EI-8900
Ages 10+
Grades 5+

GeoSafari®

10 in 1 Electronic Lab

Project Guide

⚠ **WARNING:**
CHOKING HAZARD—Small parts.
Not for children under three (3) years.

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Introduction

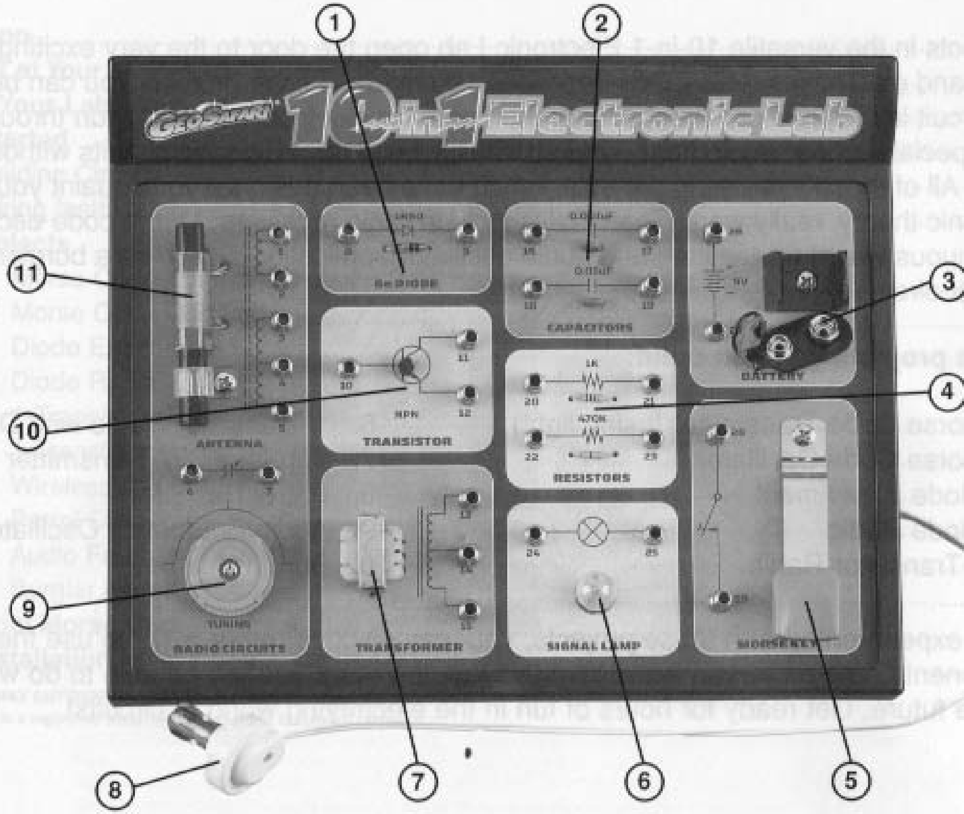
The 10 projects in the versatile 10-in-1 Electronic Lab open the door to the very exciting fields of electricity and electronics. This guide describes 10 different circuit projects you can build with this lab. A circuit is simply a continuous, unbroken path for electrical current to run through. You don't need special skills or equipment—you can easily build the electronic circuits without tools or soldering. All of these interesting projects, which have been designed to acquaint you with basic electronic theory, really work. The circuits include radio receivers, Morse code oscillators, a CW (continuous wave) transmitter, and audio oscillator applications, such as a burglar alarm and patrol car siren.

Here are the projects you can build:

1. Morse Code Transmitter (using light)
2. Morse Code Oscillator
3. Diode Experiment
4. Diode Radio
5. 1-Transistor Radio
6. 1-Transistor Radio with Diode
7. Wireless CW Transmitter
8. Patrol Car Siren
9. Audio Frequency Oscillator
10. Burglar Alarm

After you've experimented with these projects, you may discover other ways to use the same basic components. The more you learn from this lab, the more you will be able to do with circuits in the future. Get ready for hours of fun in the electrifying world of circuits!

Let's Look at Your 10-in-1 Electronic Lab!



What's in Your Lab?

