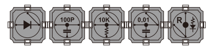


Tester Circuits

No.01 Transistor Tester

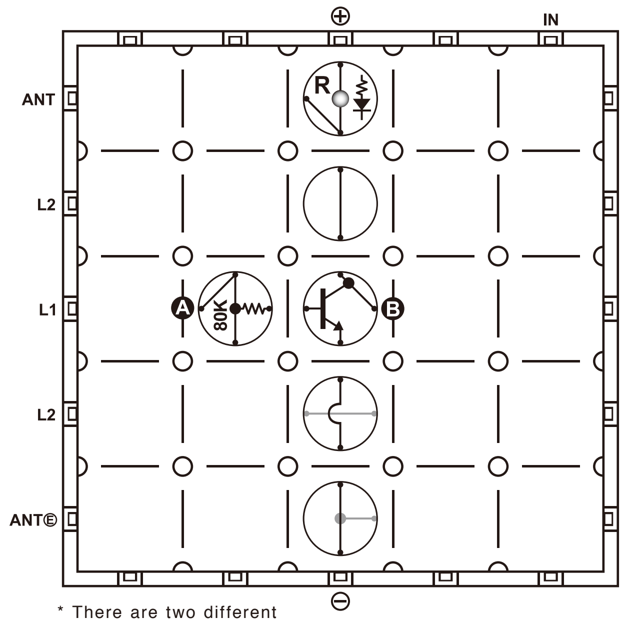
Electronic components may break down if used or connected improperly. Let's start with a simple tester circuit project designed to teach you how to handle particularly fragile components with care so as not to break them. Of the electronic component blocks in this kit, the transistor is the most fragile component. It will break down if a current over the determined limit (an overcurrent) is allowed to flow through it. This first circuit project is for a transistor tester circuit. Insert the blocks as shown in the figure and then turn on the main switch. Nothing will happen in this case.

Now, push against the contact terminals marked A and B to push the blocks together as shown in the picture below. The LED should then light up. The transistor is working normally if the LED lights up. The transistor is not working properly and may be broken if the LED lights up as soon as you turn the main switch on (without pushing against the A and B contact terminals) or if the LED fails to turn on when you push against the contact terminals. * Check in a darker area to make it easier to see when the LED lights up.

*Make sure to touch something metal with your fingers before touching the contact terminals (like a metal doorknob or window frame) in order to discharge any static electricity you may have built up in your body.

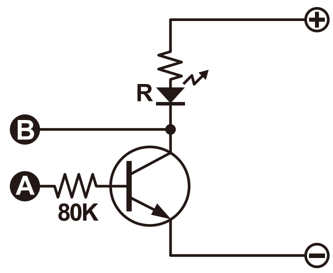
Block Layout Diagram

* In blocks with lighter lines, current only flows along the dark, solid lines.



* There are two different transistor blocks included in this supplement. Test both of them to make sure they work.

Circuit Schematic



The transistor is working properly if the LED lights up when you push against contact terminals A and B. The amount of electrical resistance produced by your fingers is high, so the LED will light only weakly.
If unable to see the LED clearly enough, check in a darker area to make it easier to see the light.

Protecting the Block Components from Breaking Down 1

❶ Make sure to keep the power turned off when not using the block kit and before you finish putting circuits together!

• If you leave the power turned on during such times, blocks may get shorted out and damaged if they're inserted incorrectly or excess current could flow through the circuit, damaging components.

❶ Make sure to take every precaution when putting circuits together!

• Be extremely careful when considering how to put circuits together, changing out components, and performing other related tasks as it will require all of your concentration to ensure that things are assembled correctly.

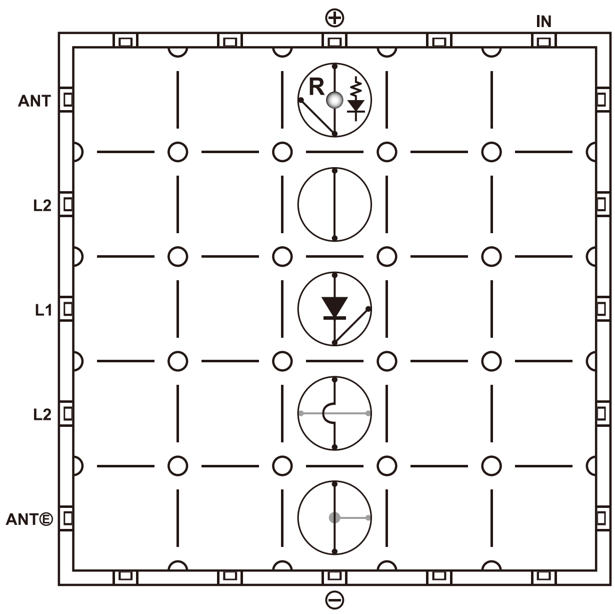
Tester Circuits

No.02 Diode Tester

The next most fragile electronic component after the transistor is the diode. Diodes will also break down if an overcurrent is applied. Let's try making a diode tester circuit to check the diodes in this kit to make sure they are working properly. Insert the blocks as shown in the figure and then turn on the main switch. Check to see if the LED lights up. If the LED lights up, turn off the main switch and take the diode block out. Now, try inserting the diode block in the other direction. If the LED remains turned off when the main switch is turned back on, the diode is working properly.

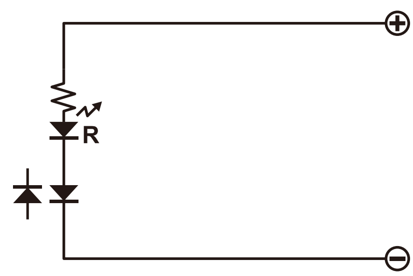
Block Layout Diagram

* In blocks with lighter lines, current only flows along the dark, solid lines.



* There are two different diode blocks included in this supplement. Test both of them to make sure they work.

Circuit Schematic



Protecting the Block Components from Breaking Down 2

Learn more about how to handle fragile parts !

- Transistors and diodes will break down if you apply too large a current to them. Germanium diodes are particularly fragile and break down easily.
- Do not apply a high DC current to antenna coils.
- Be extremely careful when replacing resistors. You may accidentally generate a large current if you connect them improperly or use the wrong one.
- Electrolytic capacitors will break down if you apply a voltage across them with the terminals reversed over a long period of time.
- Do not attempt to remove any blocks with the power on.

Shut off the power immediately if the circuit starts acting up or something just doesn't seem right!

- Make it a habit to turn off the power immediately any time you encounter problems, such as the circuit failing to run properly.

Blocks used in this project

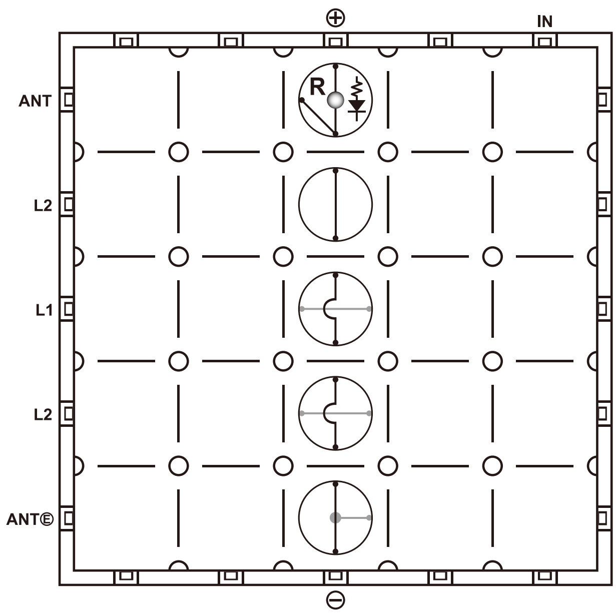
Basic Circuits

No.03 Paths for the Flow of Electricity

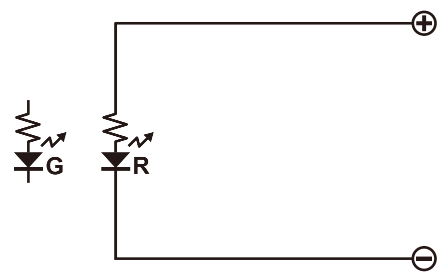
Create a path for electricity to flow through and light an LED. Insert the blocks as shown in the figure and then turn on the main switch. The LED will light up. There are two LEDs included in this supplement, a red (R) one and a green (G) one. Try out both of them. At the center bottom of the circuit board on which blocks are inserted is a terminal for connecting to the minus (-) terminal on the battery. At the top is one for connecting to the plus (+) terminal on the battery. You can create a circuit by arranging blocks on the circuit board between these two terminals to produce a path for electricity. LED is short for "light-emitting diode," meaning that it is a type of diode and exhibits diode characteristics. If you insert an LED in backwards (flipped around from what is shown in the layout diagram), it will not light up when the power is turned on.

