Breadboard

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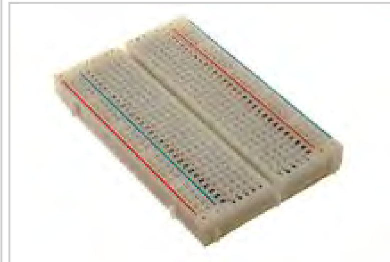
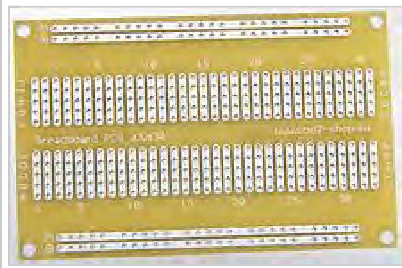


Solderless breadboard with 400 connection points



Electrical equivalent printed circuit board (PCB) of the above solderless breadboard

A **breadboard** is a construction base for prototyping of electronics. Originally it was literally a bread board, a polished piece of wood used for slicing bread. In the 1970s the **solderless breadboard** (AKA **plugboard**, a terminal array board) became available and nowadays the term "breadboard" is commonly used to refer to these. "Breadboard" is also a synonym for "prototype".[1]

Because the solderless breadboard does not require soldering, it is reusable. This makes it easy to use for creating temporary prototypes and experimenting with circuit design. For this reason, solderless breadboards are also extremely popular with students and in technological education. Older breadboard types did not have this property. A stripboard (Veroboard) and similar prototyping printed circuit boards, which are used to build semi-permanent soldered prototypes or one-offs, cannot easily be reused. A variety of electronic systems may be prototyped by using breadboards, from small analog and digital circuits to complete central processing units (CPUs).

Contents

Evolution

In the early days of radio, amateurs nailed bare copper wires or terminal strips to a wooden board (often literally a board to slice bread on) and soldered electronic components to them.[2] Sometimes a paper schematic diagram was first glued to the board as a guide to placing terminals, then components and wires were installed over their symbols on the schematic. Using thumbtacks or small nails as mounting posts was also common.

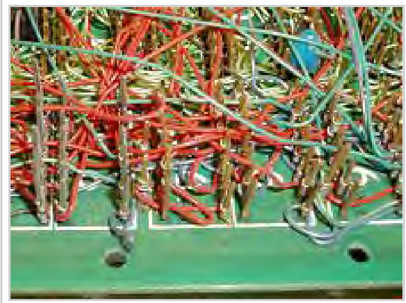
Breadboards have evolved over time, with the term now being used for all kinds of prototype electronic devices. For example, US Patent 3,145,483,[3] filed in 1961 and granted in 1964, describes a wooden plate breadboard with mounted springs and other facilities. US Patent 3,496,419,[4] filed in 1967 and granted in 1970, refers to a particular printed circuit board layout as a *Printed Circuit Breadboard*. Both examples refer to and describe other types of breadboards as prior art.


This 1920s TRF radio manufactured by Signal was constructed on a wooden breadboard.

The breadboard most commonly used today is usually made of white plastic and is a pluggable (solderless) breadboard. It was designed by Ronald J. Portugal of EI Instruments Inc. in 1971.[5]

Alternatives

Alternative methods to create prototypes are point-to-point construction (reminiscent of the original wooden breadboards), wire wrap, wiring pencil, and boards like the stripboard. Complicated systems, such as modern computers comprising millions of transistors, diodes, and resistors, do not lend themselves to prototyping using breadboards, as their complex designs can be difficult to lay out and debug on a breadboard.


Wire wrap backplane

Modern circuit designs are generally developed using a schematic capture and simulation system, and tested in software simulation before the first prototype circuits are built on a printed circuit board. Integrated circuit designs are a more extreme version of the same process: since producing prototype silicon is costly, extensive software simulations are performed before fabricating the first prototypes. However, prototyping techniques are still used for some applications such as RF circuits, or where software models of components are inexact or incomplete.

You could also use a square grid of pairs of holes where one hole per pair connects to its row and the other connects to its column. This same shape can be in a circle with rows and columns each spiraling opposite clockwise/counterclockwise.

Solderless breadboard

Typical specifications

A modern solderless breadboard consists of a perforated block of plastic with numerous tin plated phosphor bronze or nickel silver alloy spring clips under the perforations. The clips are often called *tie points* or *contact points*. The number of tie points is often given in the specification of the breadboard.

