



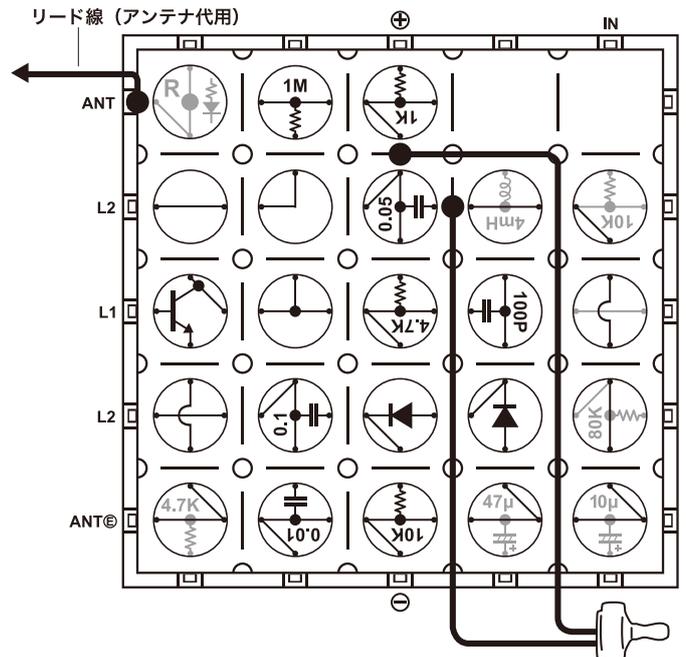
No. 17

Single-transistor Reflex Radio

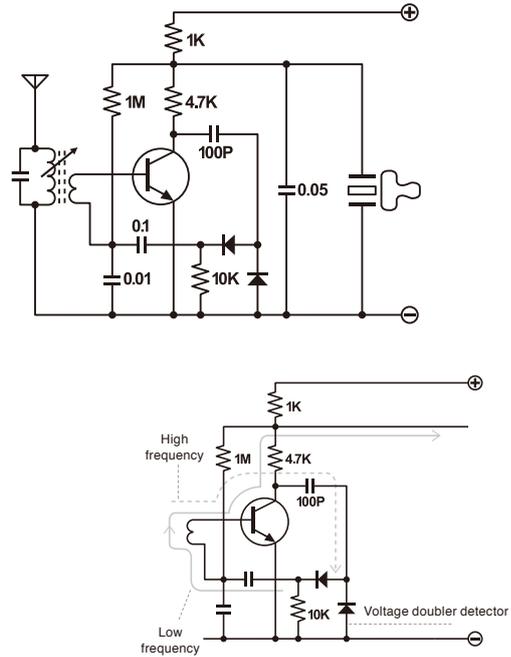
Arrange the blocks and attach the earphone and a lead wire (used as an antenna) as shown in the figure. Then, turn on the main switch. Put the earphone in one of your ears. Turn the tuning knob back and forth bit by bit until you find a radio broadcast station that you can pick up. The transistor first amplifies high-frequency signals and then amplifies the low-frequency signals detected by the diode that have been returned to the transistor. A radio that works to amplify both high-frequency signals and low-frequency signals using the same single transistor, as described, is known as a "reflex radio."

Block Layout Diagram

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



Circuit Schematic



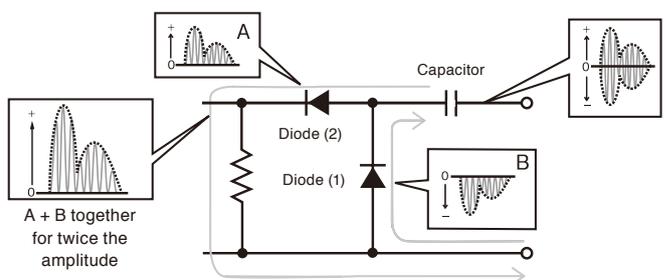
●Circuit Mechanism

As a basic outline, the transistor-based amplifier circuit formed using the 1-kΩ resistor and 1-MΩ resistor connected to the base and the 1-kΩ resistor and 4.7-kΩ resistor connected to the collector operates twice, once for high-frequency signals and once for low-frequency signals. First, the high-frequency signal current is received from the secondary coil of the tuning coil. The current is amplified by the transistor as it flows along the path indicated by the dotted line in the figure at right. The 100-pF capacitor passes only high-frequency signals. As shown, the high-frequency signals flow along the path indicated by the dotted line to enter the voltage doubler detector circuit (described below). The signal current output from the voltage doubler detector passes through the secondary coil of the tuning coil and back into the transistor-based amplifier circuit. The 10-kΩ resistor along this path is the load resistor for the diode in the voltage doubler detector circuit and functions to ensure that the signal reliably flows between the base—emitter junction in the transistor. The secondary coil of the tuning coil generates a slight induction effect (see p. 48 for details) that is used to help remove high-frequency components left remaining in the detected signals to make sure that only low-frequency components are passed. The amplified low-frequency signals are output to the earphone.

* A high-frequency coil should be used as the load of the high-frequency amplifier circuit. However, in this circuit, a 4.7-kΩ resistor is used instead, to simplify the circuit structure.

What is a voltage doubler detector circuit?

When there is no diode (1) connected, only high-frequency signals of positive polarity are passed through diode (2) and into the resistor. When diode (1) is inserted into the circuit, high-frequency signals of negative polarity are stored in the capacitor and then combined with the high-frequency signals of positive polarity. The voltage is then doubled and applied across the resistor through diode (2). This kind of circuit configuration produces twice the detector output as when only diode (2) is used. This type of circuit is referred to as "voltage doubler detector circuit."



No. 18

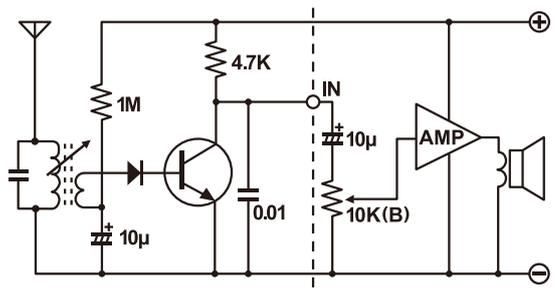
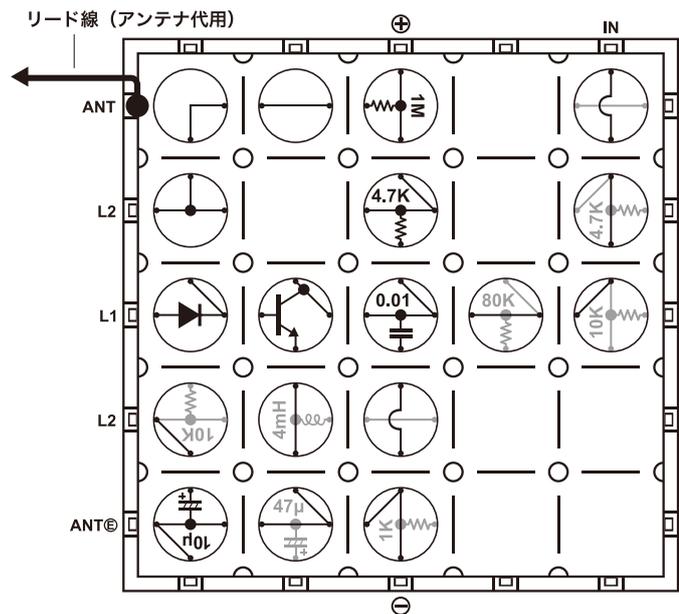
Single-transistor Diode Detector Radio with IC Amplifier

In this circuit, the output of the Single-transistor Diode Detector from Circuit No. 15 is connected to an IC amplifier. After signals are detected by the diode and amplified by the transistor, they are again amplified using an IC amplifier. Arrange the blocks and attach a lead wire that will serve as an antenna as shown in the figure. Then, turn on the main switch. Adjust the volume using the volume knob. Turn the tuning knob back and forth bit by bit until you find a radio broadcast station that you can pick up.

Block Layout Diagram

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

Circuit Schematic

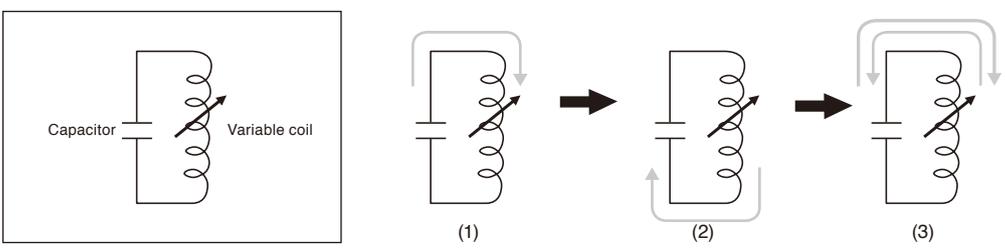


Caution
This radio circuit has low sensitivity. It may not be able to pick up broadcast signals at all times depending on the strength of the radio signals being broadcast. You may not be able to pick up signals in certain areas, even if you add an outside antenna or try other methods to improve conditions.