Block Layout Diagram

* In blocks with lighter lines, current only flows along the dark, solid lines.



Circuit Schematic



Protecting the Block Components from Breaking Down 3

Double check the layout diagram before turning on the power!

• Double check the layout in the circuit guide to make sure that the blocks are inserted correctly before turning on the power.

• Turn the volume knob all the way down before turning on the power.

Take care when putting the supplement away to ensure that components do not get connected in unforeseen ways that could cause problems!

• Take precautions to ensure that components do not accidentally connect to the plus (+) and minus (-) terminals on the battery.

• If unsure what to do when putting the kit away, assemble the blocks according to the layout shown in the photos for "Assembling the Supplement" on the front and back covers of this supplement.

Note that it might be helpful to detach the covers from the magazine and keep them close at hand when working on the projects in this guide.

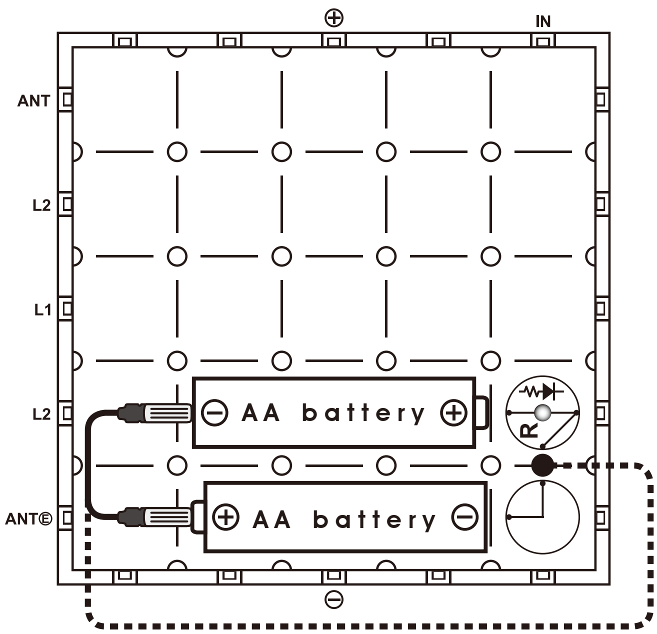
Basic Circuits

No.04 LED ON Voltage

Prepare two AA batteries. Insert the blocks and batteries as shown in the figure, making sure to orient the batteries correctly. Leave the switch turned off for now. Next, attach the lead wire terminals as shown in the figure, making sure that they make contact with the battery terminals as shown. The LED will light up. There is a total of 3 V supplied to the LED at this time, 1.5 V from one battery and 1.5 V from the other. Next, insert the lead terminal that was contacting the plus (+) terminal of the battery in between the blocks in the supplement as indicated by the dotted line in the figure. The LED will remain off. The reason is that only 1.5 V of voltage is supplied at this time instead of the full 3 V. LEDs require a set amount of voltage before they will light up.

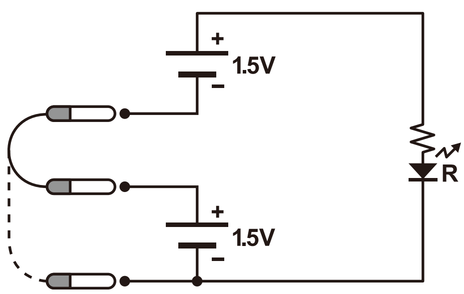
Block Layout Diagram

* In blocks with lighter lines, current only flows along the dark, solid lines.



* Firmly insert the lead wire terminals so that they make firm direct contact with the terminals on the battery.
* Be careful not to short across the plus (+) and minus (-) terminals on the battery.
* Firmly insert the black ball point on the ends of the lead wires into the terminal between blocks at each end.

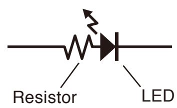
Circuit Schematic



Regarding LED ON voltage

A set amount of voltage needs to be applied across an LED to get it to light up. The amount of voltage required to turn an LED on will depend on the color of the LED. The amount of voltage (forward-bias voltage) required for red LEDs is lowest at around 1.8 V, then 2.4 V for green LEDs, and about 3.6 for blue or white LEDs. The amount of current (forward current) to use is also set. If the amount of current is exceeded, the device will break down. You can control the amount of current allowed to pass through an LED using a standard resistor with a resistance of at least 100 Ω. The LEDs used in this Electronic Blocks mini Supplement are already equipped with resistors inside the respective LED blocks for safety reasons. These resistors will work to prevent the LEDs from breaking down, under normal conditions.

Circuit symbol used to represent LEDs in the Electronic Blocks mini Supplement



Blocks used in this project

Basic Circuits

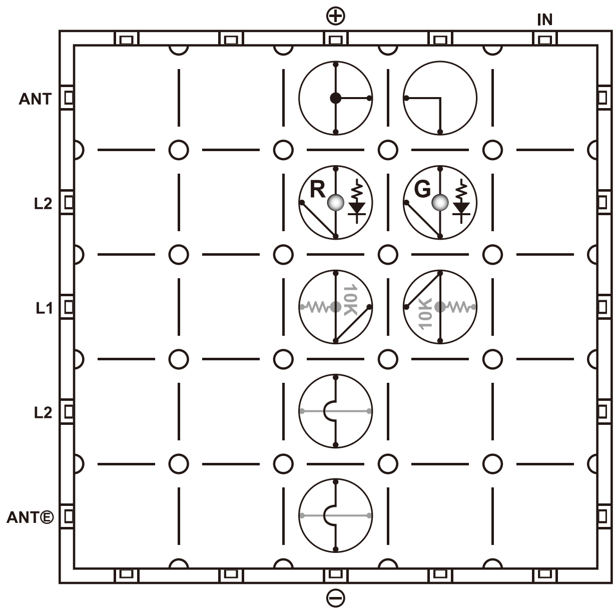
No.05 Parallel and Series LED Circuits

Let's take a look at how two LEDs light up difficulty depending on whether they are connected together in series or in parallel. First, let's connect together a parallel circuit. Line up the blocks as shown in the top figure, and turn on the main switch. The LEDs will light up. Next, try to connect the LEDs together in series. Insert the blocks as shown in the bottom figure and then turn on the main switch. How does the LED light differ from that in the first case?

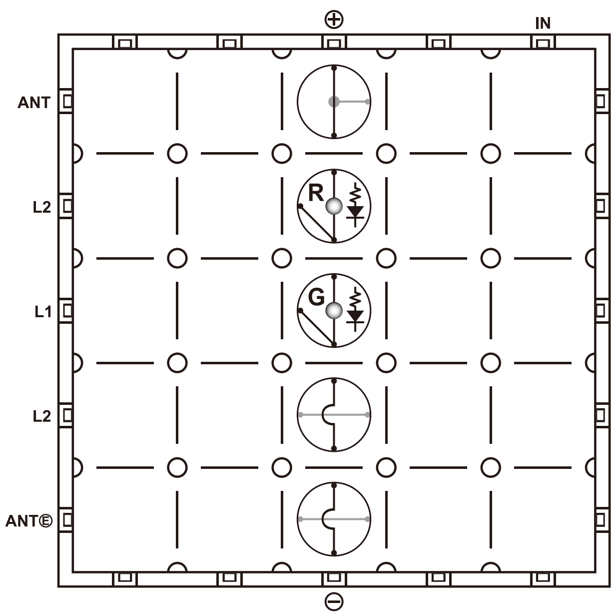
Block Layout Diagram

* In blocks with lighter lines, current only flows along the dark, solid lines.

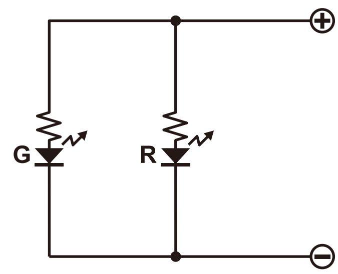
Parallel Circuit



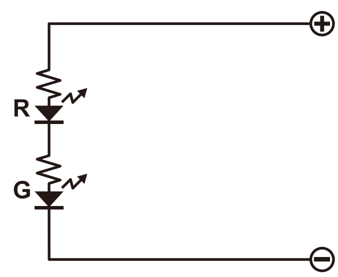
Series Circuit



Circuit Schematic

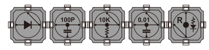


Circuit Schematic



Parallel and series LED circuits

When two LEDs are connected together in parallel, they light up at around the same brightness as just one LED. This is because the same voltage is applied across both as in a circuit with only one LED. However, they are only able to stay lit up for about half the time as when there is just one LED because the batteries are producing twice as much current. When the two LEDs are connected in series, the green LED does not light up as brightly as when it is connected alone. This is because only half as much voltage, or around 2.25 V, is applied to each LED in this case. As there are only 2.25 V applied across the green LED, it does not light up as brightly as when there are around 2.4 V.



