

How To Use a Breadboard

Digital Electronics Laboratory Task Force

Abstract

This application note introduces breadboards and gives a guide on its usage. Do not share this document outside UTM as it may contain copyrighted materials.

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1. Introduction

Breadboards are one of the most fundamental pieces when learning how to build circuits. These solderless breadboards do not require soldering and are reusable hundreds of times. In this tutorial, you will learn a little bit about what breadboards are, why they are called breadboards, and how to use one. Once you are done you should have a basic understanding of how breadboards work and be able to build a basic circuit on a breadboard.

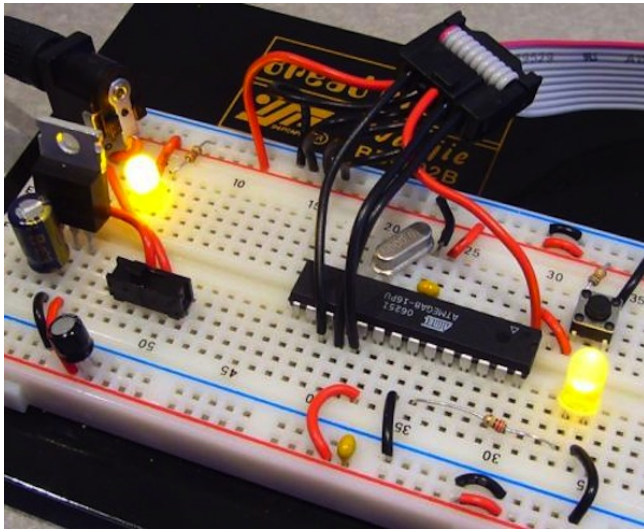


Figure 1. A circuit built on a solderless breadboard [1].

1.1 Why Is It Called Breadboard?

Okay, you might think, these plastic boards are boards, but where is the bread? In the early days of electronic engineering radio and electronic freaks used real bread boards (literally cutting boards for bread) to prototype their circuits.

Many years ago, when electronics were big and bulky, people would grab their mom's breadboard, a few nails or thumbtacks, and start connecting wires onto the board to give themselves a platform on which to build their circuits.

Since then, electronic components have gotten a lot smaller, and we've come up with better ways to connect circuits, making moms all over the world happy to have their breadboards back. However, we are stuck with the

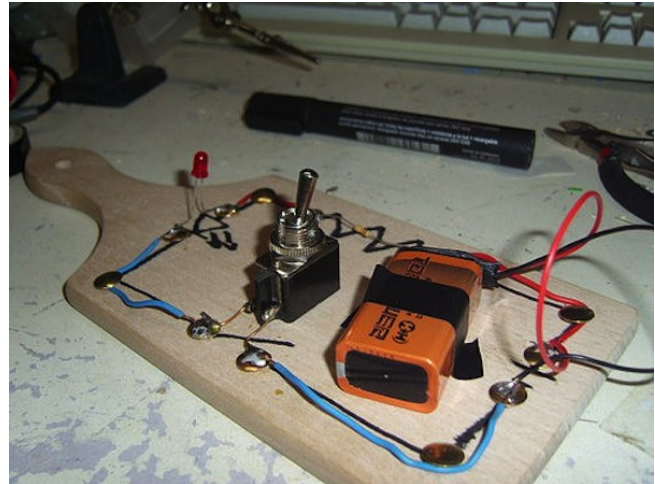


Figure 2. Circuit on an "original" breadboard (image courtesy of mischka [2])

confusing name. Technically, these are still breadboards, but this discussion is going to be on modern, "solderless" breadboards.

2. Why Use Breadboards?

A breadboard is a solderless device for temporary prototype with electronics and test circuit designs. Most electronic components in electronic circuits can be interconnected by inserting their leads or terminals into the holes and then making connections through wires where appropriate. The breadboard has strips of metal underneath the board and connect the holes on the top of the board. The metal strips are laid out as shown below. Note that the top and bottom rows of holes are connected horizontally and split in the middle while the remaining holes are connected vertically.