Mechanism behind radio tuning

The tuning circuit is formed of a coil (a tuning coil is similar to an antenna coil) and capacitor connected to each other in parallel. Take a look at the figures below. Consider a case in which electric charge is stored in the capacitor. (1) The capacitor discharges electricity in the direction of the coil (variable coil). (2) Once the capacitor finishes discharging, the coil tries to maintain the flow of current through self-induction (refer to p. 48 for reference). The capacitor then begins charging electricity of reverse polarity, which leads to the repeated discharging and charging of the capacitor shown in (3). The coil and capacitor pass the electricity back and forth between each other, like a game of catch. The frequency of these repetitions is determined by a single value based on the value between the coil and capacitor, which makes it a "fixed frequency." The antenna attached to the tuning circuit picks up electromagnetic waves of a variety of frequencies. Only waves of a fixed frequency are received by the antenna because other waves do not produce a repetitive exchange of charged electricity between the coil and the capacitor. The movement of the ferrite coil (tuning knob) used in the Electronic Blocks mini supplement can be changed easily using a fixed frequency. You can thus use the tuning circuit to select the frequency of the broadcast station that you want to listen to.

• Tuning circuit





Radio Circuits

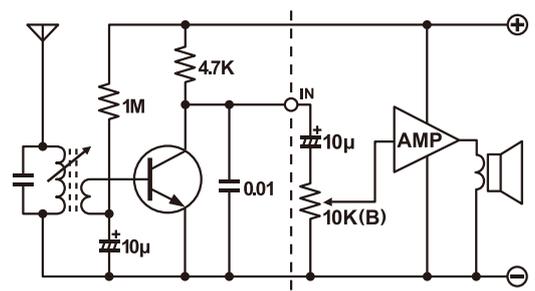
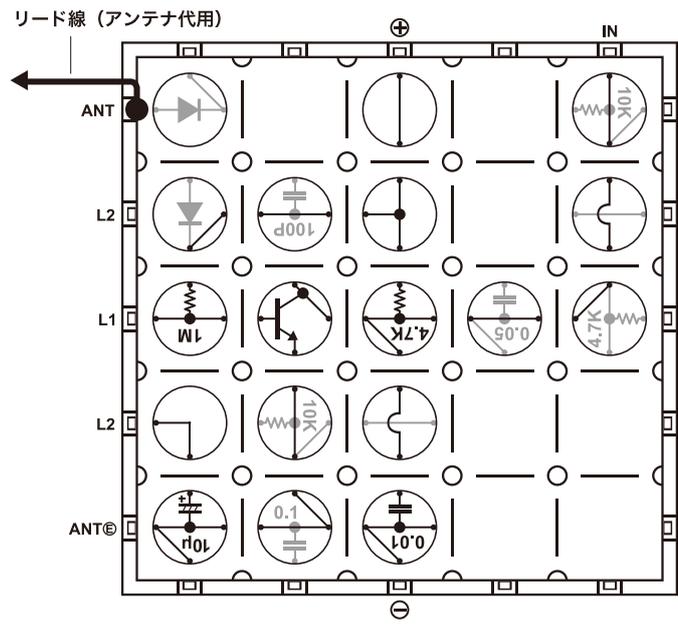
No. **19**

Single-transistor Transistor Detector Radio with IC Amplifier

Arrange the blocks and attach a lead wire (used as an antenna) as shown in the figure. Then, turn on the main switch. Adjust the volume using the volume knob. Turn the tuning knob back and forth bit by bit until you find a radio broadcast station that you can pick up. This circuit is the same as Circuit No. 18, except without the diode. The transistor functions to both detect as well as amplify signals.

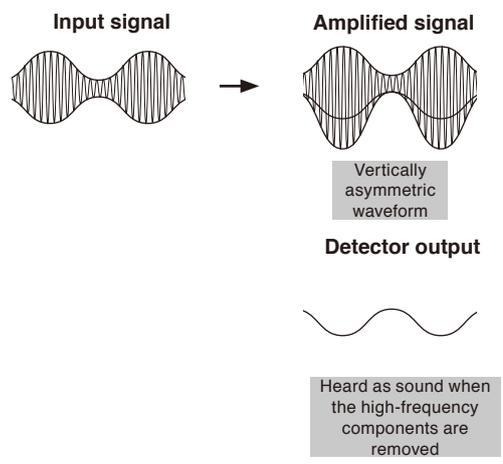
Block Layout Diagram * In blocks with lighter lines, current only flows along the dark, solid lines.

Circuit Schematic



●Circuit Mechanism

In this circuit, the transistor both detects and amplifies signals. In normal transistor-based amplifier circuits, the transistor turns on when the voltage across the base—emitter is 0.6 V when a base current is applied. Even if high-frequency signals happen to be input into the circuit, the signals are approximately symmetrical about the vertical axis, meaning that the top and bottom components cancel each other out, resulting in no audio signal being produced. If the base current is decreased to an extremely small amount, the high-frequency signals then become vertically asymmetric as in the figure at right. These high-frequency signals are then amplified, generating audible audio signals with the high-frequency components removed. This type of circuit mechanism in which the amplifier characteristics of the transistor are utilized to detect and amplify even the slightest base current is referred to as "transistor detection." Transistor detection is performed using a single transistor to detect and amplify signals, granting the advantage that such circuits can be formed using a small number of components. The 0.01- μ F capacitor attached across the collector—earth ground junction is there to remove high-frequency signal components.





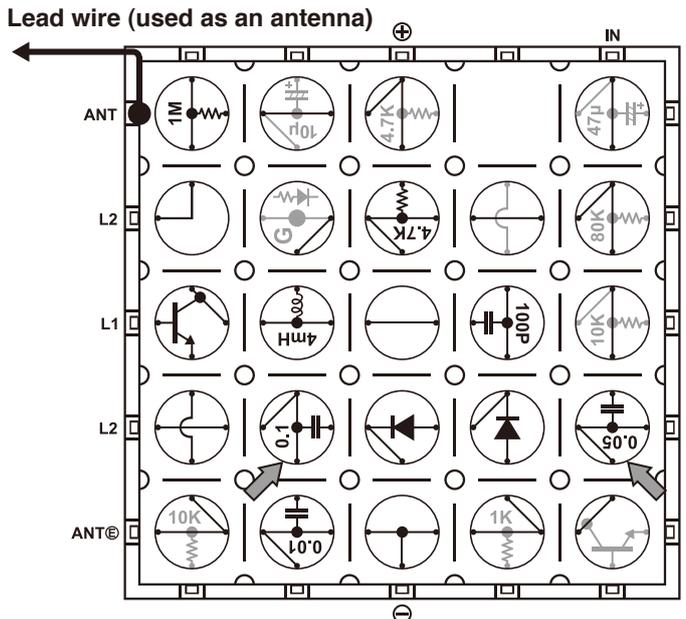
No. 21

Single-transistor Reflex Radio with IC Amplifier

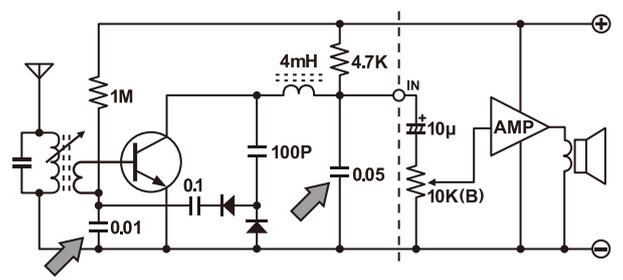
This circuit is the same basic circuit as Circuit No. 17, Single-transistor Reflex Radio, but with an IC amplifier included to further amplify signals. Arrange the blocks and attach a lead wire (used as an antenna) as shown in the figure. Then, turn on the main switch. Adjust the volume using the volume knob. Turn the tuning knob back and forth bit by bit until you find a radio broadcast station that you can pick up. Back when the transistor was invented, it was a relatively expensive component. This circuit was developed to provide increased sensitivity using as few transistors as possible.

Block Layout Diagram

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



Circuit Schematic



* Disconnect the antenna if you encounter any beeping dial tone sound at high sensitivity. If you still continue hearing a dial tone even after disconnecting the antenna, swap the 0.05- μ F and 0.1- μ F capacitors, making sure to orient them correctly.

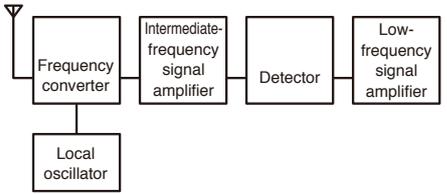
Circuit Mechanism

A reflex receiver circuit is one type of high-sensitivity radio circuit that amplifies both high-frequency and low-frequency signals using a single transistor. The electromagnetic wave signals from the broadcast station selected by the antenna coil are sent to the base of the transistor. The amplified signals are then passed from the collector through the 100-pF capacitor to be detected by the diode. The low-frequency signals detected are then sent back to the base of the transistor for amplification. The amplified low-frequency signals are sent from the collector on the transmitter through the coil (4-mH) to the amplifier and then out through the speaker, which uses the signals to produce sound. One difference between this circuit and the one in No. 17 is that this one uses a 4-mH coil as the load for the high-frequency signals. This leads to improvement in the separation of high-frequency and low-frequency circuits, resulting in increased sensitivity.

