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Redstone circuits

Redstone circuits

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A **redstone circuit** is a contraption that activates or controls mechanisms. Circuits can act in response to player or entity/mob activation, continuously on a loop, or in response to non-player activity (mob movement, item drops, plant growth, etc).

A useful distinction can be made between a **circuit** performing operations on signals (generating, modifying, combining, etc.), and a **mechanism** manipulating the environment (moving blocks, opening doors, changing the light level, producing sound, etc.). Making this distinction lets us talk about the various circuits separately, and will let players choose whichever circuits are useful for their purposes. The machines controlled by redstone circuits can range from simple devices such as automatic doors and light switches to complex devices such as elevators, automatic farms, or even in-game computers. However, *this* article provides only an overview of redstone *circuits* as above. These can be used to control simple mechanisms, or combined as parts of a larger build. Each circuit type on this page has links to its own page, which provides greater detail about them and give schematics for multiple variations of each.

Before working with any but the most basic Redstone circuits, an understanding of some basic concepts is required: "power", "signal strength", "redstone ticks", and "block updates". Other relevant articles:

- The Redstone mechanics article provides more information on these concepts.
- The Redstone components article adds a list and description of all blocks which interact with redstone power.
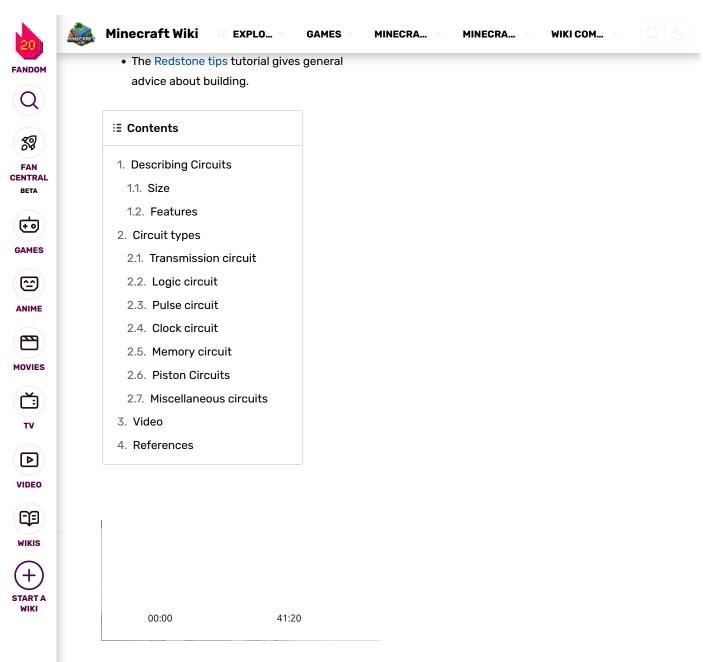- The Mechanisms tutorial complements this

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- The Redstone tips tutorial gives general advice about building.

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Describing Circuits

Most circuits are described using Schematic diagrams; some of these require multiple images to show one or two layers per image. See the Help:Schematic page for details on how various blocks and components are represented.

Size

The wiki describes circuit size (the volume of the rectangular solid it occupies) with the notation of *shorter width × longer width × height*, including support/floor blocks, but not including inputs/outputs.

Another method used for describing circuit size in the *Minecraft* community is to ignore non-Redstone blocks simply used for support (for example, blocks under Redstone dust or repeaters). However, this

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high circuits, as well as some other circuit differences.

Sometimes it is convenient to compare circuits simply by the area of their footprint (e.g., 3×4 for a circuit three-block wide by four blocks long), or by a single dimension important in a particular context (e.g., length in a sequence of sub-circuits, height in a confined space, etc.).

Features

Several features may be considered desirable design goals:

1-high

A structure is 1-high (aka "1-tall") if its vertical dimension is one block high (meaning it cannot have any redstone components that require support blocks below them, such as redstone dust or repeaters). Also see flat.

1-wide

A structure is 1-wide if at least one of its horizontal dimensions is exactly one block wide.

Flat

A structure is flat if it generally can be laid out on the ground with no components above another (support blocks under redstone components are okay). Flat structures are often easier for beginners to understand and build, and fit nicely under floors or on top of roofs. Also see 1-high.