An electronics breadboard (as opposed to the type on which sandwiches are made) is actually referring to a solderless breadboard. These are great units for making temporary circuits and prototyping, and they require absolutely no soldering.

Prototyping is the process of testing out an idea by creating a preliminary model from which other forms are developed or copied, and it is one of the most common uses for

breadboards. If you aren't sure how a circuit will react under a given set of parameters, it's best to build a prototype and test it out.

For those new to electronics and circuits, breadboards are often the best place to start. That is the real beauty of breadboards—they can house both the simplest circuit as well as very complex circuits. As you'll see later in this tutorial, if your circuit outgrows its current breadboard, others can be attached to accommodate circuits of all sizes and complexities.

Another common use of breadboards is testing out new parts, such as Integrated circuits (ICs). When you are trying to figure out how a part works and constantly rewiring things, you don't want to have to solder your connections each time.

As mentioned, you don't always want the circuit you build to be permanent. When trying to duplicate a customer's problem, SparkFun's Technical Support team will often use breadboards to build, test, and analyze the circuit. They can connect the parts the customer has, and once they've gotten the circuit setup and figured out the problem, they can take everything apart and put it aside for the next time they need to do some troubleshooting.

3. Anatomy of a Breadboard

The best way to explain how a breadboard works is to take it apart and see what's inside. Using a smaller breadboard it's easier to see just how they function.

3.1 Terminal Strips

Here we have a breadboard where the adhesive backing has been removed. You can see lots of horizontal rows of metal strips on the bottom of the breadboard.

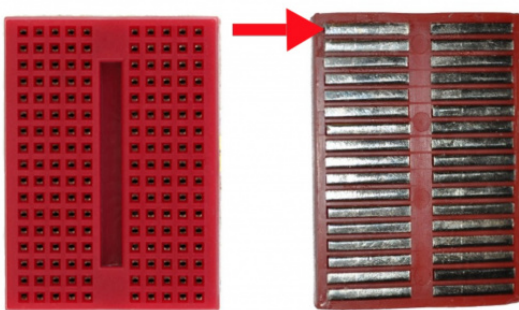


Figure 3. A SparkFun Mini Breadboard from the top (left) and the same breadboard flipped over with the adhesive back removed (right) [1].

The tops of the metal rows have little clips that hide under the plastic holes. These clips allow you to stick a wire or the leg of a component into the exposed holes on a breadboard, which then hold it in place.



Figure 4. A single strip of conductive metal removed from the above breadboard [1].

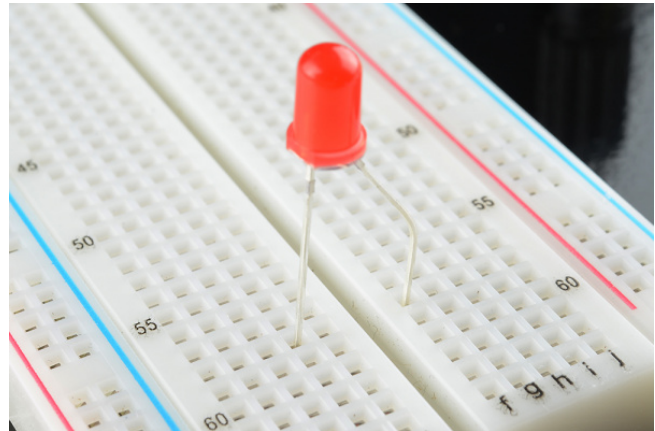


Figure 5. An LED inserted into a breadboard. Notice how each leg of the LED is placed on either side of the ravine. This prevents the connections to the LED from being shorted [1].

Once inserted that component will be electrically connected to anything else placed in that row. This is because the metal rows are conductive and allow current to flow from any point in that strip.

Notice that there are only five clips on this strip. This is typical on almost all breadboards. Thus, you can only have up to five components connected in one particular section of the breadboard. The row has ten holes, so why can you only connect five components? You'll also notice that each horizontal row is separated by a ravine, or crevasse, in the middle of the breadboard. This ravine isolates both sides of a given row from one another, and they are not electrically connected. We'll discuss the purpose of this in just a bit, but, for now, just know that each side of a given row is disconnected from the other, leaving you with five spots for components on either side.