What is a superheterodyne receiver?

The superheterodyne receiver is a radio design that was invented by Edwin Armstrong, an American engineer. High-frequency signals cannot be amplified more than once. In order to amplify such signals, Armstrong came up with an idea to use an intermediate-frequency signal amplifier. After high-frequency signals are amplified, they are reduced down to an intermediate frequency (455 kHz), amplified again, and then detected and amplified as low-frequency signals. The tuning frequency, which is adjusted using a variable capacitor, is converted at once into a set intermediate frequency, which involves a somewhat complicated circuit, one of the disadvantages of this method. However, the tuning circuit can be used to adjust the frequency as many times as desired during the intermediate-frequency amplification step, making this design a radio with an exceptionally high-performance tuning function. With so many radio stations broadcasting and crowding the airwaves, radios that remain relatively unaffected by interference have become more and more important and valued, ushering in the need for this type of design.

Some radios use a single-stage high-frequency amplifier and a two-stage intermediate-frequency amplifier. These types of radios have become more and more common due to their high performance. Most of the radios currently available on the market employ this superheterodyne design.



No. 22

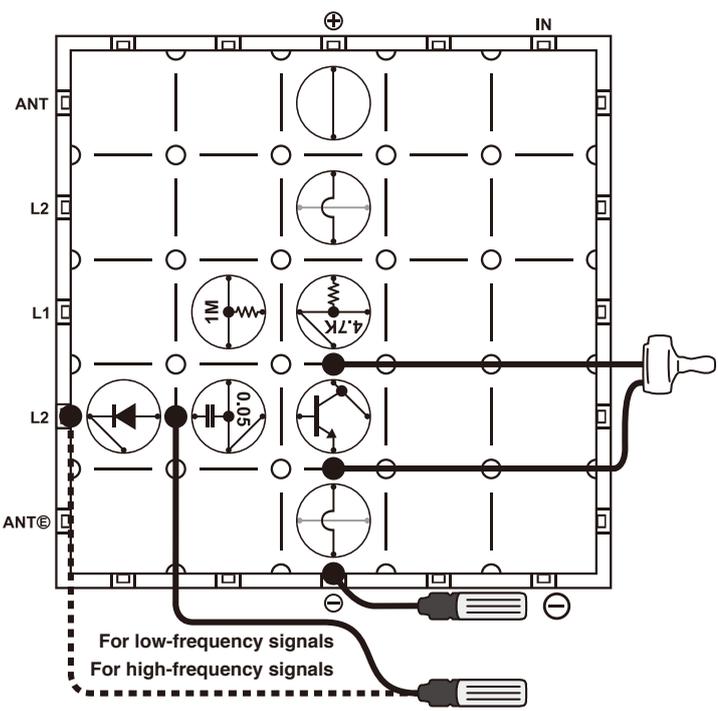
Signal Tracer

This device is used to check to see how far a signal (for radio applications, an audio signal) has progressed normally through a circuit when a radio or other piece of equipment breaks down. Insert the blocks and connect the lead wires and earphone as shown in the figure, and turn the main switch on. Connect the lead wire terminal on the minus side to the minus terminal on the radio or other device to be tested. Next, change the contact point for the lead wires, separated by high frequencies and low frequencies, to see how far the signal proceeds. The actual circuit is nothing more than a standard single-transistor, self-biasing amplifier circuit. However, with the use of a germanium diode, it can be used to check to see if signals are proceeding through not only low-frequency circuits but also high-frequency circuits.

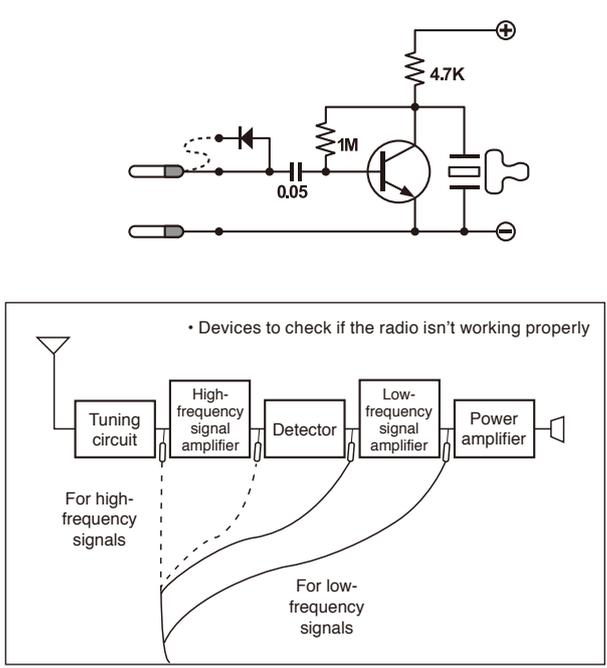
* Make sure to touch something metal before starting this experiment (like a metal doorknob or window frame) in order to discharge any static electricity you may have built up in your body.

Block Layout Diagram

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



Circuit Schematic



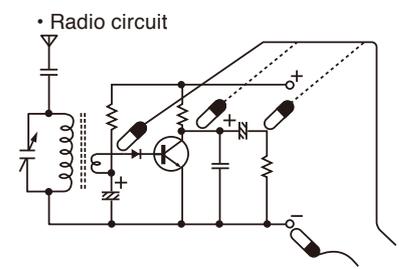
●Circuit Mechanism

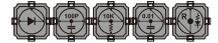
This circuit is a simple self-biasing amplifier circuit (see Circuit No. 12 for details) with a detector diode added to it. It uses a 0.05- μ F capacitor for the input capacitor. It is standard to use a 47- μ F capacitor or 10- μ F capacitor instead in applications when the audio frequencies need to be passed cleanly and clearly with little distortion. However, a problem arises in such cases. The withstand voltage (voltage that an electrolytic capacitor can tolerate before failing) of these capacitors in the Electronic Blocks mini supplement is only 16 V as specified in the component ratings (under normal conditions, you should try to stick with a voltage that is no greater than two-thirds of this withstand voltage). Some power supply voltages used in radio applications exceed 16 V. The electrolytic capacitors used in this kit would fail and break down in such cases. Therefore, the 0.05- μ F capacitor will be used instead. This capacitor has a withstand voltage of 50 V, which should be more than adequate for our purposes.

Mechanisms that can be used to determine whether a radio is malfunctioning

You can trace a signal to see how far it proceeds through a circuit and determine which components or section has been affected. Audio and other signals used do not merely pass through the base and collector on a transistor and the junction points in front of and behind a diode.

When a signal is input into the circuit, electric current will also flow through the peripheral resistor and capacitor components. The current used in the circuit will also experience change, which will affect the power supply line, as well. In other words, the signal will affect not only the immediate input components but also every other part of the signal, which allows the electrical signal to be traced along every section in the circuit. When the circuit is working properly, high-frequency signals will be detected by the diode in the signal tracer and emitted as low-frequency radio audio sounds. If all you hear is a static noise sound, then your tuning circuit may be out. If you happen to hear a ripping sound coming from some point in the circuit, try testing or changing out the bias resistor at that point. As described above, you can then trace the path of a signal through a circuit to see where it stops, which will tell you where the problem lies.





No. 23

Oscillator Circuits

Circuit Disconnect Alarm (Speaker-based)

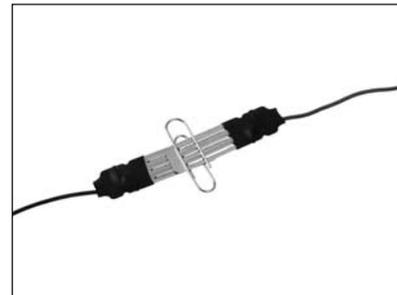
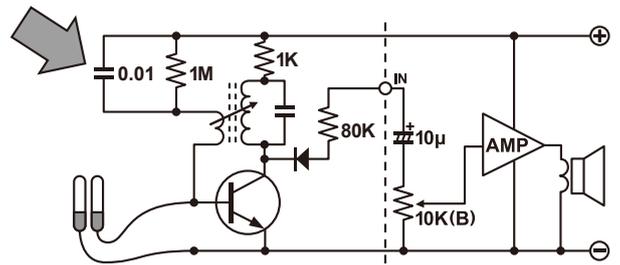
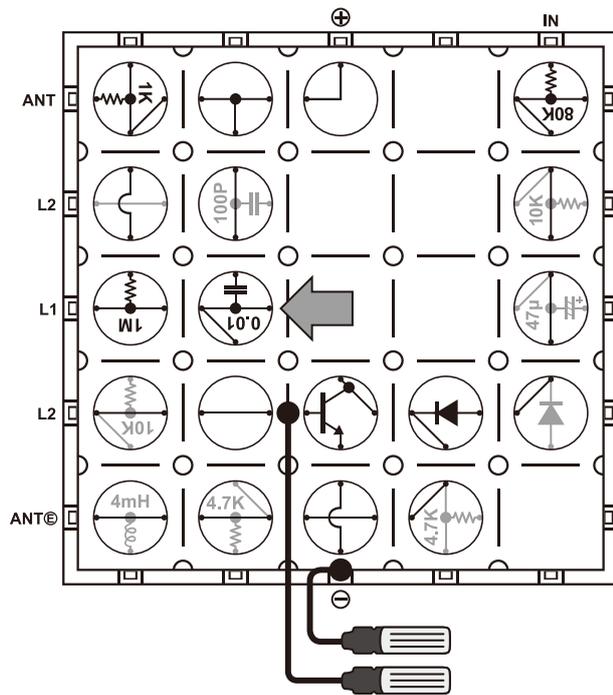
Let's try making an oscillator circuit that uses the antenna coil built into the circuit board. Insert the blocks and connect the lead wires as shown in the figure, and turn the tuning knob all the way to the right. Connect the lead wire terminals together using a paper clip as shown in the photograph. Turn the main switch on. If you disconnect either of the lead wire terminals from the paper clip, the speaker will give off an oscillating sound as an alarm (if you are unable to hear anything, turn the volume knob to the right to turn up the volume).