Flush

A structure is flush if it doesn't extend beyond a flat wall, floor, or ceiling and can still provide utility to the other side, though redstone mechanisms may be visible in the wall. Flush is a desirable design goal for piston-extenders, piston doors, etc. Also see hipster and seamless.

Hipster

A structure is hipster if it is initially hidden behind a flat wall, floor, or ceiling and can still provide utility to the other side. See also flush and seamless.

Instant

A structure is instant if its output responds immediately to its input (a circuit delay of 0 ticks).

Seamless

A structure is seamless if no redstone

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completes its task (but it's okay if some are visible during operation). Seamless is a desirable design goal for piston-extenders, piston doors, etc. See also flush and hipster.

Silent

A structure is silent if it makes no noise (such as from piston movement, dispenser/dropper triggering when empty, etc.). Silent structures are desirable for traps or peaceful homes.

Stackable

A structure is stackable if it can be placed *directly* on top of other copies of itself, and they all can be controlled as a single unit. Also see tileable.

Expandable

A structure is Expandable if it can be placed *directly* next to other copies of itself, and they all can be controlled as a single unit. Also see tileable.

Tileable

A structure is tileable if it can be placed *directly* next to or on top of other copies of itself, and each copy can still be controlled independently. Also see stackable.

Structures might be described as "2-wide tileable" (tileable every two spaces in one dimension), or "2×4 tileable" (tileable in two directions), etc. Some structures might be described as "alternating tileable", meaning they can be placed next to each other if every other one is flipped or a slightly different design.

Other design goals may include reducing the delay a sub-circuit adds to a larger circuit, reducing the use of resource-expensive components (redstone, nether quartz, etc.), and re-arranging or redesigning a circuit to make it as small as possible.

Some components are not available before a player has access to the Nether, which limits the designs available. In particular, redstone comparators, observers and daylight detectors require nether quartz, which is available only from the Nether. Additionally, redstone lamps require glowstone, which is occasionally available from trading or witches, but is much more plentiful in the Nether.

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Circuit types

Although the number of ways to construct circuits is endless, certain patterns of construction occur repeatedly. The following sections attempt to categorize the circuits that have proven useful to the *Minecraft* community, while the main articles describe the specific circuits that fall into those categories.

Some of these circuits might be used by themselves for simple control of mechanisms, but frequently the player needs to combine them into more complex circuits to meet the needs of a mechanism.

Transmission circuit

Main article: Transmission circuit

Some aspects of signal transmission can be helpful to understand: transmission types, vertical transmission, repeaters, and diodes.

Vertical transmission

Although horizontal signal transmission is straightforward, vertical transmission involves options and trade-offs.

Transmitting signals upward

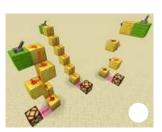
Transmitting signals downward

- *Redstone staircases:* The simplest way to transmit signals vertically is by placing redstone dust on blocks

Examples of two-way vertical ladders in Bedrock Edition

diagonally upward, either in a straight staircase of blocks, in a 2×2 spiral of blocks, or in another similar variation. Redstone staircases can transmit signals

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every 15 blocks.