3.2 Power Rails

Now that we've seen how the connections in a breadboard are made, let's look at a larger, more typical breadboard. Aside from horizontal rows, breadboards usually have what are called power rails that run vertically along the sides.

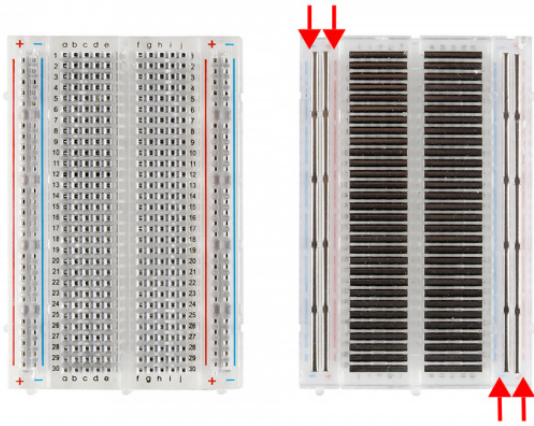


Figure 6. A medium-size breadboard with the adhesive back removed to expose the power rails [1].

These power rails are metal strips that are identical to the ones that run horizontally, except they are, typically*, all connected. When building a circuit, you tend to need power in lots of different places. The power rails give you lots of easy access to power wherever you need it in your circuit. Usually they will be labeled with a '+' and a '-' and have a red and blue or black stripe, to indicate the positive and negative side.

It is important to be aware that the power rails on either side are not connected, so if you want the same power source on both sides, you will need to connect the two sides with some jumper wires. Keep in mind that the markings are there just as a reference. There is no rule that says you have to plug power into the '+' rail and ground into the '-' rail, though it's good practice to keep everything in order.

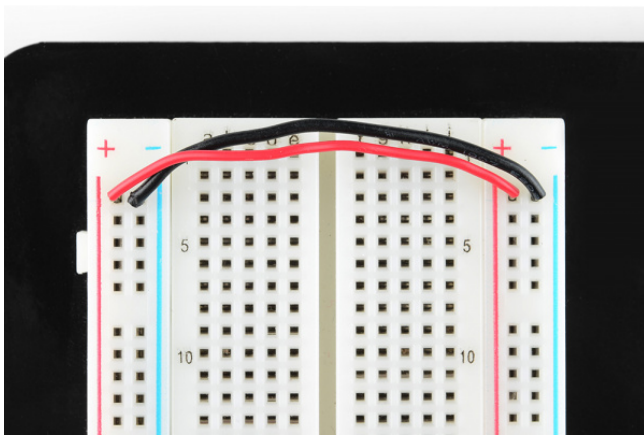


Figure 7. Two jumper wires used to connect the power rails on both sides. Always attach the '+' to '+' and the '-' to '-' [1].

3.3 DIP Support

Earlier we mentioned the ravine that isolates the two sides of a breadboard. This ravine serves a very important purpose. Many integrated circuits, often referred to as ICs or, simply, chips, are manufactured specifically to fit onto breadboards. In order to minimize the amount of space they take up on

the breadboard, they come in what is known as a Dual in-line Package, or DIP.

These DIP chips have legs that come out of both sides and fit perfectly over that ravine. Since each leg on the IC is unique, we don't want both sides to be connected to each other. That is where the separation in the middle of the board comes in handy. Thus, we can connect components to each side of the IC without interfering with the functionality of the leg on the opposite side.