The lab contains the following solid-state parts:

1. The **Diode** used in your lab is a germanium type that allows current to flow in only one direction and is used as a detector in radio receivers. One of your projects shows how a diode operates.
2. The **Capacitors** are used to store electrical charges. They consist of two conducting plates separated by insulating plates that are separated by insulating material. The capacitors in your lab are rated in microfarads (uF) and picofarads (pF).
3. The **Battery Terminal** consists of a clip and sturdy holder to secure the circuit's source of power—a 9-volt transistor battery (not supplied).
4. The **Resistors** are made of a material that "resists" current flow. These resistors are rated in kilohms (K), meaning thousands of ohms.
5. The **Morse Key** acts as a switch that is closed when pressed down. Keys are used to turn audio tones or RF signals on and off smoothly when transmitting Morse code.
6. The **Signal Lamp** flashes to verify a closed circuit in such projects as Morse Code Transmitter (using light) and the Diode Experiment.
7. A **Transformer** consists of one or more coils wound on an iron core. It is used in your lab to develop audio voltages from the audio currents supplied by the transistor.
8. The **Earphone** changes the electrical energy of an audio frequency into sound. This earphone is a high impedance (high resistance) crystal type.
9. The **Tuner** makes the radios you build sensitive to particular frequencies.
10. The **Transistor** contains three elements (base B, emitter E, and collector C) in which current can be made to flow. The transistor in your lab is an N-P-N type that is used to amplify current.
11. The **Bar Antenna** consists of a ferrite core around which a coil of wire is wound. The antenna coil is used with the variable capacitor (VC) for tuning radio frequency (RF) signals.

Getting Started

There are 10 circuit projects that may be built, one at a time, using the components in your lab and the directions found in this guide.

The directions for each circuit project include:

- a **written description** of the steps necessary to build each circuit and information about the electronic principles each circuit uses
- a **wiring diagram** showing you where to connect the wires
- a **wiring checklist** that summarizes the connections made and that allows you to double check your work
- a **schematic diagram** (electrical blueprint) that professional electricians use on the job

Building Circuits

1. Place the lab on a flat surface, giving yourself plenty of room to work.
2. Choose the circuit you wish to build. Read the description of the project and examine the wiring diagram.
3. Use the hook-up wires provided with this lab to wire the project, following the heavy, black lines shown on the diagram for each project. (See wiring instructions below.)
4. Double check that you have made the correct connections by consulting the Wiring Checklist for the project.
5. Attach the 9-volt transistor battery clip to a 9-volt transistor battery (006p, VS332, or equal, not supplied) and push the battery into the battery holder mounted on the plastic base. (See page 18 for battery installation instructions.)

IMPORTANT

To conserve battery power, remove the clip from the 9-volt battery when it is not being used.

Wiring Instructions

Most of the parts in your lab are mounted on the plastic base and their leads (wires) are connected to the spring terminals under the base. The hook-up wire in this kit is supplied in three different lengths to fit between different spring terminals.

Stripping Wires

You will notice that the ends of the three different sized hook-up wires are bare or "stripped." At times you may have to "strip" some of the wire in your lab so that you have more wire to make a better connection. To do this, carefully scrape off a section of the plastic coating at the end of the wire with wire strippers or a pair of scissors and pull the rest off with your fingers.

Spring Terminals

To connect the wire to a spring terminal, bend the spring to the side, fit the bare end of the wire into the spring and bend it around so it makes a good contact, then release the spring. The bare wire must be tight against the spring. If you have to attach a second wire to a spring, bend the spring in the opposite direction when inserting the second wire.

Earphone

To connect the earphone, simply connect the two ends of the split earphone wire to the terminals as shown in the diagram.