- *Redstone ladders:* Because glowstone, top slabs, glass, and upside-down stairs can support redstone dust but don't cut redstone dust, signals can be transmitted vertically (upward only) by alternating these blocks in a 2×1 "ladder". Redstone ladders take up less space than redstone staircases, but also require repeaters every 15 blocks. In *Bedrock Edition*, glass and pistons can be used to create two-way vertical ladders that transmit signals both upward and downward (glowstone, hoppers, and slabs still allow the dust to power upward but not downward).
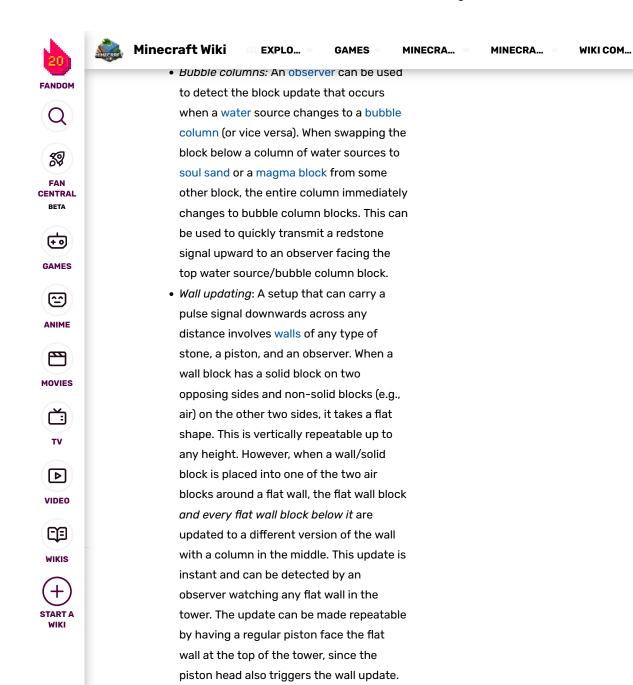
- *Torch towers and torch ladders:* A redstone torch can power a block above it, or redstone dust beneath it, allowing vertical transmission both upward and downward (different designs are required for each). Because it takes each torch a little time to change state, a torch tower can introduce some delay into a circuit, but no repeaters are necessary. However, every torch inverts the redstone signal (i.e. changes it from powered to unpowered), so having an even number of torches is required.

- *Observer towers:* An observer can power a block of a redstone circuit above or below it, allowing vertical transmission both upward and downward. Placing blocks that can be activated, such as redstone dust, noteblocks, or doors, both above and below it creates a state change when the observer is looking downward or downward when the observer is looking upward. Repeating this pattern means that updates are chained.

- *Daylight detector exploiting:* You can use daylight detectors to send a Redstone signal downward in 1 tick, but the path needs to be unobstructed by anything. You need to have a piston push a block over the sensor. It detects the change in light and emits a Redstone pulse. This design is extendable upward as far as you want, but you need to have the original hole open to sunlight. It also works only during the day, because it uses shadows.

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- *Bubble columns:* An observer can be used to detect the block update that occurs when a water source changes to a bubble column (or vice versa). When swapping the block below a column of water sources to soul sand or a magma block from some other block, the entire column immediately changes to bubble column blocks. This can be used to quickly transmit a redstone signal upward to an observer facing the top water source/bubble column block.

- *Wall updating*: A setup that can carry a pulse signal downwards across any distance involves walls of any type of stone, a piston, and an observer. When a wall block has a solid block on two opposing sides and non-solid blocks (e.g., air) on the other two sides, it takes a flat shape. This is vertically repeatable up to any height. However, when a wall/solid block is placed into one of the two air blocks around a flat wall, the flat wall block *and every flat wall block below it* are updated to a different version of the wall with a column in the middle. This update is instant and can be detected by an observer watching any flat wall in the tower. The update can be made repeatable by having a regular piston face the flat wall at the top of the tower, since the piston head also triggers the wall update.

Repeater

To "repeat" a signal means to boost it back up to full strength. The easiest way to do this is with a redstone repeater. Variations include:
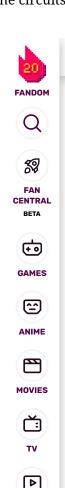
- *Instant repeater:* Repeats a solid signal without the delay introduced by a redstone repeater.
- *Two-way repeater:* Repeats a signal in both directions.

Diode

A "diode" is a one-way circuit that allows a signal to travel in one direction. It is used to protect another circuit from the chance of a signal trying to enter through the output, which could incorrectly change the circuit's state or interfere with its timing. It is also used in a compact circuit to keep one part of the circuit

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for a diode include a redstone repeater or a height elevation to glowstone or a top slab, which does not transmit a signal back down.

Many circuits are already one-way simply because their output comes from a block that can't take input. For example, a signal cannot be pushed back into a circuit through a redstone torch except through the block it's attached to.

Logic circuit

> *Main article: Logic circuit*

It's sometimes necessary to check signals against each other and output a signal only when the inputs meet some criteria. A circuit that performs this function is known as a **logic gate** (a "gate" that allows signals through only if the logic is satisfied).

In electronic or programming diagrams, logic gates are typically shown as if they were individual devices; However, when building redstone devices in *Minecraft*, all logic gates are formed from multiple blocks and components, which interact to produce the desired results.

NOT gate

A NOT gate (aka "inverter") is on if its input is off. The simplest NOT gate is an input block with a redstone torch attached.