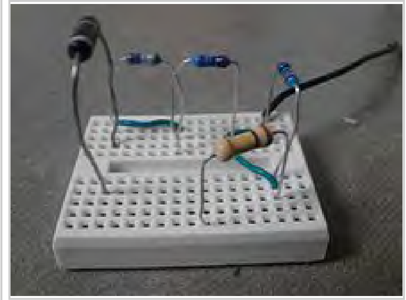
The spacing between the clips (lead pitch) is typically 0.1 in (2.54 mm). Integrated circuits (ICs) in dual in-line packages (DIPs) can be inserted to straddle the centerline of the block. Interconnecting wires and the leads of discrete components (such as capacitors, resistors, and inductors) can be inserted into the remaining free holes to complete the circuit. Where ICs are not used, discrete components and connecting wires may use any of the holes. Typically the spring clips are rated for 1 ampere at 5 volts and 0.333 amperes at 15 volts (5 watts). The edge of the board has male and female notches so boards can be clipped together to form a large breadboard.

Bus and terminal strips

Solderless breadboards are available from several different manufacturers, but most share a similar layout. The layout of a typical solderless breadboard is made up from two types of areas, called strips. Strips consist of interconnected electrical terminals.

Terminal strips

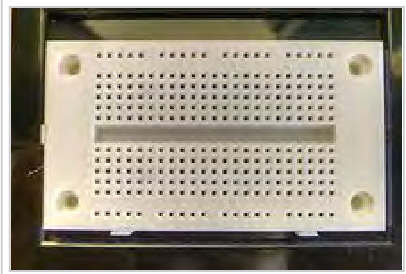
The main areas, to hold most of the electronic components.
In the middle of a terminal strip of a breadboard, one typically finds a notch running in parallel to the long side. The notch is to mark the centerline of the terminal strip and provides limited airflow (cooling) to DIP ICs straddling the centerline. The clips on the right and left of the notch are each connected in a radial way; typically five clips (i.e., beneath five holes) in a row on each side of the notch are electrically connected. The five rows on the left of the notch are often marked as A, B, C, D, and E, while the ones on the right are marked F, G, H, I and J. When a "skinny" dual in-line pin package (DIP) integrated circuit (such as a typical DIP-14 or DIP-16, which have a 0.3-inch (7.6 mm) separation between the pin rows) is plugged into a breadboard, the pins of one side of the chip are supposed to go into row E while the pins of the other side go into row F on the other side of the notch. The columns are numbered 1 - 50 or whatever number of columns there are.



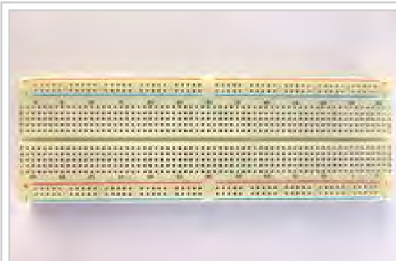
Breadboard consisting of only terminal strips but no bus strips

Bus strips

To provide power to the electronic components.
A bus strip usually contains two rows: one for ground and one for a supply voltage. However, some breadboards only provide a single-row power distributions bus strip on each long side. Typically the row intended for a supply voltage is marked in red, while the row for ground is marked in blue or black. Some manufacturers connect all terminals in a column. Others just connect groups of, for example, 25 consecutive terminals in a column. The latter design provides a circuit designer with some more control over crosstalk (inductively coupled noise) on the power supply bus. Often the groups in a bus strip are indicated by gaps in the color marking.
Bus strips typically run down one or both sides of a terminal strip or between terminal strips. On large breadboards additional bus strips can often be found on the top and bottom of terminal strips.
Note there are two different common alignments for the power bus strips. On small boards, with about 30 rows, the holes for the power bus are often aligned between the signal holes. On larger boards, about 63 rows, the power bus strip holes are often in alignment with the signal holes. This makes some accessories designed for one board type incompatible with the other. For example, some Raspberry Pi GPIO to breadboard adapters use offset aligned power pins, making them not fit breadboards with aligned power bus rows. There are no official standards, so the users need to pay extra attention to the compatibility between a specific model of breadboard and a specific accessory. Vendors of accessories and breadboards are not always clear in their specifications of which alignment they use. Seeing a close up photograph of the pin/hole arrangement can help determine compatibility.