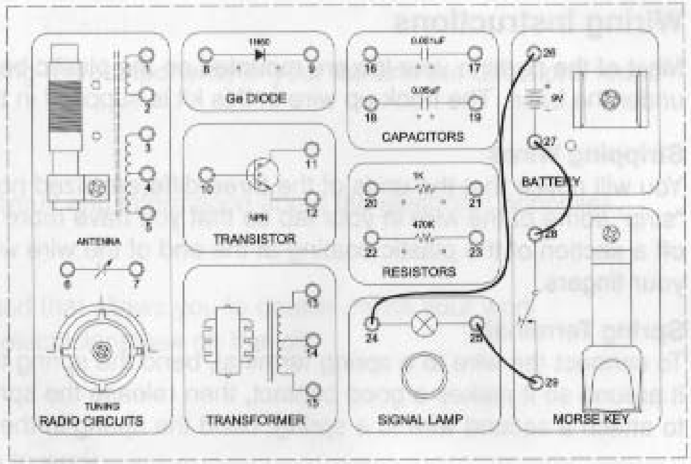
Antenna

To connect the antenna, use the long length of green wire supplied in this lab. Connect one end of this wire to the ANTENNA terminal and spread out the wire for best reception. If a ground connection is required, cut a long enough piece of the green wire and connect one end to the GROUND terminal (see wiring diagram). Take the other end and strip about six inches of the plastic insulation off the wire. Wrap the six inches of bare wire around a cold water metal pipe. Be sure to scrape off any paint or dirt from the ground pipe before wrapping the wire around it.

Circuit Project 1 Morse Code Transmitter (using light)

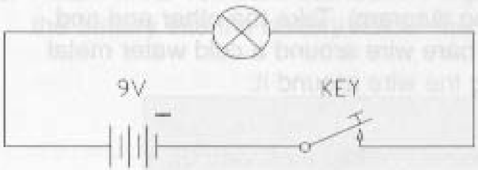
The International Morse Code, invented by Samuel Morse in 1836, was used for long distance communication before the telephone. Electrical signals were transmitted over wires using a device called a telegraph. Telegraph operators used dots for short signals and dashes for long signals. Letters and numbers were represented by different combinations of dots and dashes.

This simple series circuit will let you practice or transmit Morse code not by sound, but by light! The lamp will light whenever the key is pressed down, closing the circuit. Using two kits, you and a friend can communicate with each other without any wired connections! Just position the lamps where each of you can see the other's lamp! It is even easier to transmit and receive in the dark. To use the International Morse code properly, check the details printed on page 17 of this guide.



Wiring Checklist

• 24 to 26   25 to 29   27 to 28

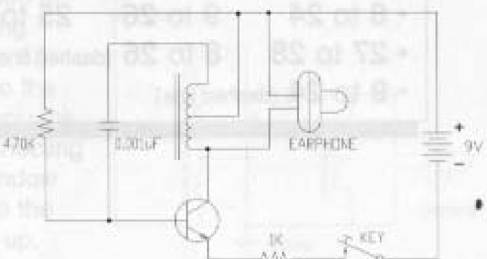


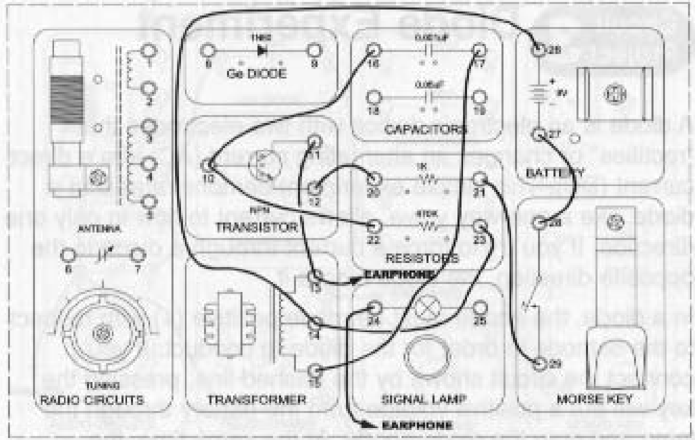
Circuit Project 2 Morse Code Oscillator

Now make a Morse code oscillator that transmits a high frequency sound signal into your earphone—allowing you to hear the dots and dashes!

This transistorized feedback oscillator produces an audio tone into the earphone whenever the key is pressed. In this circuit, the collector (output element) of the transistor is connected to one end of the transformer winding, and the transistor base (input element) is connected to the other end of the same winding through the .001 uF capacitor. As a result, the energy from the transistor output "feeds back" to the input, is amplified by the transistor, and again feeds back to the input. The circuit then "oscillates" and an audio tone is produced into the earphone.

The values of the capacitor and the resistor connected to the transistor base determine the frequency or pitch of the tone you hear. Make the tone higher or lower by changing these values. Learn how to use the International Morse Code at the end of your guide.