OR gate

An OR gate is on if *any* of its inputs are on. The simplest OR gate is to feed multiple signals into a single block or redstone wire.

NOR gate

A NOR gate is on only if *none* of its inputs are on. The simplest NOR gate is to feed multiple signals into a block with a redstone torch attached.

AND gate

An AND gate is on only if *all* of its inputs are on.

NAND gate

A NAND gate is on if *any* of its inputs are off.

XOR gate

An XOR gate is on if its inputs are *different*.

XNOR gate

An XNOR gate is on if its inputs are *equal*.

IMPLY gate

An IMPLY gate is on unless the first input is on and the second input is off.

Shows the output (red) of each gate, for each combination of inputs A and B (green).

A	ON	ON	off	off	Question Answered
B	ON	off	ON	off	
A AND B	ON	off	off	off	Is A and B on?
NOT (A IMPLIES B)	off	ON	off	off	Is A on and B off?
NOT (B IMPLIES A)	off	off	ON	off	Is B on and A off?
A NOR B	off	off	off	ON	Are both inputs off?
A	ON	ON	off	off	Is A on?
A XOR B	off	ON	ON	off	Are the inputs different?
NOT A	off	off	ON	ON	Is A off?
A XNOR B	ON	off	off	ON	Are the inputs the same?
B	ON	off	ON	off	Is B on?
NOT B	off	ON	off	ON	Is B off?
A NAND B	off	ON	ON	ON	Is either input off?
A IMPLIES B	ON	off	ON	ON	If A is on, is B also on?
B IMPLIES A	ON	ON	off	ON	If B is on, is A also on?
A OR B	ON	ON	ON	off	Is either input on?

Pulse circuit

Main article: Pulse circuit

Some circuits require specific pulses; other circuits use pulse duration to convey information. Pulse circuits manage these requirements.

A circuit that is stable in one output state and unstable in the other is known as a monostable circuit.[note 1] Many pulse circuits are monostable because their OFF state is stable, but their ON state soon reverts to OFF.

Pulse generator

A pulse generator produces a pulse of a specific duration.

Pulse limiter

A pulse limiter (aka pulse shortener) reduces the duration of pulses that are too long.

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A pulse extender (aka pulse sustainer, pulse lengthener) increases the duration of pulses that are too short.

Pulse multiplier

A pulse multiplier outputs multiple pulses for every input pulse (it multiplies the number of pulses).

Pulse divider

A pulse divider (aka pulse counter) outputs a signal only after a certain number of pulses have been detected through the input (the number of pulses is indicative of the number of loops).

Edge detector

An edge detector reacts to either a redstone signal changing from OFF to ON (a "rising edge" detector), from ON to OFF (a "falling edge" detector), or switching between ON and OFF in either order(a "dual edge" detector).

Pulse length detector

A pulse length detector reacts only to pulses in a certain range of durations (often only to pulses of one specific duration).

Clock circuit

Main article: Clock circuit

A clock circuit is a pulse generator that produces a loop of specific pulses repeatedly. Some are designed to run forever, while others can be stopped and started.

A simple clock with only two states of equal duration is named for the duration of its ON state (e.g., for example, a clock that alternates between a 5-tick ON state and a 5-tick OFF state is called a 5-clock) while others are usually named for their period (the time it takes for the clock to return to its original state; for example, a "1-minute clock" might produce a 1-tick pulse every 60 seconds).

Observer clock 1

A repeating clock made with Observers and Pistons (an Observer looking at a piston).

Observer clock 2

A repeating clock made with two Observers with their faces facing each other.

Repeater clock

A repeater clock consists of a loop of repeaters

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off the appropriate pulses.

Hopper clock

A hopper clock produces timed pulses by moving items back and forth between 2 hoppers feeding into each other and taking a redstone output with comparators. This was revolutioninised by ethoslab, as he created the etho hopper clock, a staple in redstone timers.

Piston clock

A piston clock produces a loop of pulses by passing a block back and forth (or around, with many pistons) and drawing off a redstone pulse when the block is in a certain location.

Comparator clock

The clock of short or moderate cycle length utilizing comparator's subtraction or signal fading feature.

Clocks can also be built using daylight sensors, minecarts, boats, water flow, item despawn, etc.