* 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



How to connect the lead wires together using a paper clip

● Try changing out the capacitor block

Try replacing the 0.01- μF capacitor in the block layout diagram with the 0.1- μF capacitor block and then with the 0.05- μF capacitor later on, making sure to orient the blocks in the proper direction. Changing the capacitor block should change the pitch of the oscillating sound given off by the speaker. Try it out to see what happens.

Caution: Make sure to turn the main switch off before attempting to change out any blocks.

What are oscillators?

Several different types of oscillator circuits are introduced throughout the Electronic Blocks mini supplement materials, including the multivibrator oscillator, blocking oscillator, twin-T oscillator, and the LC (inductor (L) coil-capacitor (C)) oscillator. The oscillator is a basic type of electronic circuit that is essential for experiments involving sound, high-frequency circuits, timer circuits, and other related applications. It is used to produce electrical oscillations (AC) using specific combinations of components. Oscillator circuits are formed of two parts, a circuit used to set the oscillating frequency and a circuit used to maintain the oscillation. The oscillating frequency is determined automatically according to the natural frequency for the specific combination of resistors/capacitors or coils/capacitors used based on their component values (resistance in Ω for resistors, capacitance in μF for capacitors, and inductance in mH for inductor coils). A transistor amplifier circuit is used to maintain a fixed oscillation in the circuit. The fixed oscillating signal is applied to the base of the transistor, amplified, and the resulting amplified collector signal is then applied back to the base. If the current gain (amplification ratio) of this closed loop is greater than 1, the oscillating will continue. For further details, refer to the specific descriptions and explanations for each relevant circuit.

No. 24

Oscillator Circuits

Lie Detector (Earphone-based)

Arrange the blocks, connect the lead wires, and connect the earphone as shown in the figure. Have another person grasp the lead wire terminals in their hands, one in each hand. Have the person grasp the terminals lightly as if lightly pinching them with their fingers. Turn the main switch on. Make adjustments using the method given below, and put the earphone in one ear. Ask yes-or-no questions, and have your test subject answer all questions with a "yes" (or all with a "no"). If the volume or pitch of the sound changes, it indicates that the person is (probably) lying. The reason why this works is that when the person tells a lie, for example, he or she may grasp onto the lead wires a little more tightly, or his or her hands may begin to sweat, which will affect the resistance of the connections, which will affect the volume and pitch of the sound emitted.

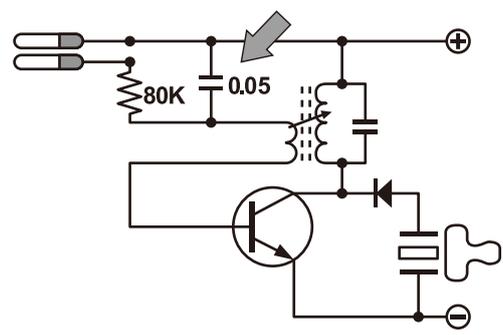
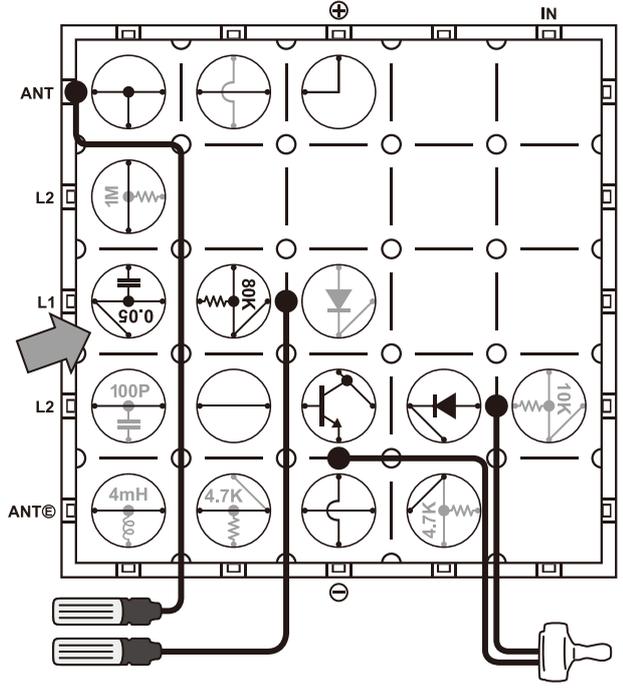
Note: As this is merely an experiment examining the operation of an electric circuit, it cannot be determined with absolute certainty whether or not the person under test is actually telling a lie.

* 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



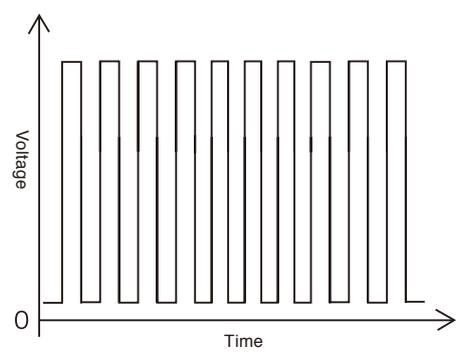
● Making adjustments before starting the experiment

After having the person you plan to test grasp onto the lead wire terminals lightly with their hands, turn the tuning knob all the way to the right. Make sure not to have the earphone inserted into your ear when you turn the knob as the earphone may emit loud sounds while you are making adjustments. If you hear sound coming from the speaker, turn the volume knob to the left until the sound cuts out. Turn the tuning knob slowly to the left until the sound becomes somewhat stabilized then release your hand from the knob. This completes the adjustments for the test.

* The volume may be too low in some cases depending on the person under test. If this happens, switch out the 0.05- μF capacitor and replace it with the 0.1- μF or 0.01- μF capacitor to see if one of those will work better. Different capacitances should provide you with a greater range to change the volume from when you first start hearing sound come out.

What is blocking oscillation?

First, current flows through the base on the transistor, turning the transistor on and causing collector current to flow through the primary coil on the collector side. A large amount of current begins flowing suddenly, which induces a current in the secondary coil and stops the flow of current through the base. After a while, current begins flowing through the base once again, and the whole process starts over. This repeated cycle is blocking oscillation. This sudden and distinct repetitive switching between on and off creates a waveform like that shown at right. If the resistance in the hands of the person holding onto the lead wires changes due to sweat or for other reasons, the base current will change, which will change the oscillating frequency. These changes can be picked up and recorded. This is the basic mechanism behind lie detector tests.





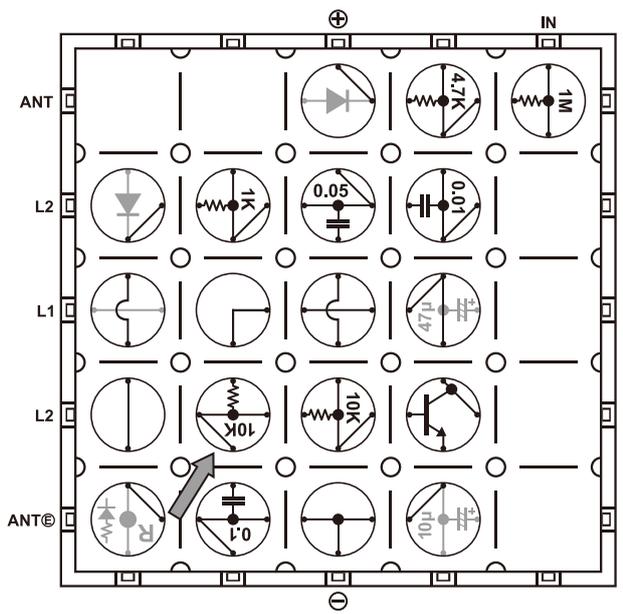
Oscillator Circuits

No. 25 Twin-T Oscillator Circuit

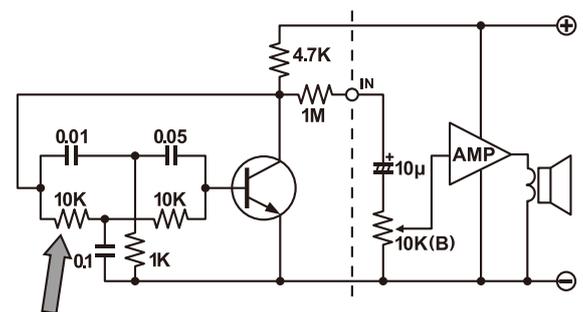
Insert the blocks as shown in the figure and then turn on the main switch. A sound will be emitted from the speaker. A clearer sound should be emitted in this case than with the oscillator circuits we looked at in previous projects (Circuit No. 23, Circuit No. 24). If you measure this oscillation using an oscilloscope (a device that displays electronic waveforms), you should see a clear sine wave displayed on the screen.