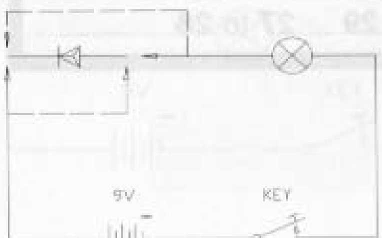
Wiring Checklist

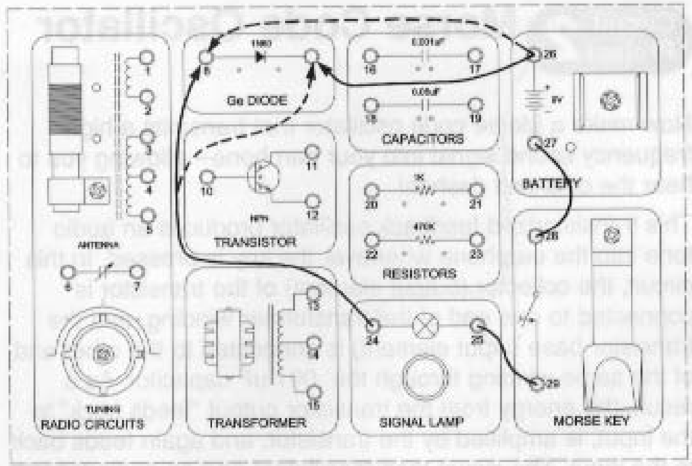
• 10 to 16	10 to 22	11 to 13
• 12 to 20	14 to 23	14 to 26
• 15 to 17	21 to 29	27 to 28

Circuit Project 3 Diode Experiment

A diode is an electronic device with two electrodes that "rectifies" or changes an alternating current (AC) into a direct current (DC). This simple experiment demonstrates that a diode, like a one-way valve, allows current to flow in only one direction. If you try to force a current through a diode in the opposite direction, the diode blocks it.

In a diode, the anode must be made positive (+) with respect to the cathode in order for the diode to conduct. If you connect the circuit shown by the dashed line, pressing the key will put a positive voltage from the battery through the lamp and onto the diode anode. At the same time, the negative battery terminal will be connected to the cathode. This satisfies the diode requirement, causing the diode to conduct (like a closed switch) and the lamp to go on. Now reverse the connections to the diode and the lamp will go off! Use this circuit to mystify your friends!





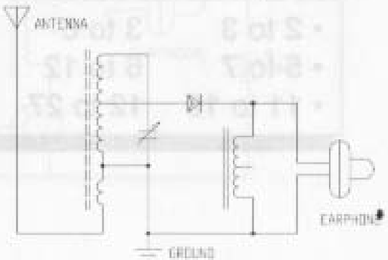
Wiring Checklist

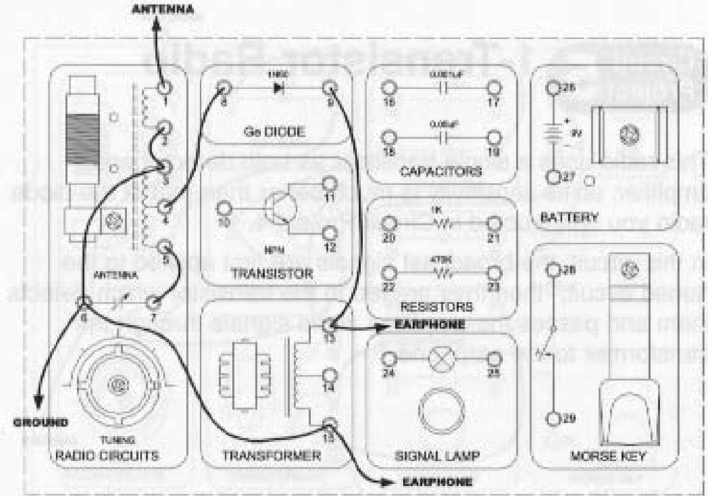
- 8 to 24 9 to 26 25 to 29
- 27 to 28 8 to 26 (dashed line)
- 9 to 24 (dashed line)

Circuit Project 4 Diode Radio

This diode radio uses no power! Radio signals picked up by the antenna are fed to the coil and variable capacitor that make up the "tuning" circuit. When you turn the tuning knob on the capacitor, you tune the radio to different broadcast stations. The audio signals in the selected broadcast station signal are "detected" by the diode and transformer circuit, then are reproduced by the earphone.