Memory circuit

Main article: Memory circuit

Unlike a logic circuit whose state always reflects its current inputs, a memory circuit's output depends not on the current state of its inputs, but on the *history* of its inputs. This allows a memory circuit to "remember" what state it should be in, until told to remember something else. There are five basic types of memory circuits. (A few circuits combine two different types.)

RS latch

An RS latch has two inputs, one to set the output on and another to reset the output back to off. An RS latch built from NOR gates is known as an "RS NOR latch", which is the oldest and most common memory circuit in *Minecraft*.

T flip-flop

A T flip-flop is used to toggle a signal (like a lever). It has one input, which toggles the output between on and off. Before the 1.21 updates, they had to be big, chunky machines, but now we can use a copper bulb as one, and it only takes up 2 blocks (copper bulb and comparator)

Gated D latch

A gated D latch has a "data" input and a "clock"

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confused with a D flip-flop, which sets the output equal to its data input on a clock rising transition.

JK latch

A JK latch has two inputs, one to set the output on and another to reset the output back to off (like an RS latch), but when both turn on simultaneously it toggles the output between on and off (like a T flip-flop).

Counter

Unlike T flip-flops and RS latches, which can hold two states (ON or OFF), a counter can be designed to hold a greater number of states.

Many other memory circuits are possible.
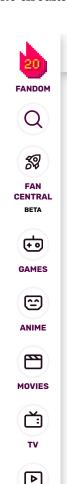
Piston Circuits

Main article: Piston circuits

Pistons have allowed players to design circuits that are smaller and/or faster than the standard, redstone-only counterparts. An understanding of standard **redstone circuits** is helpful, as this tutorial is focused on the circuit design rather than the function. The main components here are sticky pistons, redstone wire, repeaters, and redstone torches. Regular pistons can also see use, especially combined with gravity blocks.

There are several benefits of piston circuitry:

- Neither repeaters nor pistons 'burn out', unlike redstone torches.
- Piston circuits are often (not always) smaller and/or faster than their redstone counterparts. This allows building devices such as fast clocks and "instant" signal transmission.
- Pistons' ability to move blocks within the world makes them a natural for memory circuits, as well as the obvious doorways and switchable bridges. With slime or honey blocks involved, entire structures can "get up and move" (see also the Flying Machines tutorial).
- Piston circuits can sharply reduce the use of redstone in favor of wood, stone, and iron.

These circuits aren't generally needed for redstone projects, but might find use in complex projects, proofs of concept, and thought experiments. Some examples:

Multiplexers and relays

A multiplexer is an advanced form of logic gate that chooses which of two inputs to let through as output based on an additional input (for example, if input A is ON then output input B, otherwise output input C). The reverse of this is a relay, which copies a data input to one of two outputs, depending on whether the additional input is ON or OFF.

Randomizers

A randomizer produces output signals unpredictably. Randomizers can be designed to produce a pulse at random intervals, or to randomize which of multiple outputs are turned ON (such as random number generators, or RNGs). Some randomizers use the random nature of *Minecraft* (such as cactus growth or dispenser slot selection), while others produce pseudo-randomness algorithmically.

Multi-bit circuits

Multi-bit circuits treat their input lines as a single multi-bit value (something other than zero and one) and perform an operation on them all at once. With such circuits, possibly combined with arrays of memory circuits, it's possible to build calculators, digital clocks, and even basic computers inside *Minecraft*.

Block update detectors

A block update detector (BUD, or BUD switch) is a circuit that reacts to a block changing its state (for example, stone being mined, water changing to ice, a pumpkin growing next to a pumpkin stem, etc.). BUDs react by producing a pulse, while T-BUDs (toggleable BUDs) react by toggling their output state. These are generally based on subtle quirks or glitches in device behavior; current circuits most often depend on pistons. As of *Java Edition* 1.11, many of the functions of BUDs were condensed into the

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other changes undetectable by observers, like a furnace finishing smelting or something being crafted in a crafting table. The addition of this was made to move toward feature parity with *Bedrock Edition* versions.

More advanced circuits

> *Main article: Tutorials/Advanced redstone circuits*

Many other complex circuits are possible.

Video

References

1. Note: Some players refer to edge detectors as monostable circuits

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