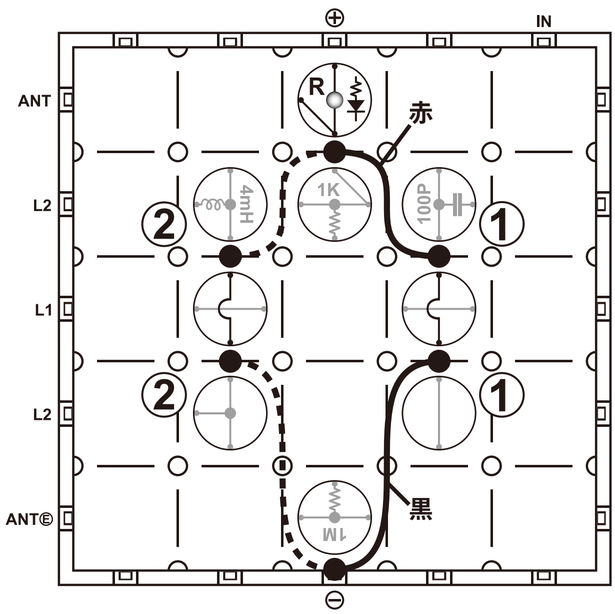
Basic Circuits

No.06 Two-switch Circuit for Turning an LED On/Off

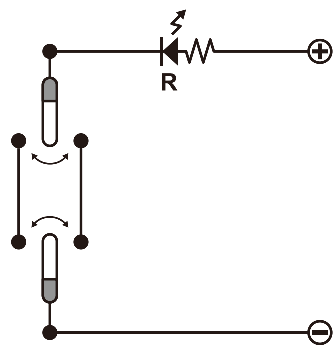
This is a circuit that can be used to turn an LED on and off at two different places using two separate lead wires. Insert the blocks and attach the red and black lead wires as indicated by the solid black lines marked by (1), as shown in the figure. Then, turn the main switch on. The LED will light up. Next, move the black lead wire only over to the dotted line section marked by (2). The LED should turn off. Connect the red lead wire as indicated by the dotted line marked by (2). The LED should turn back on.

Block Layout Diagram

* In blocks with lighter lines, current only flows along the dark, solid lines.



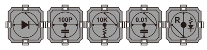
Circuit Schematic



Lighting for a staircase

You may notice that oftentimes staircases in houses have lights mounted at around the halfway point of the staircase. When it's dark and you want to go upstairs, you can turn on the switch at the bottom of the stairs to turn the light on. The switch at the top is turned to the off position. Once you reach the top, you can flip the switch at the top to the on position, which will turn the light off. When you go downstairs, you can repeat this in the opposite direction. This mechanism uses the same kind of circuit as the one used in the above project. The red lead wire in the above circuit represents the switch at the bottom of the stairs and the black lead wire, the switch at the top.

Blocks used in this project



Basic Circuits

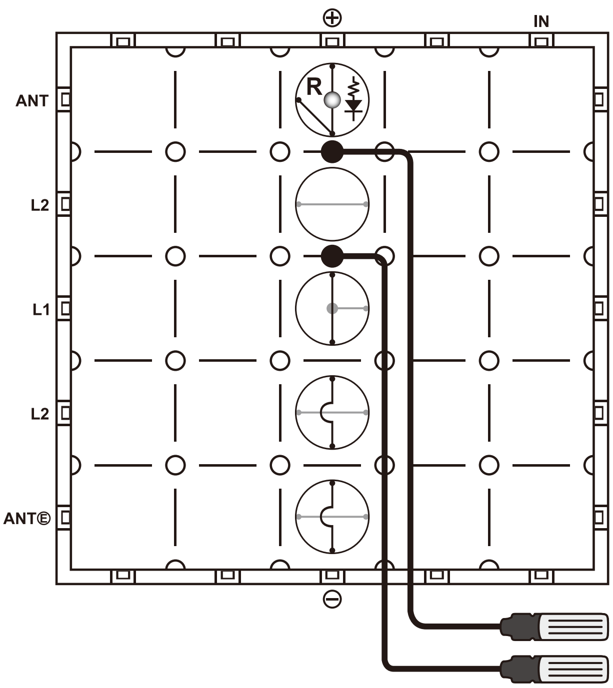
No.07 Conductors and Non-conductors

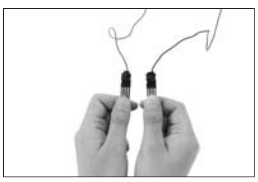
This circuit project uses an LED to check to see if an object is a conductor which passes electricity or a non-conductor (an insulator) which prevents electricity from flowing. Insert the blocks and connect the lead wires as shown in the figure. Touch the terminals on the lead wires to the object you want to test. Turn the main switch on. If the LED lights up, the object you are testing is a conductor. If the LED remains off, the object is probably a non-conductor (an insulator). There may be objects that are conductors that fail this test (where the LED remains turned off) because their electrical resistance is too high.

* Make sure to touch something metal before starting this experiment (like a metal doorknob or window frame) in order to discharge any static electricity you may have built up in your body.

Block Layout Diagram

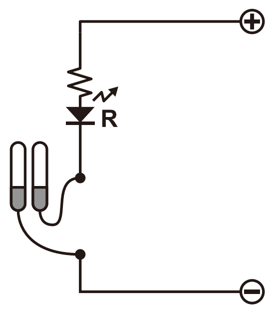
* In blocks with lighter lines, current only flows along the dark, solid lines.



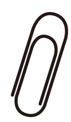


Hold one lead wire terminal in each hand. The human body does act as a conductor. However, it contains a high amount of resistance. This resistance prevents the LED from turning. Even if the LED should light, it would only emit a very faint level of light.

Circuit Schematic

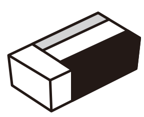


Conductor



Clip

Non-conductor (Insulator)



Eraser

Hold one lead wire terminal in each hand. The human body does act as a conductor. However, it contains a high amount of resistance. This resistance prevents the LED from turning. Even if the LED should light, it would only emit a very faint level of light.

Semiconductors

Most objects in our world are either conductors or non-conductors. There are conductors that like metals contain particles (electrons) that carry charge and also those that like water in a pipe contain particles (ions) that pass electricity.

There are also rather unique materials that cannot be called either a conductor or a non-conductor. These materials are called semiconductors. The number of particles that these materials contain that conduct electricity is somewhere between that for conductors and that for non-conductors. At times, they act as a conductor, and at other times, as a non-conductor. There are a lot of different conditions and properties that determine under what conditions they act as conductors and under what conditions they act as non-conductors.

If you study the characteristics of these materials and learn how to combine them properly, you can use them to create high-performance electronic components such as diodes and transistors. Semiconductors actually serve as the main components of TVs and computers. Most semiconductors in use today are made using silicon. Other new base materials that are becoming more popular include gallium and arsenic (such as in gallium arsenide).

Basic Circuits

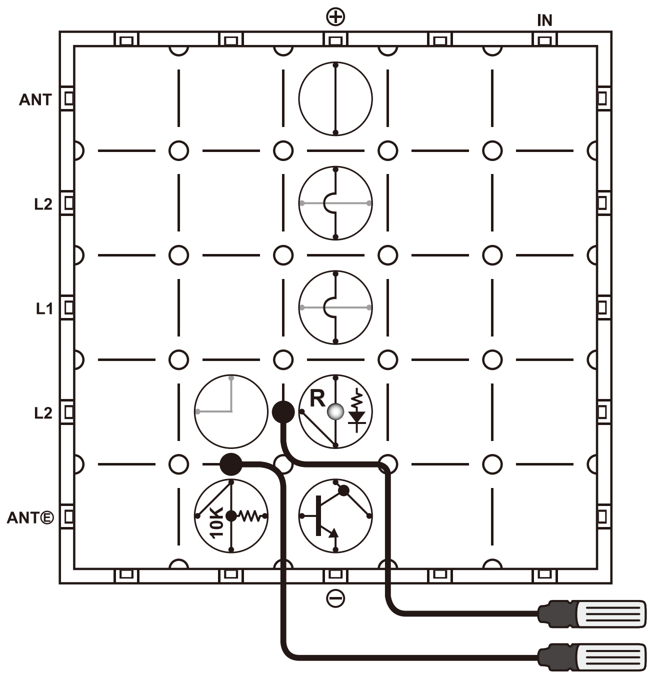
No.08 Transistor Current Gain

Arrange the blocks as shown in the figure, connect the lead wire terminals as indicated and grasp one in each hand, and then turn on the main switch. Although the LED in Circuit No. 07 either didn't light up or only lit up weakly due to the large amount of resistance in the human body, it should light up brightly in this circuit because the amount of current flowing is amplified by the transistor by about 150 times. As can be seen through this experiment, the transistor can be used to amplify a slight amount of current flowing through the base to produce a large current to flow between the collector and emitter.
* It may be difficult to see the LED light in bright areas. Try it in a darker area if you can't see the LED light clearly.