Since there are no amplifiers in this radio, you must start out with a clear, strong station signal. To get good reception, make sure your antenna has a good ground connection! Use the long green wire in your kit for the antenna, connecting one bare end to the ANTENNA terminal and spreading out the rest of the wire. Cut off another piece of the same wire and connect it between the GROUND terminal on your lab and a cold water pipe or the frame (outside) of an electrical conduit. (Both wire ends must be stripped of insulation. See Wiring Instructions on page 6.) Move the antenna to the position that gives you the best reception. Connecting the antenna to a window screen may improve the signal you can pick up.





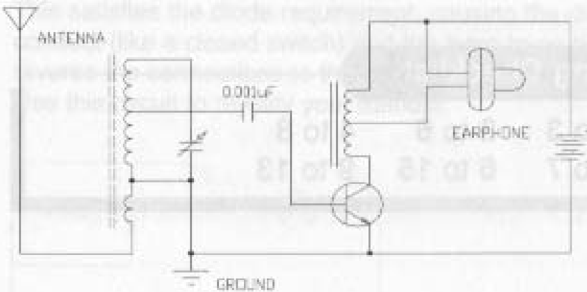
Wiring Checklist

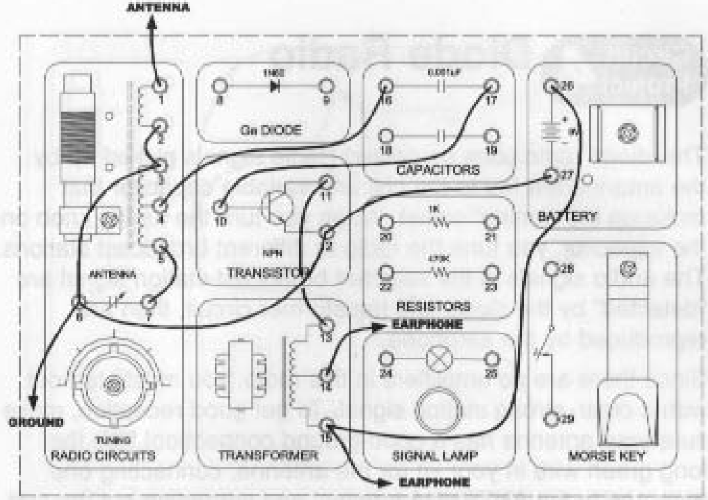
• 2 to 3	3 to 6	4 to 8
• 5 to 7	6 to 15	9 to 13

Circuit Project 5 1-Transistor Radio

This radio uses a single transistor as both detector and amplifier, so its sensitivity is much better than that of the diode radio you constructed in Circuit Project 4.

In this circuit, the broadcast signals are first applied to the "tuned circuit," then they are fed to the transistor which detects them and passes the amplified audio signals through the transformer to the earphone.