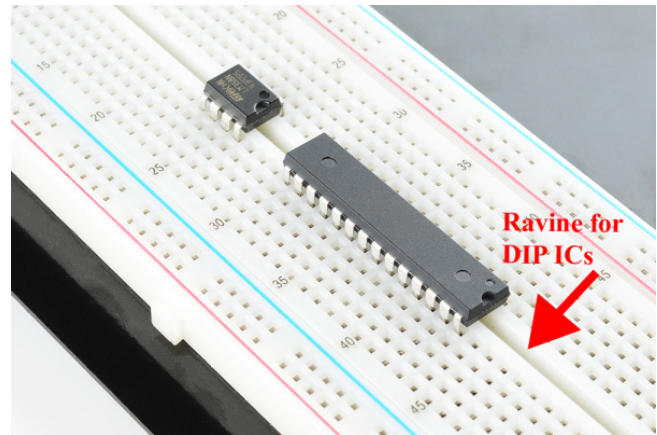


Figure 8. Two DIP ICs, the LM358 (top), a very common op-amp, and the ever-popular ATmega328 microcontroller (bottom) [1].

3.4 Rows and Columns

You may have noticed that many breadboards have numbers and letters marked on various rows and columns. These don't serve any purpose other than to help guide you when building your circuit. Circuits can get complicated quickly, and all it takes is one misplaced leg of a component to make the entire circuit malfunction or not work at all. If you know the row number of the connection you are trying to make, it makes it much simpler to plug a wire into that number rather than eyeballing it.



Figure 9. Solderless breadboard top view [3].

Note how all holes in the selected row are connected together, so the holes in the selected column. The set of connected holes can be called a node:

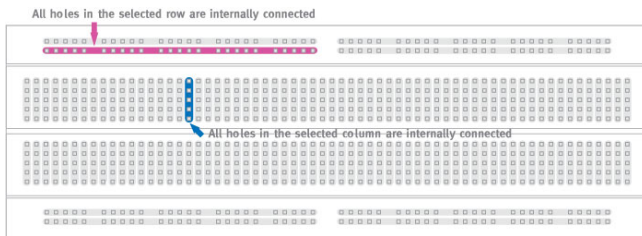


Figure 10. Holes in a row are connected together [4].

To interconnect the selected row (node A) and column (node B) a cable going from any hole in the row to any hole in the column is needed. Now the selected column (node B) and row (node A) are interconnected:

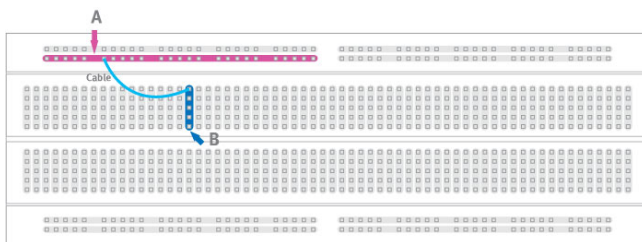


Figure 11. Use a cable to connect row and column to connect node A and node B [4].

4. From electronic diagrams to actual circuit connections

A circuit diagram makes use of standardized symbols that represent electrical components or devices. It is easier to draw these symbols than drawing the actual pictures of the components. The actual components might change appearance as the electronics industry revises them or renders them obsolete. The diagrams describe the way in which the components are connected together electrically. There are drawn lines that represent wires or conductors between the appropriate connection points on the symbols; no particular type of wire or physical distance between components is implied; two components might be separated by a few inches or centimeters or a meter or feet.

The following tutorial translates from a circuit diagram to actually connecting components on a breadboard. Note that the circuit diagrams are the universal way of representing circuits; books, on-line resources, and materials use them to communicate the circuit connections. They are very useful compared with pictorial diagrams of the connections. The circuit diagrams presented in the Wiring website will work with any other type of microcontroller.

The following electronic diagram shows how to connect an LED to a microcontroller:

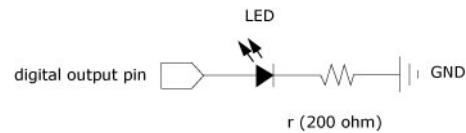


Figure 12. Connecting an LED to a digital output pin [5].