Breadboard with one bus strip on both sides



Breadboard with two bus strips on both sides

Some manufacturers provide separate bus and terminal strips. Others just provide breadboard blocks which contain both in one block. Often breadboard strips or blocks of one brand can be clipped together to make a larger breadboard.

In a more robust variant, one or more breadboard strips are mounted on a sheet of metal. Typically, that backing sheet also holds a number of binding posts. These posts provide a clean way to connect an external power supply. This type of breadboard may be slightly easier to handle. Several images in this article show such solderless breadboards.

Diagram

A "full size" terminal breadboard strip typically consists of around 56 to 65 rows of connectors, each row containing the above-mentioned two sets of connected clips (A to E and F to J). Together with bus strips on each side this makes up a typical 784 to 910 tie point solderless breadboard. "Small size" strips typically come with around 30 rows. Miniature solderless breadboards as small as 17 rows (no bus strips, 170 tie points) can be found, but these are only suitable for small and simple designs.

Jump wires

Stranded 22AWG jump wires with solid tips

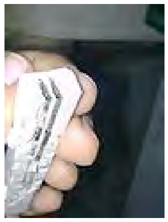
Jump wires (also called jumper wires) for solderless breadboarding can be obtained in ready-to-use jump wire sets or can be manually manufactured. The latter can become tedious work for larger circuits. Ready-to-use jump wires come in different qualities, some even with tiny plugs attached to the wire ends. Jump wire material for ready-made or homemade wires should usually be 22 AWG (0.33 mm^2) solid copper, tin-plated wire - assuming no tiny plugs are to be attached to the wire ends. The wire ends should be stripped $^3⁄_{16}$ to $^5⁄_{16}$ in (4.8 to 7.9 mm). Shorter stripped wires might result in bad contact with the board's spring clips (insulation being caught in the springs). Longer stripped wires increase the likelihood of short-circuits on the board. Needle-nose pliers and tweezers are helpful when inserting or removing wires, particularly on crowded boards.

Differently colored wires and color-coding discipline are often adhered to for consistency. However, the number of available colors is typically far fewer than the number of signal types or paths. Typically, a few wire colors are reserved for the supply voltages and ground (e.g., red, blue, black), some are reserved for main signals, and the rest are simply used where convenient. Some ready-to-use jump wire sets use the color to indicate the length of the wires, but these sets do not allow a meaningful color-coding schema.

Inside a breadboard: construction

The following images show the inside of a bus strip.

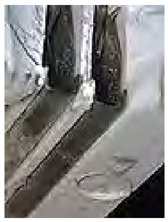

Inside breadboard 1


Inside breadboard 2


Inside breadboard 3


Inside breadboard 4


Inside breadboard 5


Inside breadboard 6

Advanced solderless breadboards

Some manufacturers provide high-end versions of solderless breadboards. These are typically high-quality breadboard modules mounted on a flat casing. The casing contains additional equipment for breadboarding, such as a power supply, one or more signal generators, serial interfaces, LED display or LCD modules, and logic probes.[6]

Solderless breadboard modules can also be found mounted on devices like microcontroller evaluation boards. They provide an easy way to add additional periphery circuits to the evaluation board.

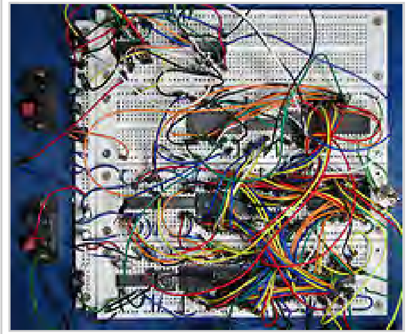
High frequencies and dead bugs

For high-frequency development, a metal breadboard affords a desirable solderable ground plane, often an unetched piece of printed circuit board; integrated circuits are sometimes stuck upside down to the breadboard and soldered to directly, a technique sometimes called "dead bug" construction because of its appearance. Examples of dead bug with ground plane construction are illustrated in a Linear Technologies application note.[7] For other uses of this technique see Dead Bug.