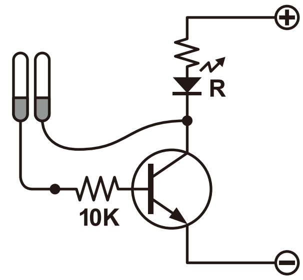
* Make sure to touch something metal before starting this experiment (like a metal doorknob or window frame) in order to discharge any static electricity you may have built up in your body.

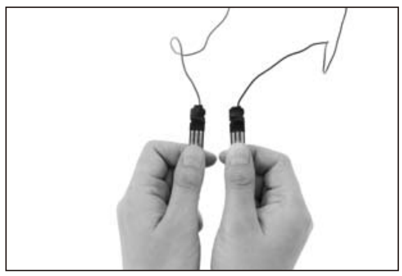
Block Layout Diagram

* In blocks with lighter lines, current only flows along the dark, solid lines.



Circuit Schematic

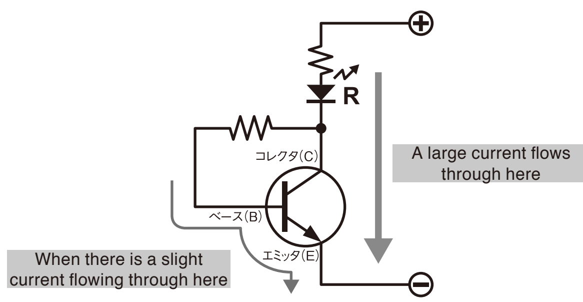


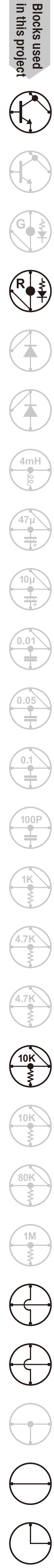


Hold one lead wire terminal in each hand. The slight amount of current that flows through the base of the transistor will be amplified, causing the LED to light up brightly.

Why does a large current flow through the transistor from the collector?

The transistor produces a large amount of current from the collector (C) to the emitter (E) when a slight current is made to flow from the base (B) to the emitter (E). The current flowing between the collector (C)—emitter (E) is 150 times that flowing from the base. This occurs due to the transistor's amplifying property. The amount of current flowing through the base (B) is amplified little by little, and the amount flowing between the collector (C)—emitter (E) is also amplified simultaneously.
This property allows a large electrical signal to be controlled using a small one.
Of course, you can't just magically produce a large electric signal from a small one. The reason why such a large current flows between the collector (C) and emitter (E) in the transistor from the slight current flowing from the base (B) to the emitter (E) is because the resistance between the collector (C)—emitter (E) is infinitesimally small.





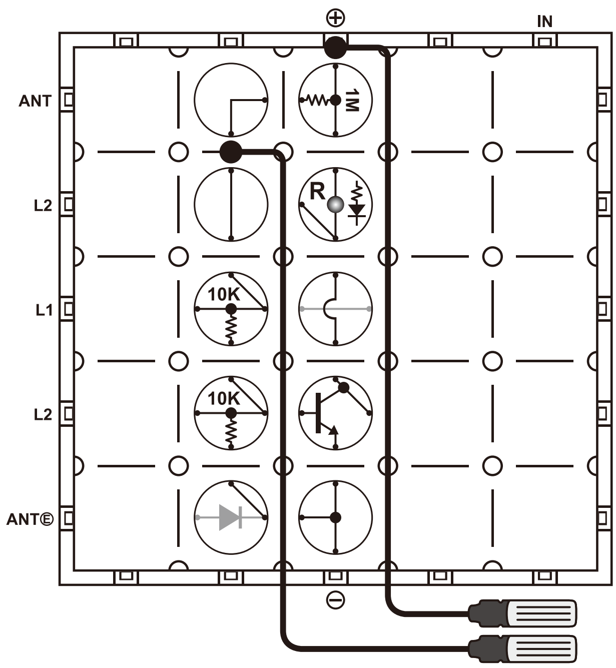
No.09 Transistor Switching Property

One of the functions of the transistor is to act as a switch. The transistor switching property is used to turn a switch on and off using slight changes to currents running to the base. Insert the blocks and connect the lead wires as shown in the figure and then turn the main switch on. The LED will remain off. Touch the two lead wire terminals together. The LED will light up. Touching the lead wire terminals together increases the current flowing to the base, which activates the transistor's switch property.

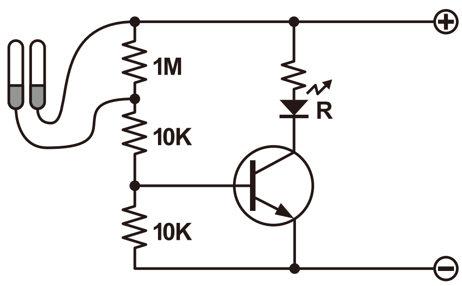
* Make sure to touch something metal before starting this experiment (like a metal doorknob or window frame) in order to discharge any static electricity you may have built up in your body. When holding onto the lead wire terminals, make sure to grip the black wire coverings.

Block Layout Diagram

* In blocks with lighter lines, current only flows along the dark, solid lines.



Circuit Schematic

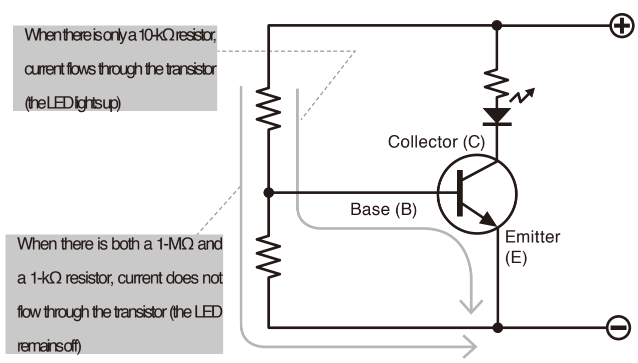


Turning components on and off with a transistor

The collector current in a transistor is around 150 times the base current (using the transistor current gain property). The amount of base current flowing through the circuit will determine whether the component is turned on or off using the switch property of the transistor.

When the lead wire terminals are touched together in the circuit pictured above, current flows through the 10-kΩ resistor and through the base on the transistor, and the LED lights up. When you let go of the terminals, current flows through the 1-MΩ and 10-kΩ resistors, preventing current from flowing into the transistor and the LED remains off. To put it another way, you can turn a component on and off like a switch by controlling the amount of current that flows to the transistor. This comes from the transistor's switching property.

The word "transistor" comes from "transfer" and "resistor." As such, the word "transistor" refers to a component that transfers resistance. One of the main advantages of the transistor's on/off switching property is that you can use it to turn a large current on/off using a small current.



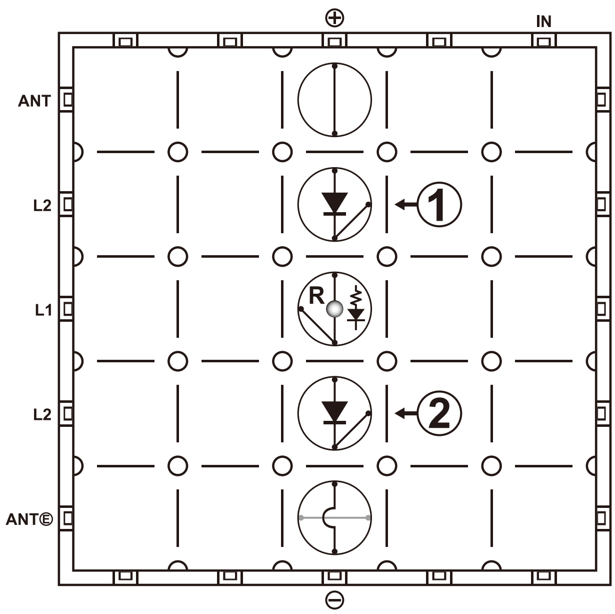
Basic Circuits

No. 10 Diode Characteristics

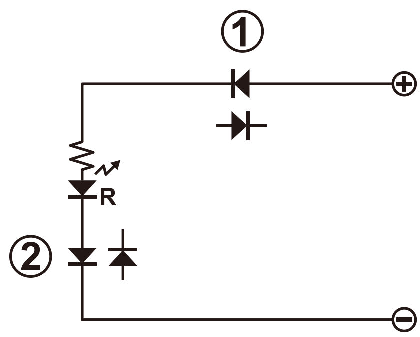
Insert the blocks as shown in the figure and then turn on the main switch. The LED will light up. Next, try flipping the diode (1) block around the other way as indicated in the figure. The LED should stay off. Turn off the main switch, and return the diode (1) block to its original orientation. Then, flip the diode (2) block around the other way as indicated in the figure. The LED should remain off even after the main switch is turned on. This is because current will not flow through a diode circuit unless all of the diodes are oriented correctly with regard to the plus (+) and minus (-) terminals.