Block Layout Diagram

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



Circuit Schematic



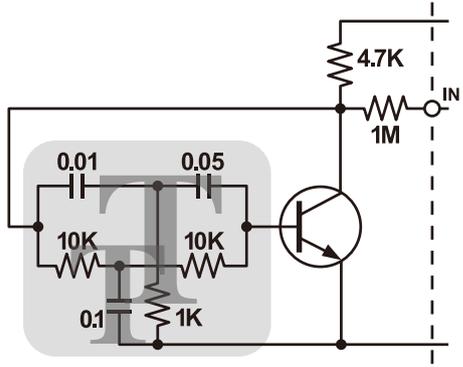
● Try changing out the one resistor block

Try replacing the 10-kΩ resistor in the block layout diagram with the 4.7-kΩ resistor block or 80-kΩ resistor, making sure to orient the block in the proper direction. Changing this resistor block should change the frequency of the oscillation. Try it out to see what happens.

Caution: Make sure to turn the main switch off before changing out any blocks.

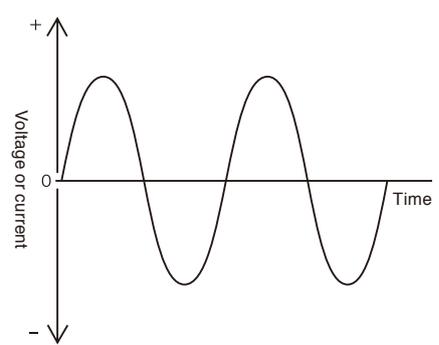
● Circuit Mechanism

Noise generated in the circuit while the main switch is turned on is passed through and filtered out by two high-quality T-shaped filters, one formed of the 0.05-μF capacitor, the 0.01-μF capacitor, and the 1-kΩ resistor and one formed of a 10-kΩ resistor, a second 10-kΩ resistor, and the 0.1-μF capacitor. The oscillating frequency of this circuit is set according to the values of the resistors and capacitors used. The collector signal from the transistor is transmitted to the base through the filters, and only the frequency components that pass through the filter are amplified and sent back to the base to produce oscillation. The filters used are high-performance filters that produce a clean sine wave signal. The 1-MΩ resistor connected to the amplifier is used to adjust the sound volume.



Alternating current and sinusoidal (sine) waves

Alternating current is current that switches its direction of flow after a set amount of time has passed. The graph at right displays a typical clear, clean alternating current wave that is a sinusoidal (or sine) wave. Carrier waves for high-frequency signals and other such waves are also sine waves. However, not all alternating current signals are such clean, clear sine waves. Some audio signals are rather distorted or otherwise irregular in shape. The electrical signals that make up sound signals are always AC because, to produce an output, such signals are repeatedly increased and decreased in intensity and then used to vibrate the speaker.



No. 26

Multivibrator Circuits

Monostable Multivibrator Circuit (1)

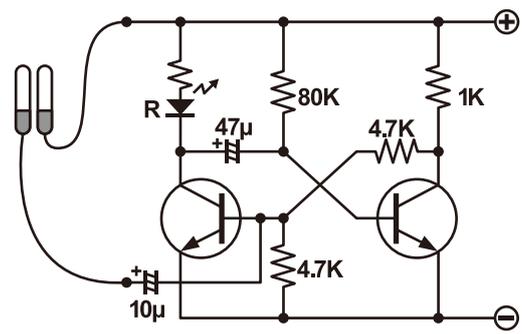
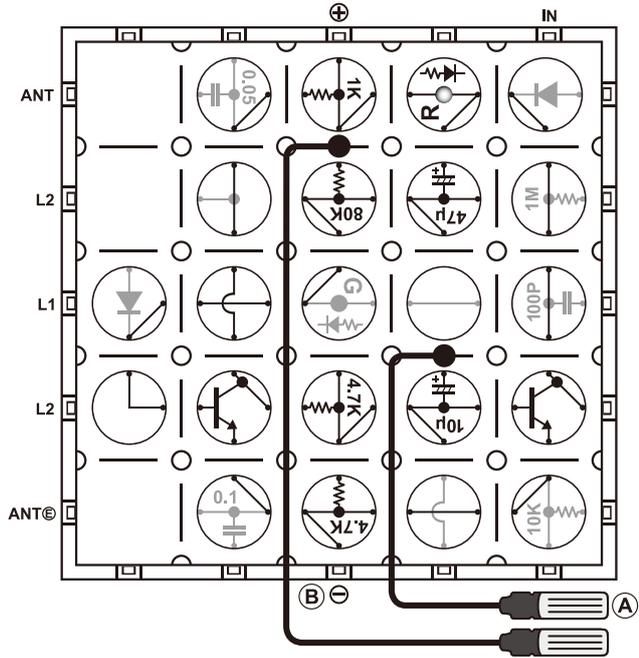
Insert the blocks and connect the lead wires as shown in the figure and then turn the main switch on. If you touch the lead wire terminals momentarily, the LED will turn on once and then go back out.

* 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



* Holding onto the lead wire terminals may make it difficult for the circuit to advance to the next stage. If this is the case, touch the terminal of lead wire (A) to (B) (the negative terminal on the circuit board) to discharge the electric charge stored in the 10- μ F capacitor.

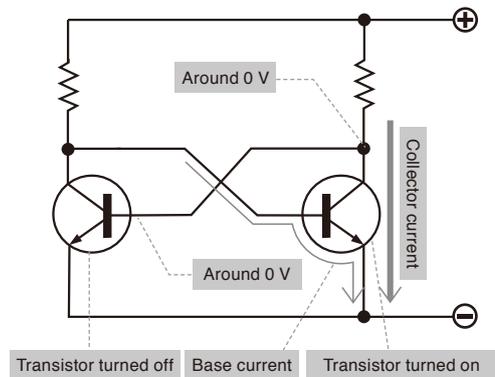
Circuit Mechanism

Look at the circuit diagram. You can see that the collector of one of the transistors is connected to the base on the other transistor. This type of connection functions such that when one transistor is turned on, the other transistor is always turned off. This type of circuit configuration is called a "multivibrator circuit." Multivibrators generate electrical vibrations by turning multiple transistors on and off. Monostable multivibrator circuits generate electrical vibrations one time only.

Basic principles behind multivibrator circuits

When the right transistor is on, a large amount of current flows between the collector—emitter junction in that transistor. The resistance between the collector—emitter junction is essentially 0, and the collector voltage is also around 0 V. The main point behind this type of circuit is that the collector voltage is 0 V when a collector current flows through the collector.

The collector on this transistor is connected to the base of the left transistor. The base voltage of the left transistor is 0 V at this time, and the transistor is turned off. In other words, as described, if you combine transistors together as shown, one will be turned off while the other is on and vice versa. The one to which a base voltage is applied will turn on. The length of time can be adjusted using the resistors and capacitors. Forcibly increasing the base voltage of the transistor using the discharge and charge of the capacitors will reverse the on/off states of the two transistors (turn one on, off, and the other off, on.)



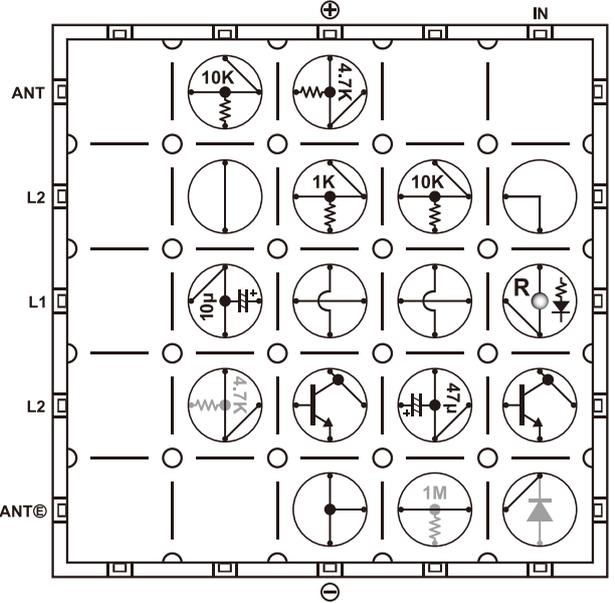
No. 27

Astable Multivibrator Circuit

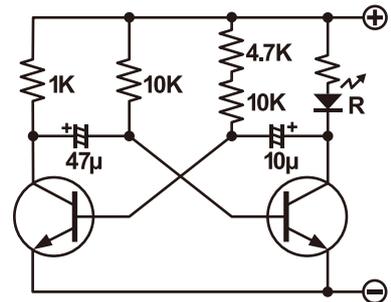
Insert the blocks as shown in the figure and then turn on the main switch. The LED will begin flashing. In most cases, the term "multivibrator" refers to an astable multivibrator circuit. This type of circuit is stable when operation is shut down. Here, the circuit remains unstable until the power is turned off because operation continues to be performed. This is what the term "astable" means.