Limitations

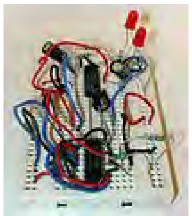
Due to relatively large parasitic capacitance compared to a properly laid out PCB (approx 2pF between adjacent contact columns[8]), high inductance of some connections and a relatively high and not very reproducible contact resistance, solderless breadboards are limited to operation at relatively low frequencies, usually less than 10 MHz, depending on the nature of the circuit. The relatively high contact resistance can already be a problem for some DC and very low frequency circuits. Solderless breadboards are further limited by their voltage and current ratings.

Solderless breadboards usually cannot accommodate surface-mount technology devices (SMD) or components with grid spacing other than 0.1 in (2.54 mm). Further, they cannot accommodate components with multiple rows of connectors if these connectors do not match the dual in-line layout—it is impossible to provide the correct electrical connectivity. Sometimes small PCB adapters called "breakout adapters" can be used to fit the component to the board. Such adapters carry one or more components and have 0.1 in (2.54 mm) spaced male connector pins in a single in-line or dual in-line layout, for insertion into a solderless breadboard. Larger components are usually plugged into a socket on the adapter, while smaller components (e.g., SMD resistors) are usually soldered directly onto the adapter. The adapter is then plugged into the breadboard via the 0.1 in (2.54 mm) connectors. However, the need to solder the components onto the adapter negates some of the advantage of using a solderless breadboard.

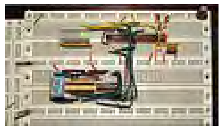

An example of a complex circuit built on a large breadboard consisting of 4 smaller boards clipped together. The circuit is an Intel 8088 single board computer.

Very complex circuits can become unmanageable on a solderless breadboard due to the large amount of wiring required. The very convenience of easy plugging and unplugging of connections also makes it too easy to accidentally disturb a connection, and the system becomes unreliable. It is possible to prototype systems with thousands of connecting points, but great care must be taken in careful assembly, and such a system becomes unreliable as contact resistance develops over time. At some point, very complex systems must be implemented in a more reliable interconnection technology, to have a likelihood of working over a usable time period.

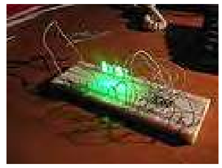
Gallery



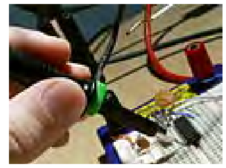
A solderless breadboard with a completed circuit.



A binary counter wired up on 2 solderless breadboards.



Logical 4-bit adder with output bits linked to LEDs on a typical breadboard.



Close-up of a solderless breadboard. An IC straddling the centerline is probed with an oscilloscope probe. The solderless breadboard is mounted on a blue painted metal plate base. Red and black binding posts are also present on the base; the black one is partly obscured by the oscilloscope probe.

Example breadboard drawing. Two bus strips and one terminal strip in one block. 25 consecutive terminals in a bus strip connected (indicated by gaps in the red and blue lines). Four binding posts depicted at the top.

Example of use of a "Breadboard" in electronics construction. QST Magazine August 1922

Example of use of a "Breadboard" in electronics construction. QST Magazine August 1922

See also

- Brassboard
- Expansion spring
- Fahnestock clip
- Iterative design
- Perfboard

References

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2. Description of the term breadboard (http://tangentsoft.net/elec/breadboard.html)
3. U.S. Patent 3,145,483 (https://www.google.com/patents/US3145483) *Test Board for Electronic Circuits*
4. U.S. Patent 3,496,419 (https://www.google.com/patents/US3496419) *Printed Circuit Breadboard*
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6. Powered breadboard (http://pundit.pratt.duke.edu/wiki/PBB_272)
7. Linear Technology (August 1991). "Application Note 47: High Speed Amplifier Techniques" (pdf). Retrieved 2016-02-14. Dead-bug breadboards with ground plane, and other prototyping techniques, illustrated in Figures F1 to F24, from p. AN47-98. There is information on breadboarding on pp. AN47-26 to AN47-29.
8. Jones, David. "EEVblog #568 - Solderless Breadboard Capacitance". EEVblog. Retrieved 15 January 2014.

External links

- Large parallel processing design prototyped on 50 connected breadboards (http://www.objectivej.com/hardware/propcluster/_IMG_0031_pac_bboard_2_of_10_partial_completion.JPG)

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Categories: Electronics substrates | Electronic design | Electronic test equipment | Electronics work tools