Block Layout Diagram

* In blocks with lighter lines, current only flows along the dark, solid lines.



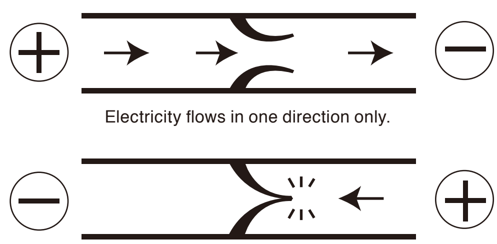
Circuit Schematic



Two diode properties,“ rectification” and “detection”

The characteristic of a diode to only pass current in a single direction is referred to as its “rectification property.” It can only pass current in one direction and thus cannot pass current coming from the opposite direction. You can use this rectifying property to control the direction of the flow of current within a circuit. It allows the diode to be used like a valve for when you want to keep electricity from flowing backwards in a circuit. One of the main advantages of this property, however, is its ability to rectify AC voltage and convert it to DC voltage. The electricity coming out of a residential electrical outlet is an AC voltage. But most of the electronic devices that we use in our everyday lives run on DC power. That’s why rectification is needed to convert the electricity from a wall outlet into a voltage that devices can use. The detection property of a diode is used to enable the radio signals coming from an AM radio station or other station into audio signals that can be heard by the human ear. Music and voice broadcasts at a radio station cannot be broadcast over the airwaves as is. They wouldn’t be able to travel over the long distances required to reach their listeners without some help. That’s why radio stations transmit voice and music broadcast signals together with electromagnetic signals (radio waves) using a radio antenna. Diode detection is to extract voice and music signals from the radio waves broadcast from a radio station so that they can be heard and enjoyed by their listeners. Diodes are essential components for radios, all thanks to this detection property that they possess.

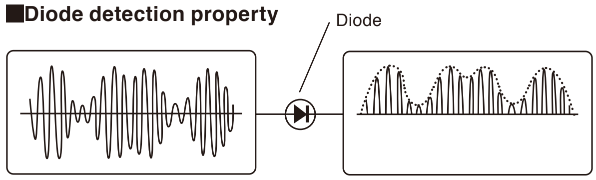
■Diode rectification property



Electricity flows in one direction only.

Electricity does not flow in the opposite direction.

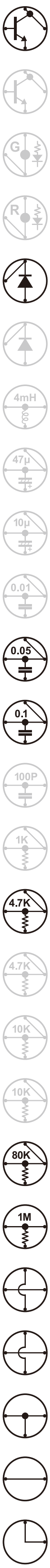
■Diode detection property



Waveform before detection applied

Waveform after detection applied

Blocks used in this project



Amplifier Circuits

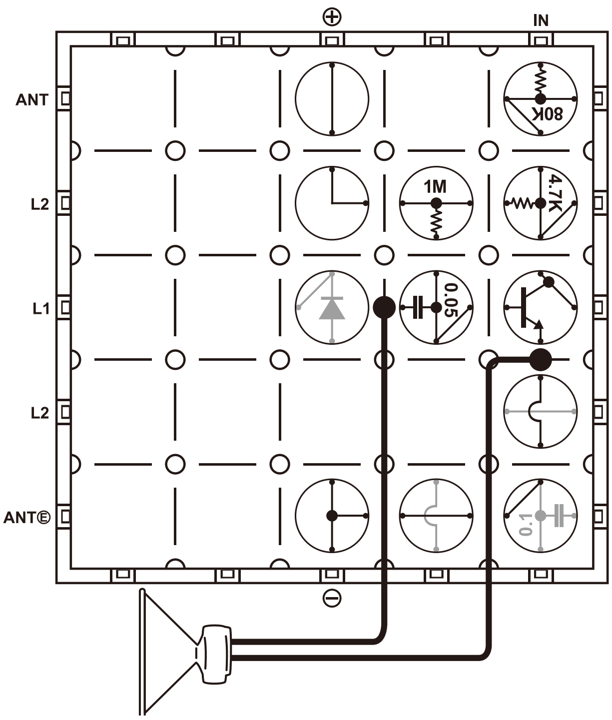
No. 11 Single-transistor IC Amplifier with Fixed Bias

This project marks the start of the amplifier circuit projects section. Sound input from a microphone is amplified and then released. Insert the blocks and connect the microphone as shown in the figure and then turn the main switch on. When you say something into the microphone, the sound should be output from the speaker at increased volume (if you hear a whistling or beeping sound, you may be experiencing howling. Try moving the microphone and speaker away from each other, turning down the volume, etc.).

* Howling occurs due to sound from the speaker feeding back into the microphone (sound from the speaker loops back into the microphone).

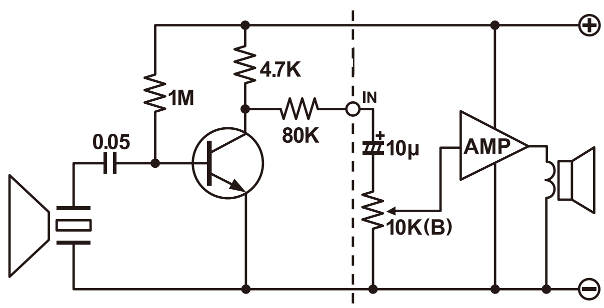
Block Layout Diagram

* In blocks with lighter lines, current only flows along the dark, solid lines.



Circuit Schematic

The section to the right of the dotted line is the schematic for the internal IC amplifier.



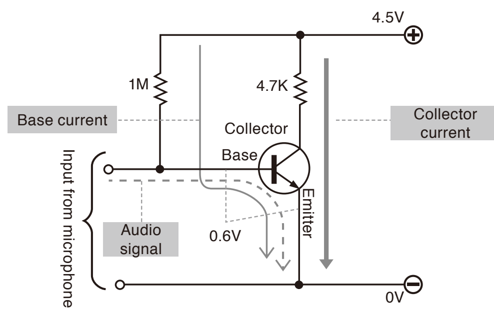
●Circuit Mechanism

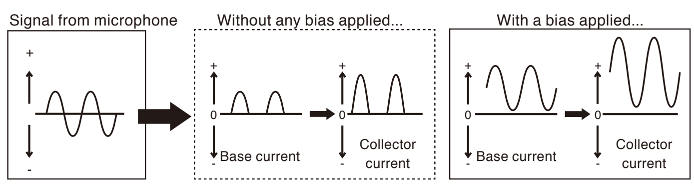
The schematic shown is for a fixed-bias amplifier circuit. A bias is applied to the base of the transistor through a 1-MΩ resistor. The fixed-bias amplifier circuit is not as stable as the self-bias circuit that we will look at in the next project in this guide. However, it's a simpler circuit, which makes it a popular choice. The 4.7-kΩ resistor on the collector is a load resistor, and the 80-kΩ resistor connected to the amplifier is used to adjust sound volume.

What is a bias?

Transistor-based amplifiers take audio signals input to the emitter from the base and amplify them between the collector and emitter before outing them. This voltage is then applied to the next amplifier in the cycle and so on until it reaches the target voltage. The audio signals input from the microphone are applied to the base for amplification by the transistor. However, if the signals are merely input from the microphone to the base as is, the base—emitter junction will work as a diode and cut off signals of negative polarity. To prevent this from happening, a resistor is inserted between the power supply and the base. A voltage is then applied between the base and emitter junction (usually 0.6 V) that pulls the voltage signals up to the positive side. This operation is referred to as "applying a bias" and the current made to flow into the base referred to as the "base current." The base on the transistor in this circuit is connected to the power supply voltage through a 1-MΩ resistor in order to apply a bias to the circuit. The bias applied in this way is called a "fixed bias."

When current flows through the base, a corresponding amplified current flows from the collector to the emitter. This current is known as the "collector current." A resistor or similar component is used to draw a voltage from the collector. The 4.7-kΩ resistor in this circuit fulfills this role. A resistor applied in this way is called a "load resistor."





