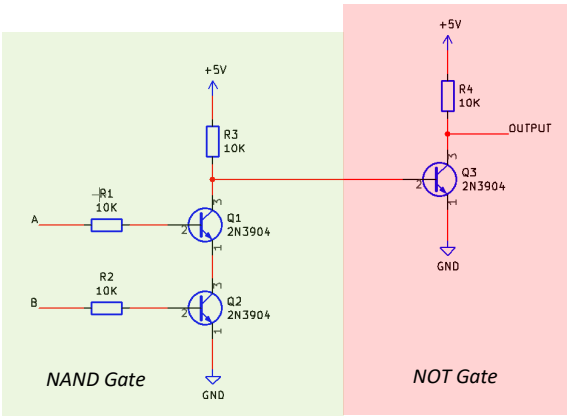
The RTL OR Gate is an RTL NOT gate with a NOT gate attached to the output. The NOT gate inverts the output of the NOR gate to realise the OR function whereby the output is on if either or both inputs are on (remember, the NOR gate is the opposite to an OR gate).

SCHEMATIC EXPLANATION

The RTL NAND / AND Gate



NAND Gate



AND Gate

Supply voltage shown as 5V but RTL gates can operate on voltages as low as 1V and as high as 12V

NAND gate truth table

Input (A)	Input (B)	Output
0 (GND)	0 (GND)	1 (VDD)
0 (GND)	1 (VDD)	1 (VDD)
1 (VDD)	0 (GND)	1 (VDD)
1 (VDD)	1 (VDD)	0 (GND)

AND gate truth table

Input (A)	Input (B)	Output
0 (GND)	0 (GND)	1 (VDD)
0 (GND)	1 (VDD)	0 (GND)
1 (VDD)	0 (GND)	0 (GND)
1 (VDD)	1 (VDD)	0 (GND)

The RTL NAND Gate is made up of two transistors whose are connected in series. When both inputs are off (0V) both transistors are switched off which means the output is connected to 5V through the resistor R1. If either input is on (A or B) then the associated transistor is switched on but since only one of the transistors are on the output is still not connected to 0V. If both inputs are on then both transistors conduct and this causes the output to be connected to 0V and therefore switch the output off.

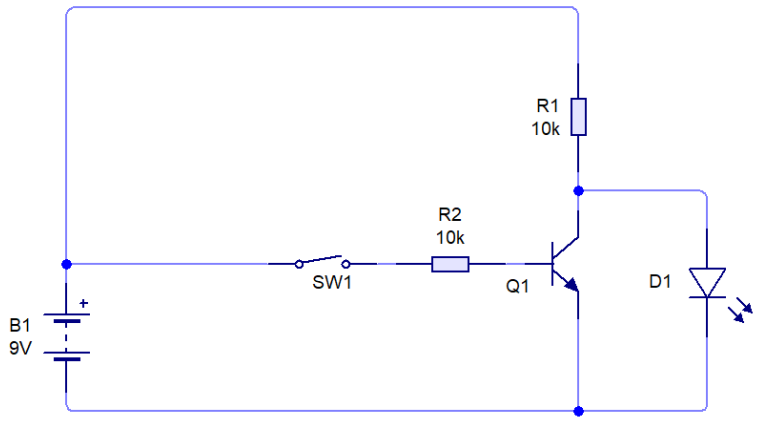
The RTL AND Gate is an RTL NAND gate with a NOT gate attached to the output. The NOT gate inverts the output of the NAND gate to realise the AND function whereby the output is on if both inputs are on (remember, the NAND gate is the opposite to an AND gate).

SCHEMATIC EXPLANATION

Using the gates

The RTL gates do not come with header pins or wires as they are designed to be as customisable as possible. You may choose to insert straight header connectors for inserting into a breadboard flat or use 90 -degree pins for inserting into a matrix board. Sockets could be used for easily inserting wires into the gates while wires could be directly soldered for use as single logic gates.

Testing the gates for educational purposes can be easily done with the use of small tactile switches, and LEDs. One of the advantages of RTL is that the output has a series resistor with power which allows for directly connecting LEDs to the output for indication but remember that an LED being a diode may prevent any other gates from operating correctly who are also connected to that same output. The circuit wizard example below shows how to use the RTL NOT gate with a switch and LED. Note that super bright LEDs are required for a direct connection due to the use of the 10K pull-up resistor on the RTL outputs. If low power LEDs are to be used then consider changing the 10K resistors to 1K resistor.



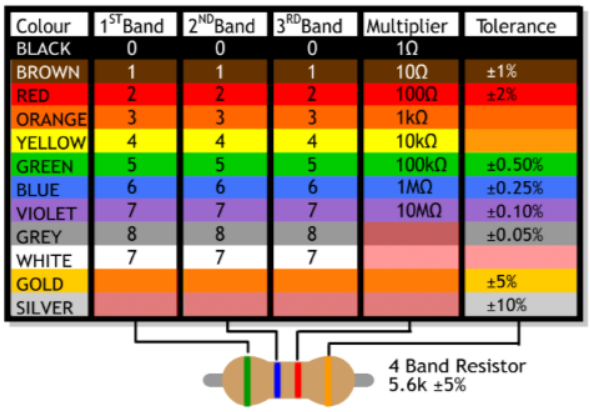
The fan-out of RTL depends on resistor values and transistor characteristics but practically you can expect to drive up to 5 other RTL inputs from a single RTL output.

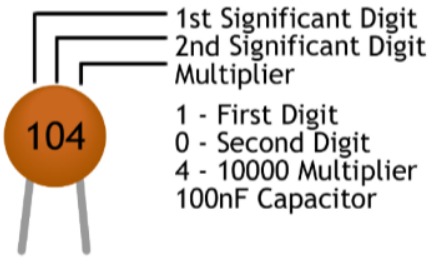
MATERIALS

Check that you have the following components

Component	Component Name	Quantity	Looks like
2N3904 BJT	All transistors (Q)	-	
10KΩ Resistor	All resistors (R)	-	
PCB	-	1	

RESISTOR AND CAPACITOR IDENTIFICATION





CONSTRUCTION

Download the electronics construction manual

To learn how to construct circuits on PCBs download the Electronics Construction Manual from Mitch-Electronics using the link below. This document shows you how to install all electronic components used in MitchElectronics kits. The list below shows the sections relevant to this kit so do not worry if you see component sections in the document that don't come with this kit!

www.mitchelectronics.co.uk/electronicsConstructionManual.pdf

Relevant sections in the electronics construction manual

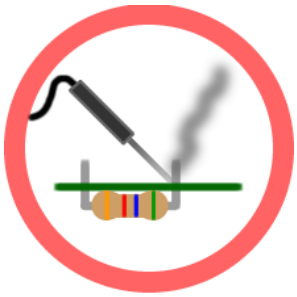
Resistors

Transistors

IMPORTANT INFORMATION

RoHS Compliant Kit (Lead free)

Low Voltage Kit



Caution! Soldering Required