Block Layout Diagram

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



Circuit Schematic



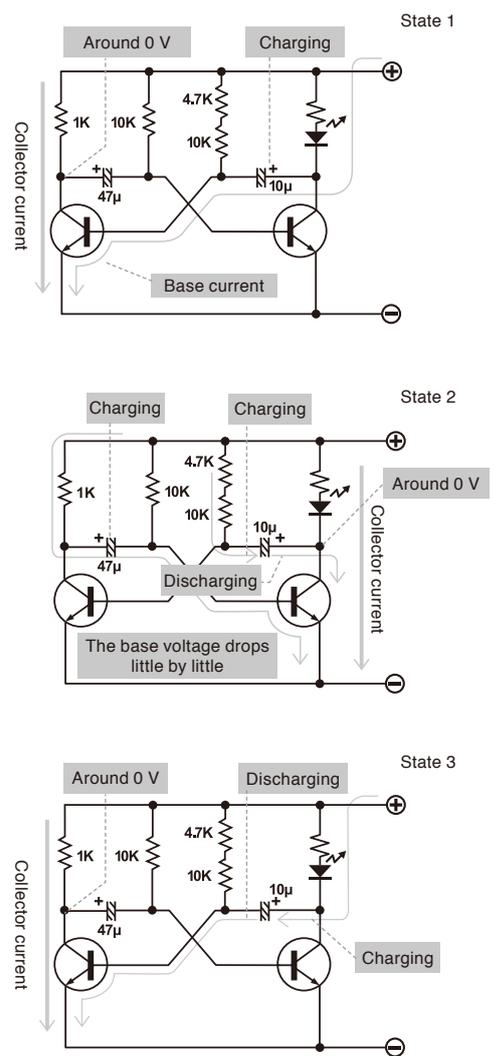
Circuit Mechanism

State 1: The multivibrator starts operating
 When the main switch is turned on, one of the transistors, either the right or the left, is turned on, as well.

Let's consider an example in which the left transistor is the one that is turned on. The right transistor would be turned off. Although current does flow to the LED in this case, the LED remains turned off because the base current is too low. The 10- μ F capacitor begins charging at this time. Once the 10- μ F capacitor finishes charging, the base voltage drops, and the left transistor turns off.

State 2: The transistor on the right turns on
 When the left transistor turns off, the right transistor turns on.
 Current flows through the collector on the right transistor, which turns on the LED. At this time, the 10- μ F capacitor that was charged up begins discharging and then charging in the opposite direction through the 4.7-k Ω and 10-k Ω resistors. At the same time, the charge from the 47- μ F capacitor that has flowed into the base on the right transistor progresses through the circuit, causing the base voltage for the right transistor to continue dropping.
 Once the capacitor finishes charging, the right transistor turns off, and the LED goes out.

State 3: The transistor on the left turns on
 As soon as the right transistor turns off, current from the 10- μ F capacitor begins flowing through the base on the left transistor, which turns the left transistor on. Once the 10- μ F capacitor finishes discharging, it begins charging in the opposite direction.
 Once the capacitor finishes charging in this direction, the left transistor turns off, and the circuit returns to State 2.



No. 28

Multivibrator Circuits

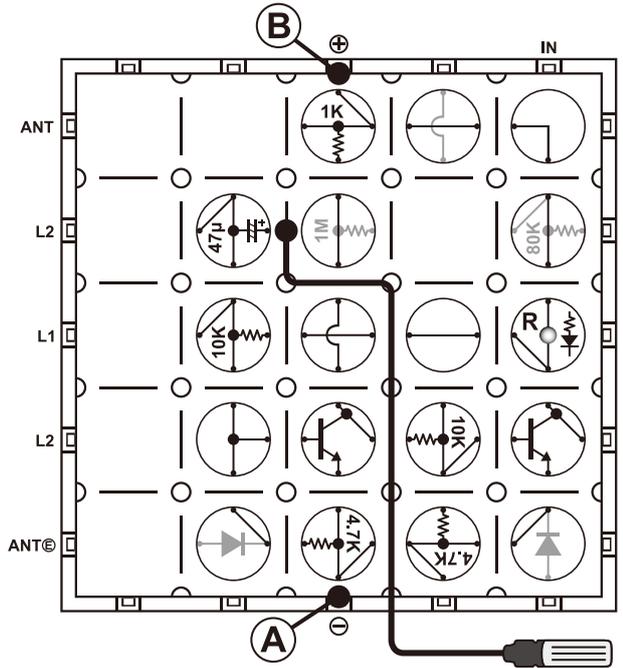
Bistable Multivibrator Circuit

Insert the blocks and connect the lead wires as shown in the figure. Turn the main switch on (the LED may turn on in some cases or remain off at this time). Touch the lead wire terminal to contact point A on the case and then remove it immediately, which will cause the LED to remain on. Next, touch the lead wire terminal to contact point B and remove it immediately, which will turn the lit LED off. Letting go of the lead wire terminal will produce no effect. This will register the state of the contact with the lead wire terminal.

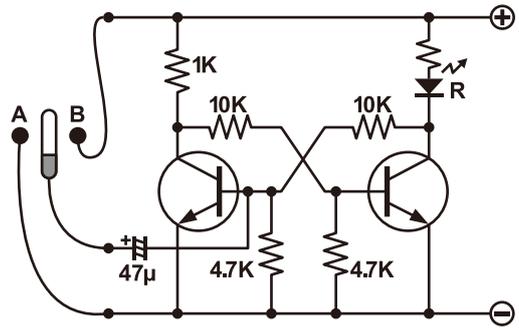
* Make sure to touch something metal before starting this experiment (like a metal doorknob or window frame) in order to discharge any static electricity you may have built up in your body. When holding onto the lead wire terminals, make sure to grip the black wire coverings.

Block Layout Diagram

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



Circuit Schematic



Circuit Mechanism

State 1: First, the circuit enters a stable state
In multivibrator circuits that use two transistors, as long as the circuit is powered on, the two transistors will always be in opposite states, with one on and the other off.

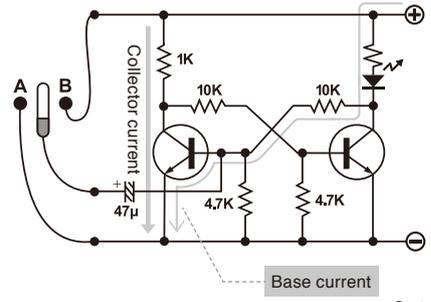
Consider an example in which the base voltage of the left transistor increases at first, causing the left transistor to turn on. When this happens, the collector voltage drops and the right transistor is turned off, causing the LED to be off. The base voltage of the left transistor is high, resulting in the left transistor remaining turned on and placing the circuit in a stable state (the transistors in this explanation may be reversed in some cases, depending on which transistor is turned on at power on).

State 2: Touching the lead wire to A...
Try touching the lead wire terminal to contact point A, which is the minus (-) terminal on the circuit board.

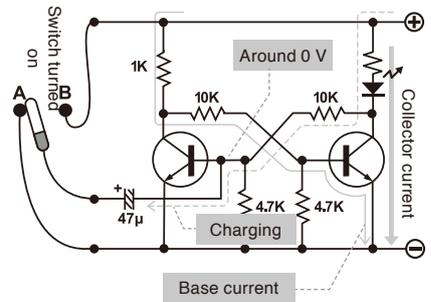
The 47-µF capacitor will start charging. The base voltage on the left transistor will drop to 0 V temporarily, causing the transistor to turn off. The right transistor will then turn on, which will turn the LED on so that it lights up. While the right transistor is on, the base voltage on the left transistor drops, causing the left transistor to remain off. The LED will remain turned on in this state, as long as no outside influences are applied.

State 3: Touching the lead wire to B...
Next, try touching the lead wire terminal to B, the plus (+) terminal on the circuit board. The 47-µF capacitor begins discharging to the base on the left transistor and simultaneously begins charging in the opposite direction from before. This causes current to flow through the base on the left transistor, turning the left transistor on. The right transistor is turned off at this time, causing the LED to go out. The direction of charge of the capacitors changes depending on which contact point the lead wire terminal makes contact with, which is the main point to remember here.