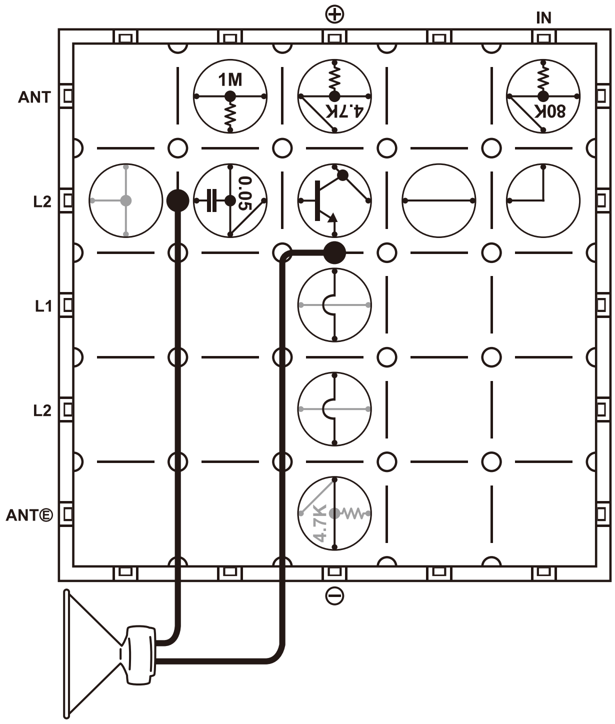
Amplifier Circuits

No. 12 Single-transistor IC Amplifier with Self Bias

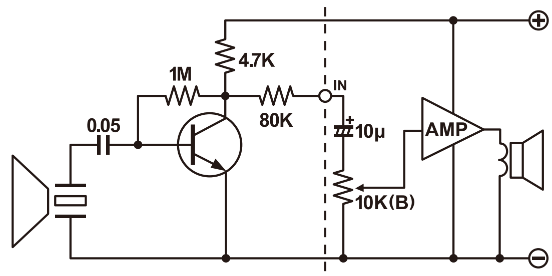
Insert the blocks and connect the microphone as shown in the figure and then turn the main switch on. When you speak or call into the microphone, a corresponding sound will be emitted from the speaker at a louder volume. If you hear any whistling or beeping sounds coming from the speaker, adjust the volume using the volume knob until they go away. Unlike thone circuit used in project No. 11, you can see that the 1-MΩ resistor used in this circuit to apply the bias to the base is not connected directly to the power supply voltage. Instead, it is connected indirectly through the 4.7-kΩ resistor connected to the collector. Circuits connected in this way are referred to as "self-bias circuits."

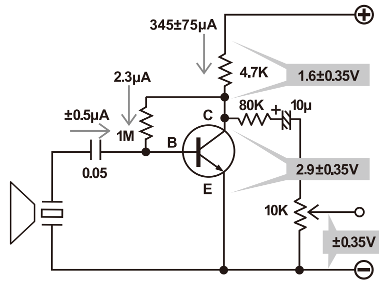
Block Layout Diagram

* In blocks with lighter lines, current only flows along the dark, solid lines.



Circuit Schematic



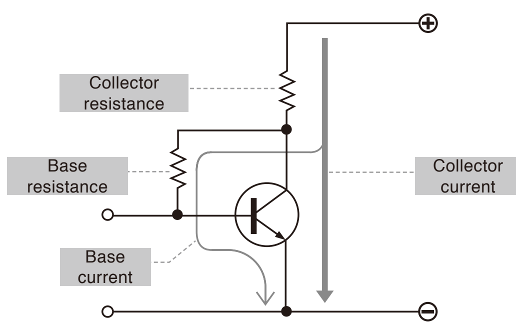


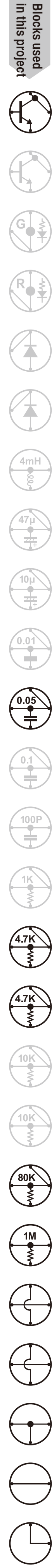
●Circuit Mechanism

Look at the figure on the right. The 4.7-kΩ collector resistor applies a bias to the base of the transistor through the 1-MΩ base resistor. The bias applied is considered a self-bias. It stabilizes when the base current and the collector current are low at 2.3 μA and 345 μA, respectively, under normal conditions. Let's consider an example where the signal current from the microphone is ±0.5 μA. Putting the current gain at 150 and using a base current of 2.3 μA ± 0.5 μA yields a collector current of 345 μA ± 75 μA, which produces a voltage of 1.6 V ±0.35 V across the load resistor connected to the collector. You can use these properties to produce an extra voltage of ±0.35 V.

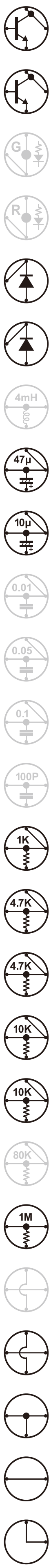
What is a self-bias?

Current needs to be applied to the base on a transistor in order to activate the transistor.
Transistors are affected by a property by which the current gain increases as the temperature increases. Because of this characteristic, transistors may fail to behave according to design specifications even when the appropriate base current is applied because the collector current increases or decreases too much due to changes in temperature. The self-bias circuit was designed to combat this problem. Take a look at the circuit schematic at right. The circuit is designed such that the base current flows through the resistor connected to the collector. This connection layout ensures that the base current will drop as the collector current increases. The collector current, amplified from the base current, will then begin to decrease. This will help to stabilize the collector current. This mechanism is referred to as feedback. This is called self-bias because the transistor works to control itself.





Blocks used in this project

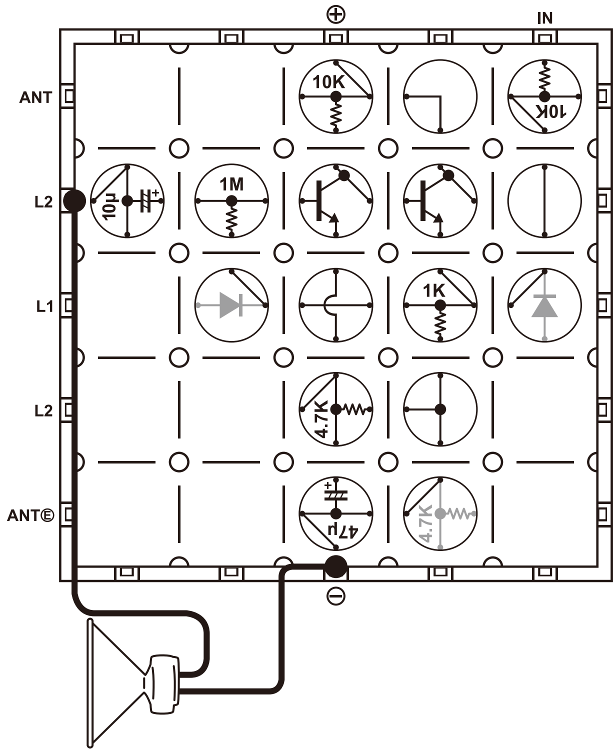


No. 13 Two-transistor Direct-coupled IC Amplifier

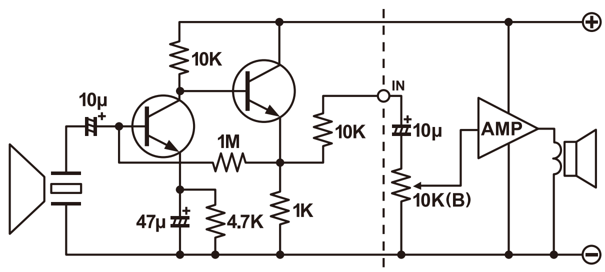
Insert the blocks and connect the microphone as shown in the figure and then turn the main switch on. When you speak or call into the microphone, a corresponding sound will be emitted from the speaker at a louder volume. Take a look at the way in which the two transistors are arranged in the circuit. The collector on the first transistor is directly connected to the base on the other. The “direct-coupled” arrangement used here refers to a circuit connection in which the collector on one transistor is directly connected, or coupled, to the base on the other.

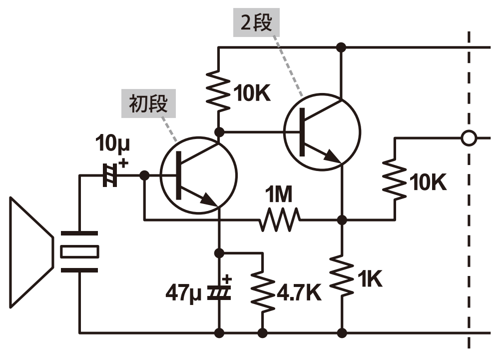
Block Layout Diagram

* In blocks with lighter lines, current only flows along the dark, solid lines.