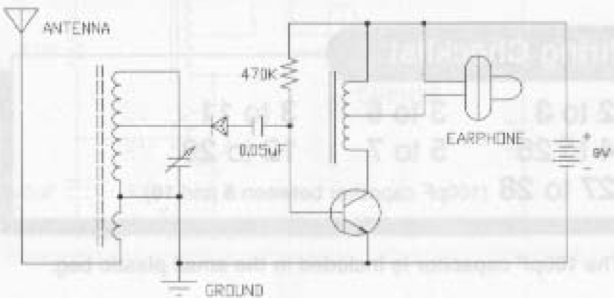


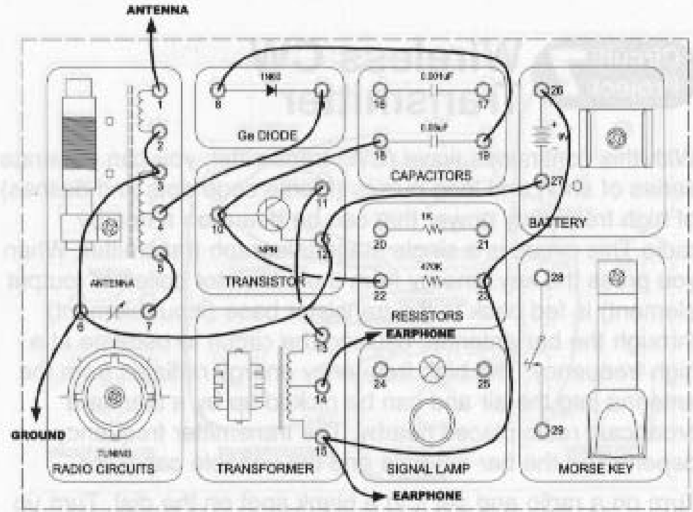
Wiring Checklist

• 2 to 3	3 to 6	4 to 16
• 5 to 7	6 to 12	10 to 17
• 11 to 13	12 to 27	14 to 26

Circuit Project 6 1-Transistor Radio with Diode

This radio uses a diode for detection and a transistorized audio stage to greatly improve signal sensitivity. The tuning circuit is similar to the one used in Circuit Project 5, but the broadcast station signals are now detected by the diode so that low level audio signals are developed across the resistor. Since the resistor is in the transistor-input circuit, the audio frequencies are amplified by the transistor and transferred from the transformer to the earphone. If an antenna is used properly and a good ground connection is made, you will be pleasantly surprised by the excellent reception you get from this 1-transistor radio.





Wiring Checklist

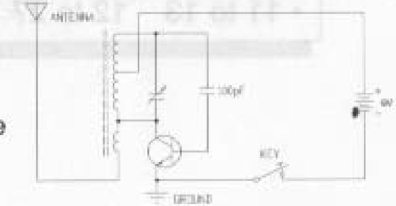
• 2 to 3	3 to 6	4 to 9	5 to 7
• 6 to 12	8 to 19	10 to 18	10 to 22
• 11 to 13	12 to 27	15 to 23	23 to 26

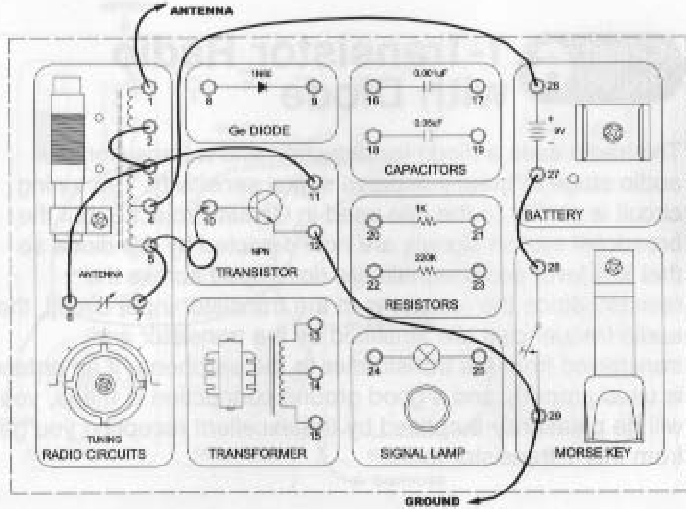
Circuit Project 7 Wireless CW Transmitter

With this continuous wave (CW) transmitter, you can generate a series of short and long pulses (Morse code dots and dashes) of high frequency power that can be heard on a nearby radio. This circuit is a single stage telegraph transmitter. When you press the key, energy from the transistor collector (output element) is fed back to the transistor base (input element) through the bar antenna, causing the circuit to oscillate at a high frequency. The high frequency energy radiates from the antenna into the air and can be picked up by a standard broadcast radio placed nearby. The transmitter frequency depends on the bar antenna and the variable capacitor.

Turn on a radio and set it to a blank spot on the dial. Turn up the volume so you can hear a hiss from the radio, indicating there is no station at that position. Press down the key on the wireless CW transmitter, and adjust the turning knob on the board until you hear sound on the radio.

Now you can practice the Morse code by keying your transmitter and listening to the radio. (You can transmit to two or more radios this way, so your friends can listen to your messages.) If the signal in the radio is too weak, connect a piece of wire to the ANTENNA terminal.