The next step would be to identify the components and their terminals:

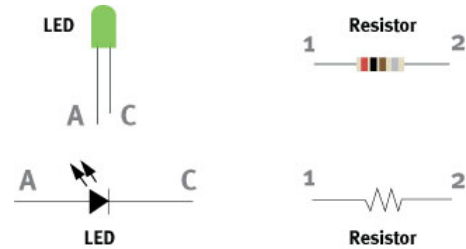
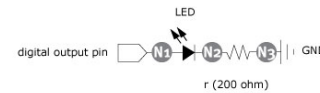


Figure 13. Identify components and terminals [5].

Next, identify the connection nodes between components, connections between different components are formed by putting their legs (or terminals) in a common node:



CORRECT: locate the component on the breadboard so the legs (terminals) are located in different nodes (columns)

INCORRECT: the component's legs (terminals) are located in the same node (column)



Figure 14. Put different legs of LEDs on different columns [5].

Note the difference between the correct and incorrect connections. In the correct version the two legs are on different columns (nodes), in the incorrect version the two legs are connected to the same column (node) which is equivalent to solder or tie together the two legs of the LED.

The LED has two legs, from the second diagram the leg marked as A is connected to a digital I/O pin (Node N1), the leg marked C is connected to the leg marked 1 on the resistor (Node N2) and the leg marked 2 on the resistor is connected to GROUND (Node N3). The LED is a polarized device, which means it matters the way it is connected, the resistor is not polarized so pins can be inverted with no effect on the circuit's behavior. To learn more about a specific component try to find its datasheet. Search on the Web using the component's reference number to become familiar with its functions, terminals and specs.

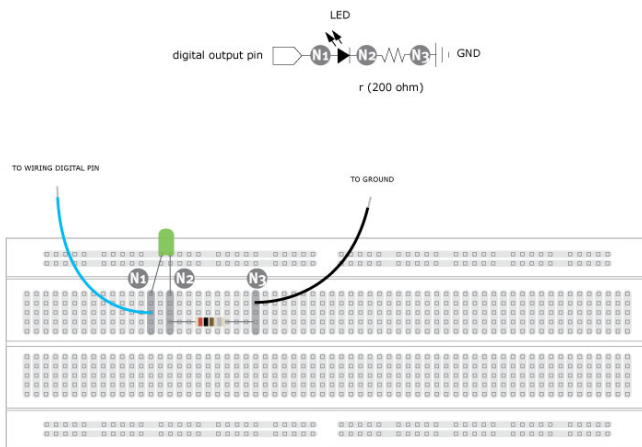


Figure 15. Adding a resistor.

References

- [1] Michelle Shorter and Joel E B. *How to Use a Breadboard*. May 2013. URL: <https://learn.sparkfun.com/tutorials/how-to-use-a-breadboard>.
- [2] mischka. *Use a Real Bread-Board for Prototyping Your Circuit*. Instructables. 2011. URL: <https://www.instructables.com/id/Use-a-real-Bread-Board-for-prototyping-your-circuit/>.
- [3] Walt Kester. “Breadboarding and Prototyping Circuits”. In: *Analog Dialogue* 50.11 (Nov. 2016). URL: <https://www.analog.com/en/analog-dialogue/articles/studentzone-november-2016.html>.
- [4] D. Barragán. *What is a breadboard?* Accessed on 21.01.2019. Wiring. URL: <http://wiring.org.co/learning/tutorials/breadboard/index.html>.
- [5] D. Barragán. *From electronic diagrams to actual circuit connections*. Accessed on 21.01.2019. Wiring. URL: <http://wiring.org.co/learning/tutorials/diagrams/index.html>.
- [6] Munim Zabidi et al. *A Book on Digital Electronics*. Universiti Malaysia Pahang, 2019.
- [7] Munim Zabidi, Izam Kamisian, and Ismahani Ismail. *The Art of Digital Design*. 2019.
- [8] Jim Lindblom. *How to Read a Schematic*. SparkFun. July 2013. URL: <https://learn.sparkfun.com/tutorials/how-to-read-a-schematic>.
- [9] Jim Lindblom. *Using EAGLE: Schematic*. SparkFun. Sept. 2013. URL: <https://learn.sparkfun.com/tutorials/using-eagle-schematic>.