Circuit Schematic



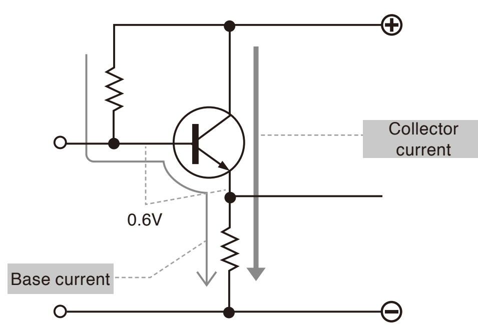


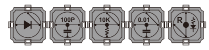
●Circuit Mechanism

First, the audio signals from the microphone are passed through the base on the first transistor and amplified. They are then input from the collector on the first transistor to the base on the second transistor where they are once again amplified. This two-transistor IC amplifier circuit is characterized for its biasing method. The self-biasing feature enables it to be used as an more stable amplifier circuit. When the temperature or other conditions change, the base current of the first transistor goes up, causing the collector current to go up and the collector voltage to go down. The base voltage and even the emitter voltage of the second transistor drop, but the 1-MΩ resistor keeps the conditions of the base from varying further. The circuit cycles through these changes and returns to its original state rather quickly, applying a stable bias to compensate for any changes that occur in the transistors.

Emitter follower circuit

The amplifier circuit of the second transistor has a load not on the collector but on the emitter. This amplifier circuit, called an “emitter follower circuit,” is completely different from the amplifier circuits we have looked at so far. The emitter follower circuit is noted for two characteristics: One is that it amplifies the current 150× for a signal voltage amplification of 1×, and the other is that the output voltage is always around 0.6 V lower than the base voltage, independent of the value of the emitter resistance in either case. This type of circuit does not amplify the output but does provide an extremely stable output that makes it useful not only for direct-coupled circuits but also for driving circuits for speakers and motors, amplifier circuits with high-quality amplifiers, and other such applications.



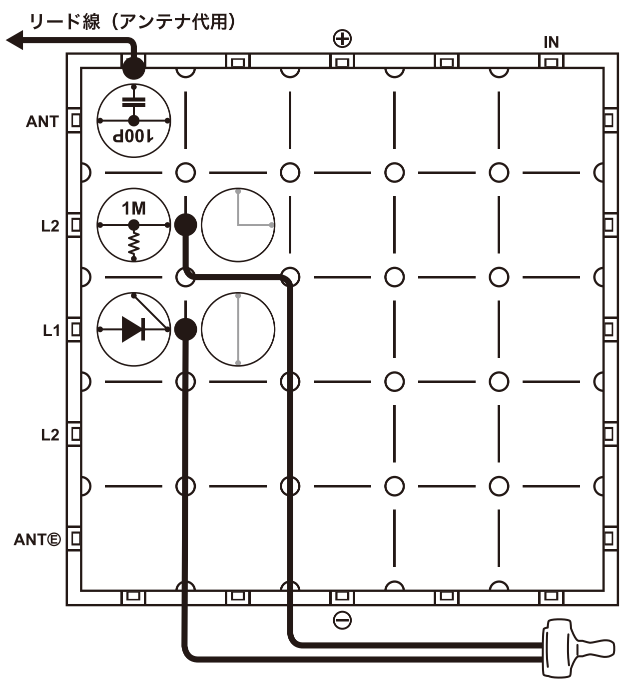


No. 14 Diode Detector Radio

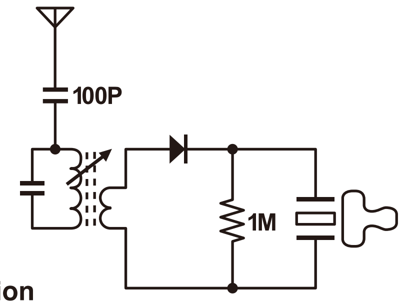
Arrange the blocks and attach the earphone and a lead wire, which will serve as an antenna, as shown in the figure. Leave the main switch turned off for now. Put the earphone into one of your ears. Turn the tuning knob back and forth bit by bit until you find a radio broadcast station that you can pick up. Diode detector radios operate using electromagnetic signals transmitted from radio broadcast stations. They use the sound produced by oscillating waves disturbing the surrounding air. For this reason, it is important that the receiver be placed in a good location with little interference to increase the chances of the signal being picked up. It may be difficult to hear the transmitted sounds inside buildings and in other places with weak signal reception. Refer to page 49 for ideas on how you can improve radio signal reception such as by connecting an antenna, trying in the evening of a clear day, and so on.

Block Layout Diagram

* In blocks with lighter lines, current only flows along the dark, solid lines.



Circuit Schematic

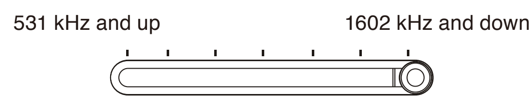


●Caution

This radio circuit has low sensitivity. It may not be able to pick up broadcast signals at all times depending on the strength of the radio signals being broadcast. The signals may be too weak to pick up adequately in certain areas, even if you add an outside antenna or try other methods to improve conditions.

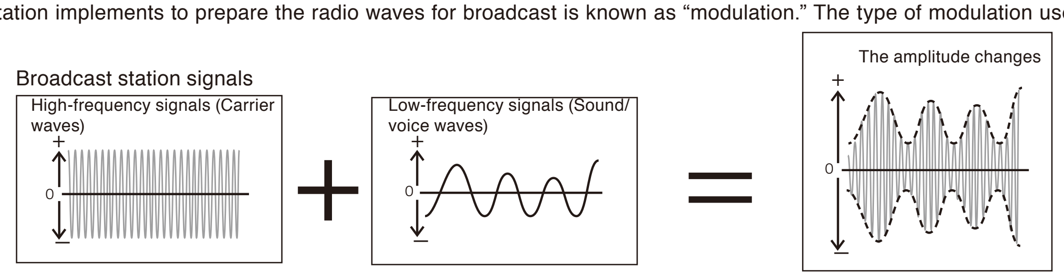
*** Frequencies corresponding to tuning knob positions**

The frequency band for the radio circuits in the Electronic Blocks mini supplement ranges from 531 kHz to 1602 kHz (along the sliding indicator). Turn the tuning knob to the left for lower frequencies.



Radio station broadcast signals

Radios use high-frequency signals. These high-frequency signals change in polarity from plus to minus and back again at rapid speed. As the direction of flow of electricity begins to change at higher speeds, electricity can travel not only through transmission lines directly but also through air as electromagnetic waves traveling at the speed of light. The frequencies of signals that can be received range from 531 kHz to 1602 kHz for AM radio and from 76 MHz to 90 MHz for FM radio (in Japan). The “k” in kHz stands for “kilo,” which is 1000 times, and the “M” in MHz for “mega,” which is 1,000,000 times. The signals that can be heard by the human ear are low-frequency tones. However, low-frequency signals cannot be broadcast over air as electromagnetic signals. AM broadcast stations broadcast AM radio signals using high-frequency signals that have been converted in direct proportion to low-frequency signal waveforms. The broadcast signal is strong when the low-frequency signal is high in amplitude and weak when the signal is low. High-frequency signals that transmit low-frequency signals are referred to as "carrier waves." The process that the broadcast station implements to prepare the radio waves for broadcast is known as “modulation.” The type of modulation used here in which low-frequency signals are transmitted by varying the strength of the carrier waves is known as AM.
(“AM” is short for “amplitude modulation.”)



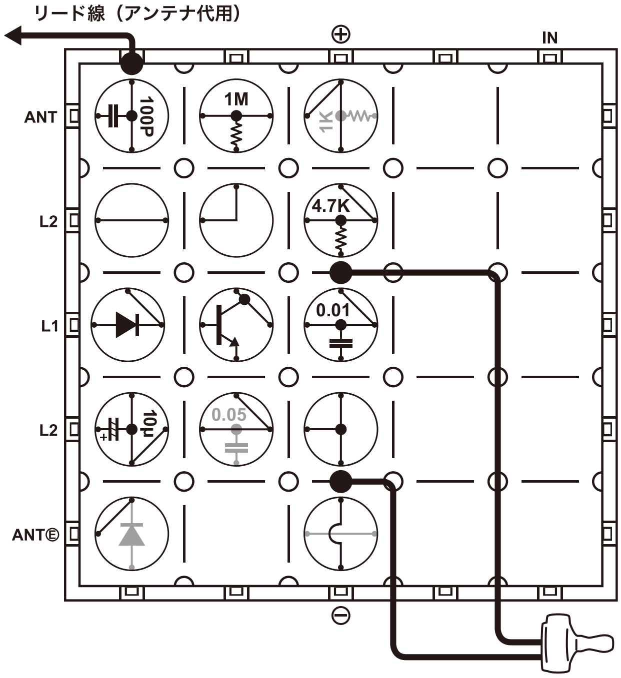
Radio Circuits

No. 15 Single-transistor Diode Detector Radio

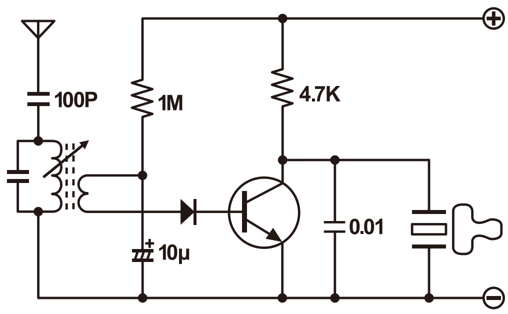
This is a radio circuit in which a single-transistor-based amplifier is connected to a diode detector radio. Arrange the blocks and attach the earphone and a lead wire, which will serve as an antenna, as shown in the figure. Then, turn on the main switch. Put the earphone in one of your ears. Turn the tuning knob back and forth bit by bit until you find a radio broadcast station that you can pick up. The amplifier will work to increase the volume of the sound. The sensitivity of this circuit is not high enough for it to work well as a good radio, however. The diode detector signal will be weak in areas with low reception, so you may experience times where all you encounter is noise (a static sound), even if you try to amplify the signal using the amplifier.