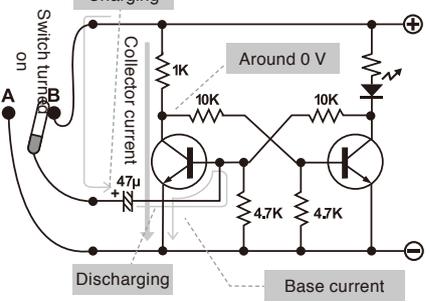
State 1



State 2



State 3





No. 29

Multivibrator Circuits

Monostable Multivibrator Circuit (2)

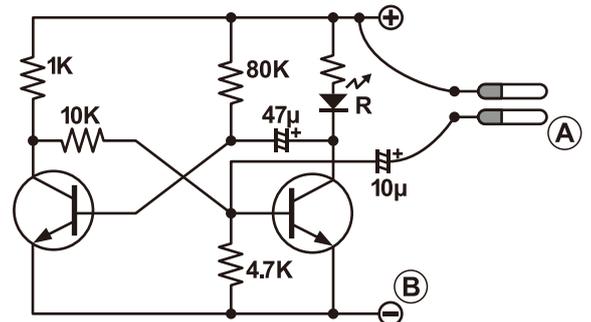
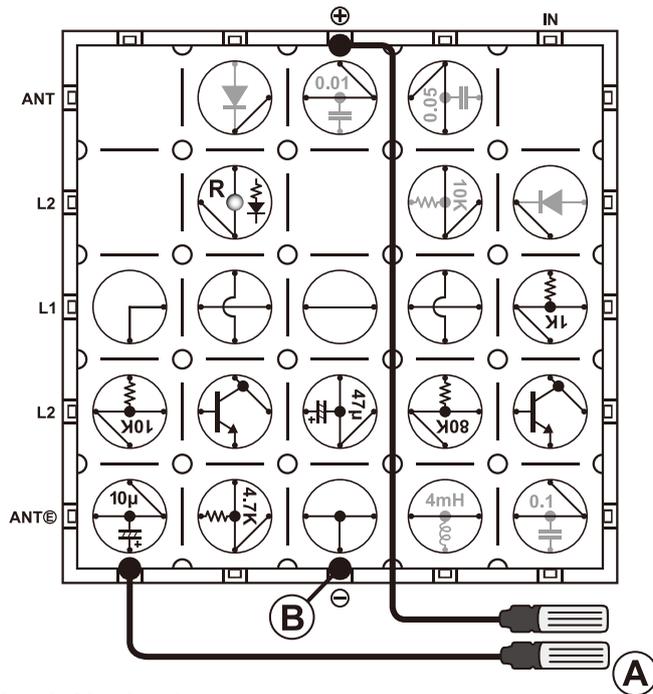
Insert the blocks and connect the lead wires as shown in the figure and then turn the main switch on. The LED will turn on if you touch the lead wire terminals and quickly release your grasp on them. The LED will remain turned on for 3 to 5 seconds before turning off.

* 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



●Circuit Mechanism

State 1: First, the main switch is turned on.

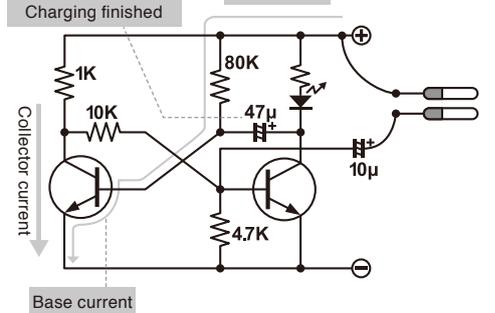
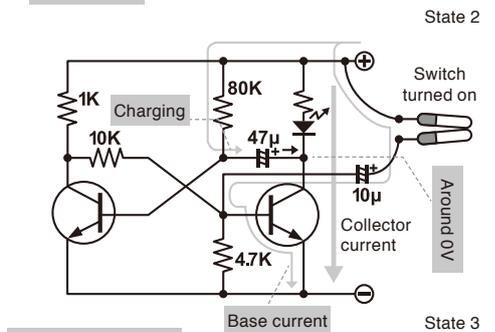
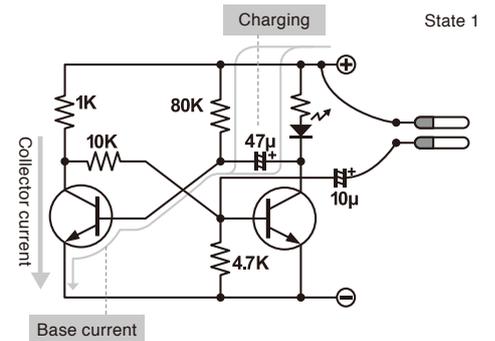
When the main switch is turned on, the resistance in the LED is low, which will cause the 47- μ F capacitor to charge and current to flow. When current begins to flow, the base voltage of the left transistor rises more quickly than that of the right transistor, causing the left transistor to turn on. The current flowing through the LED is weak and the capacitor finishes charging quickly, resulting in the LED remaining off. The circuit will stabilize and remain in this state.

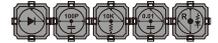
State 2: When the lead wire terminals are touched together.

Next, touch the lead wire terminals together. The 10- μ F capacitor will begin charging, causing current to flow. This, in turn, causes the base voltage on the right transistor to rise, which turns on the right transistor. Current then flows through the collector on the right transistor, causing the LED to turn on. At this time, current flows through the collector on the right transistor, causing the collector voltage to drop to around 0 V and the left transistor to turn off. The 47- μ F capacitor begins charging through the 80-k Ω resistor. This type of circuit state is used as a timer.

State 3: The LED turns off, causing the circuit to return to a stable state.

When the aforementioned 47- μ F capacitor finishes charging, the base on the left transistor becomes disconnected from the collector on the right transistor. This causes the base voltage of the left transistor to increase, turning it on. The collector voltage in the left transistor then drops to around 0 V, causing the base voltage on the right transistor to also drop to around 0 V, resulting in the LED turning off.





No. 31

Multivibrator Circuits (Reference Circuit)

Single-transistor One Shot Circuit

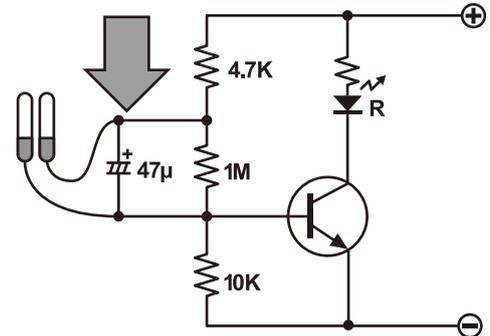
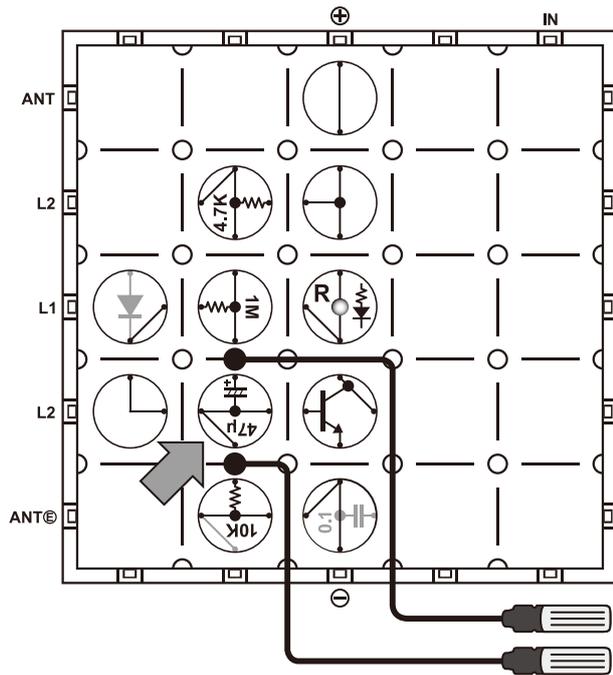
This circuit uses capacitor charging and discharging. Insert the blocks and connect the lead wires as shown in the figure and then turn the main switch on. Touching the lead wires together temporarily and then quickly separating them will cause the LED to turn on for a set amount of time.

* 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



● Try changing out the capacitor block

Replacing the 47- μ F capacitor in the block layout diagram with the 10- μ F capacitor block, making sure to orient the block in the proper direction, will shorten the length of time that the LED remains lit. Try it out to see what happens.

Caution: Make sure to turn the main switch off before changing out any blocks.

● Circuit Mechanism

Touch the lead wires together to turn the transistor and the LED on at the same time.

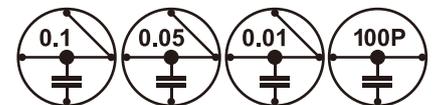
When you release the lead wires, the capacitor will begin charging through the 4.7-k Ω resistor. As the charging proceeds, the base voltage will drop which will, in turn, cause the LED to turn off. This circuit only uses one transistor, which allows it to operate in the same way as the monostable multivibrator circuit.

Capacitor types and unit values

The capacitors used in the Electronic Blocks mini supplement are either ceramic capacitors or electrolytic capacitors. Ceramic capacitors are small in size and resistant to heat but are low in capacity. Electrolytic capacitors provide larger capacities but are not recommended for use with larger voltages. Electrolytic capacitors are polarized and are thus marked with a plus sign (+) on their positive terminals.

The amount of charge that a capacitor can store is referred to as its electrostatic capacitance, which is expressed in terms of the unit, farad (F). In general, most electronic circuits use capacitors with capacitances that range in the microfarads, μ F, where 1 μ F is one-millionth (1/1,000,000) of a farad. Some capacitors measure in the picofarad (pF) range, where one pF is one-millionth of one microfarad (1/1,000,000 of 1 μ F). Electrolytic capacitors are usually imprinted with the unit of measure included along with the capacitance value, but ceramic capacitors usually only show the numerical value. For example, a ceramic capacitor may only be imprinted with a number such as "102," which would indicate 10 \times 10² pF (1 \times 10³ pF), or 1000 pF.