Block Layout Diagram

* In blocks with lighter lines, current only flows along the dark, solid lines.



Circuit Schematic



● Caution

This radio circuit has low sensitivity. It may not be able to pick up broadcast signals at all times depending on the strength of the radio signals being broadcast. You may not be able to pick up signals in certain areas, even if you add an outside antenna or try other methods to improve conditions.

●Circuit Mechanism

You can see that there is a bias applied to the transistor through the secondary coil of the tuning coil (refer to Circuit No. 18 for reference) from the 1-MΩ resistor. The secondary coil of the tuning coil has fewer windings than the primary coil. This enables it to be used to amplify current. This ensures that radio signals are kept stable with little change in the signal current, even if a current is passed through the base of the transistor. The 10-μF capacitor in the circuit reliably applies the signal current generated in the secondary coil to the transistor while blocking direct current signals from passing through. The 0.01-μF capacitor connected across the crystal earphone is there to cut off any remaining high-frequency signals that have gotten through.

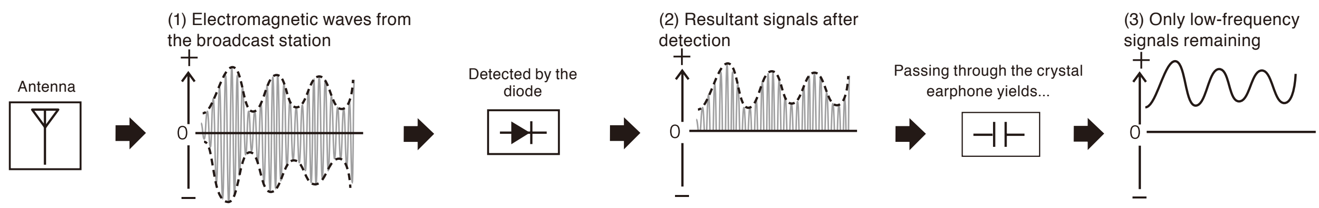
Mechanism behind radio detectors

Radio detectors are used to extract low-frequency signals (sounds) from the high-frequency signals (waves) selected by the tuning circuit. Take a look at the figures below.

(1) The same electromagnetic waves transmitted to the tuning circuit from the broadcast station are sent to the diode.

(2) Diodes pass current flowing only in a certain direction. They thus enable you to pass waves of only one polarity from waves that are changing from plus to minus and back again.

(3) The crystal earphone acts as a capacitor to cut off high-frequency signals, leaving only low-frequency signals behind.

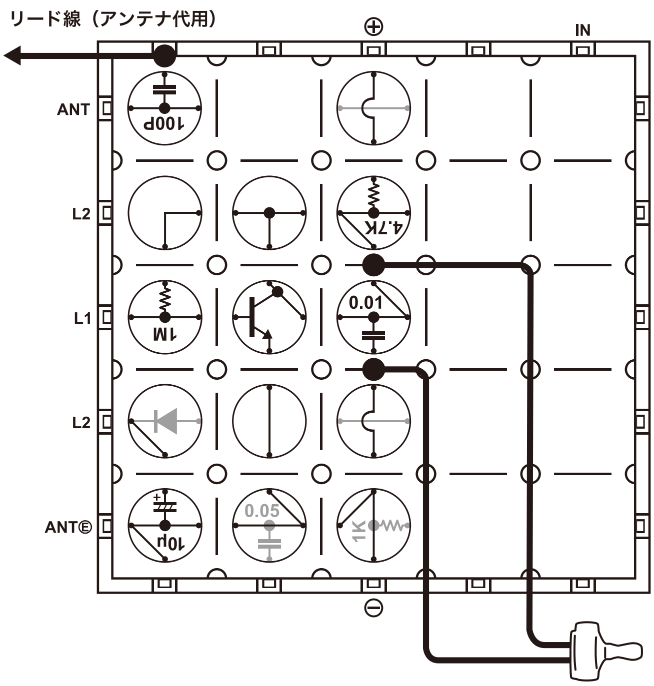


No. 16 Single-transistor Transistor Detector Radio

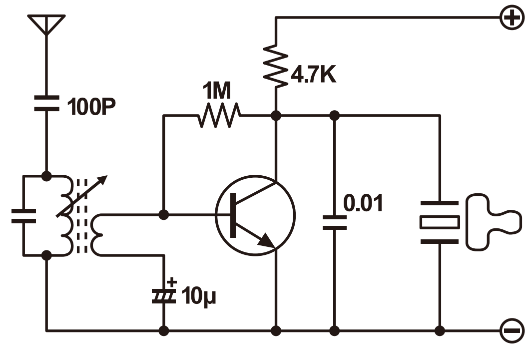
Arrange the blocks and attach the earphone and a lead wire, which will serve as an antenna, as shown in the figure. Then, turn on the main switch. Put the earphone in one of your ears. Turn the tuning knob back and forth bit by bit until you find a radio broadcast station that you can pick up. The transistor will work to detect and then amplify high-frequency signals. In other words, in this circuit, a transistor is used to detect signals in place of a diode.

Block Layout Diagram

* In blocks with lighter lines, current only flows along the dark, solid lines.



Circuit Schematic



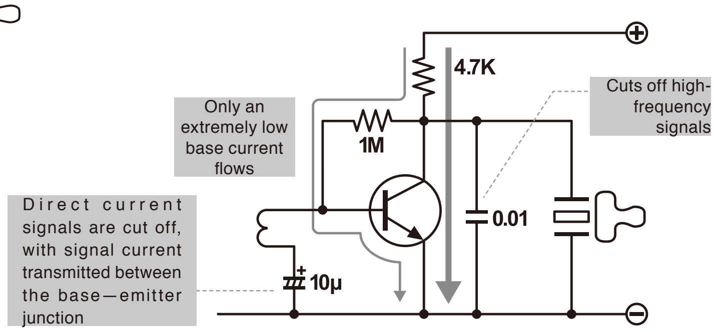
●Caution

This radio circuit has low sensitivity. It may not be able to pick up broadcast signals at all times depending on the strength of the radio signals being broadcast. You may not be able to pick up signals in certain areas, even if you add an outside antenna or try other methods to improve conditions.

●Circuit Mechanism

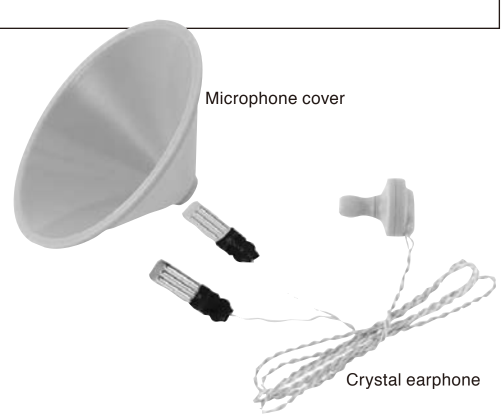
This circuit is the same as Circuit No. 15, Single-transistor Diode Detector Radio, except without the diode.

Amplifiers are self-biasing circuits (refer to Circuit No. 12). This particular amplifier circuit is not used to stabilize the amplifier circuitlike a standard amplifier. The main purpose of this circuit is to increase the resistance in the circuit so as to restrict the flow of current to enable transistor detection.



Crystal earphone

Early crystal earphones were formed using Rochelle salt crystals. Even though they had high sensitivity, they degraded quickly and, for this reason, are no longer made. The crystal earpieces manufactured and sold today are formed of a ceramic material. The one included in this Electronic Blocks mini supplement is also of the ceramic type. Crystal earpieces produce clear sounds with extremely high sensitivity levels, making them an obvious choice in diode detector radios and similar applications. However, the low-pitched tones they produce are too soft, and sounds become distorted easily with larger input levels, meaning that they produce low sound quality. They cannot adequately meet the needs of more recent applications, so they have fallen in popularity in recent years. In this Electronic Blocks mini supplement, the crystal earphone provided can also be used as a microphone when the microphone cover is attached.



Blocks used in this project