The number "503" would indicate 50 \times 10³ pF, which is equal to 50000 pF or 0.05 μ F.



Ceramic capacitors



Electrolytic capacitors



Timer Circuits

No. **33**

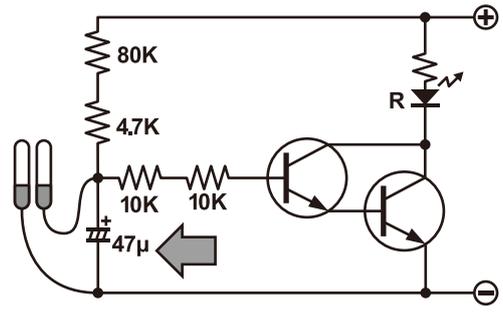
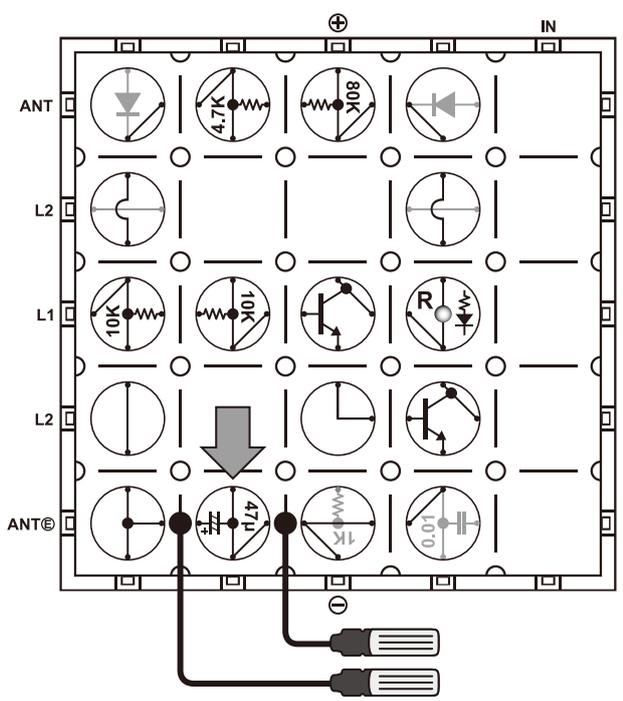
Principles of a Basic Self-Timing Timer Circuit

Insert the blocks and connect the lead wires as shown in the figure and then turn the main switch on. The LED will light up. If you touch the lead wire terminals together for a moment and quickly release them, the LED will turn off and then turn back on after around 2 seconds. This circuit functions as a capacitor-based timer, meaning that it will take some time for the LED to turn back on after the lead wires are disconnected. The self-timer function in a camera, which leaves open some time from when the shutter button is pressed until the shutter is released, operates using this basic principle. The two transistors in this circuit are connected using a Darlington connection (see Circuit No. 45 for details on Darlington transistors).

* 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



● **Try changing out the capacitor block**

Replacing the 47- μ F capacitor in the block layout diagram with the 10- μ F capacitor block, making sure to orient the block in the proper direction, will change the timing period of the timer. Try it out to see what happens.

Caution: Make sure to turn the main switch off before changing out any blocks.

● **Circuit Mechanism**

This circuit operates as a timer circuit that uses resistors and capacitors. The charging and discharging circuit is formed using a 4.7-k Ω resistor, an 80-k Ω resistor, and a 47- μ F capacitor. First, touch the lead wire terminals together to make the 47- μ F capacitor discharge. When the lead wires are disconnected from each other, the capacitor begins charging through the 4.7-k Ω and 80-k Ω resistors, the base voltage in the transistor gradually begins to rise, and current begins flowing through the collector, which causes the LED to turn on. The LED is driven by the Darlington connection, which provides a high current gain. This allows the LED to be turned on in a clear state, even if the base voltage gradually increases.

Stones that form the basis of electric components

Have you ever seen thin, flaky, fragile rocks lying along the side of the road or banks of a river? This kind of rock is known as mica. Mica is part of the composition of many other types of rocks as well, including granite, and can be found all over the world. Mica produces high levels of reliability when used in capacitors and is used even now in the more expensive, high-quality capacitors. Another type of rock found in many other stones and in sand is quartz (silicon dioxide), a translucent mineral. Electric heaters that use long, thin tubes are called “quartz tube heaters” and utilize quartz tubes that contain Nichrome wires. Quartz is often used because it is abundant in the earth’s crust, is easy to process and shape, and has high electrical resistance and high resistance to heat. Silicon can be obtained from quartz rock if the oxygen is removed. Silicon is used to make transistors. Silicon wafers are thinly sliced wafers of highly pure silicon that are used as the principle material in the manufacture of large-scale integration (LSI) components. Thinking about it this way,, the next rock that you pick up on the side of the road may just be a potential component in electronic circuits.

No. 34

Timer Circuits

Schmitt Trigger Timer

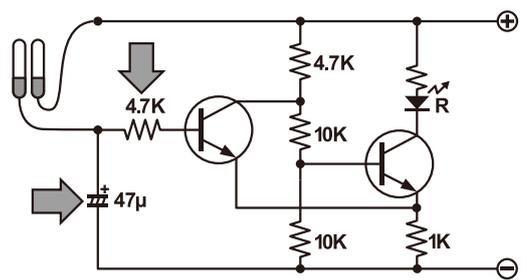
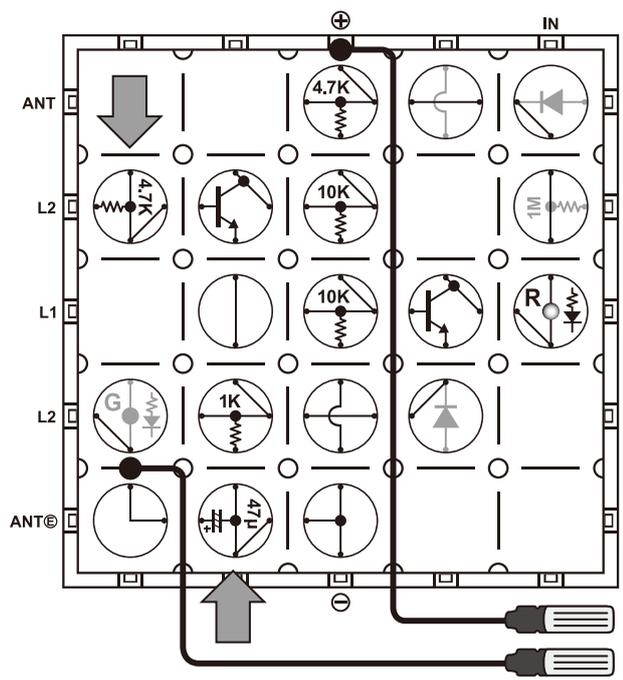
Insert the blocks and connect the lead wires as shown in the figure and then turn the main switch on. The LED will light up. Touch the lead wire terminals together momentarily to turn the LED off. If you release the lead wire terminals, the LED should turn on again automatically after around 6 seconds.

* 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



Try changing out the resistor and capacitor blocks

Try replacing the 4.7-kΩ resistor in the block layout diagram with the 80-kΩ resistor block and the 47-µF capacitor with the 10-µF capacitor, making sure to orient the blocks in the proper direction. Changing out these blocks should change the length of time that it takes for the LED to turn back on automatically to around 3 seconds. Try it out to see what happens.

Caution: Make sure to turn the main switch off before changing out any blocks.

Circuit Mechanism

If the input voltage is raised gradually, the LED will turn on when the voltage reaches a set level. Next, if the input voltage is gradually decreased, the LED will turn off instantaneously at a slightly low voltage level. This is the main feature of a Schmitt trigger circuit. The on/off states are clear-cut and distinct, even when the voltage used comes from an unstable capacitor charge. The hysteresis for this circuit can be specified using the ratio between the emitter and controller resistances.

What is a Schmitt trigger circuit?

Refrigerators cool the inside of the refrigerator box by using a coolant that has been compressed by a compressor. Let's take a look at an example involving a temperature control that turns on and off at the 5°C (41°F) temperature mark. Each time the air flowing in and out of the refrigerator changes the sensor temperature even slightly, the compressor will turn on and off, which could shorten the compressor life. A Schmitt trigger circuit can be used in the temperature control circuit to resolve this issue and prevent problems from occurring.

When the temperature control is set to 5°C (41°F), the compressor turns on if the temperature rises to 6°C (42.8°F) and off if the temperature drops to 4°C (39.2°F). The compressor will turn off once the temperature drops to 4°C (39.2°F) or lower and will only turn back on once the temperature increases to 6°C (42.8°F) or higher. Hysteresis is used to describe this difference in set temperature and can be applied to ensure that the refrigerator system continues to operate stably in response to even the slightest changes in temperature. This same principle is also applied to the temperature control systems (thermostats) used in air conditioners and fan heaters.