Wiring Checklist

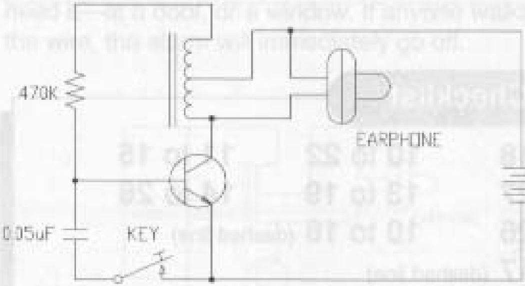
- 2 to 3 — 3 to 6 — 3 to 11
- 4 to 26 — 5 to 7 — 12 to 29
- 27 to 28 (100pF capacitor between 5 and 10)

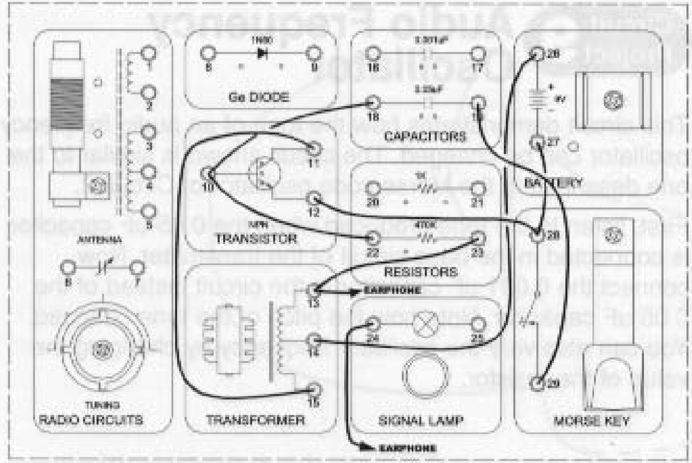
Note: The 100pF capacitor is included in the small plastic bag.

Circuit Project 8 Patrol Car Siren

This circuit generates an audio frequency tone that sounds like a patrol car siren when keyed.

By connecting the transistor collector to one end of the transformer and the transistor base to the other end (through the resistor), the circuit is made to oscillate. Whenever the key is pressed, the capacitor is switched into the circuit, changing the frequency. Keep pressing and releasing the key to produce the sound of the siren.





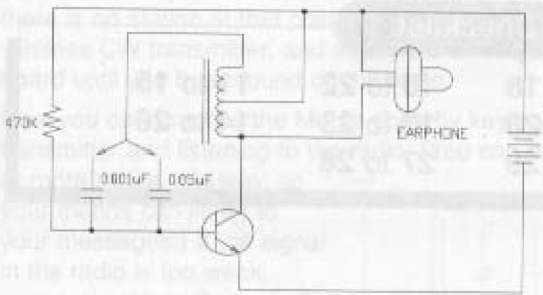
Wiring Checklist

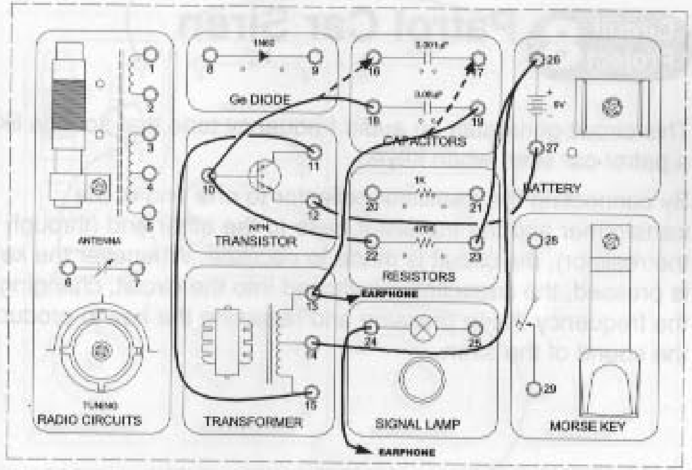
- 10 to 18
- 12 to 28
- 19 to 29
- 10 to 22
- 13 to 23
- 27 to 28
- 11 to 15
- 14 to 26

Circuit Project 9 Audio Frequency Oscillator

This circuit demonstrates how the tone of an audio frequency oscillator can be changed. The circuit shown is similar to the one described in the Morse code oscillator of Circuit 2.

First, listen to the tone produced when the 0.05 uF capacitor is connected in the base circuit of the transmitter. Now, connect the 0.001 uF capacitor in the circuit instead of the 0.05 uF capacitor. Note how the pitch of the tone changed. You can also vary the oscillator frequency by changing the value of the resistor.





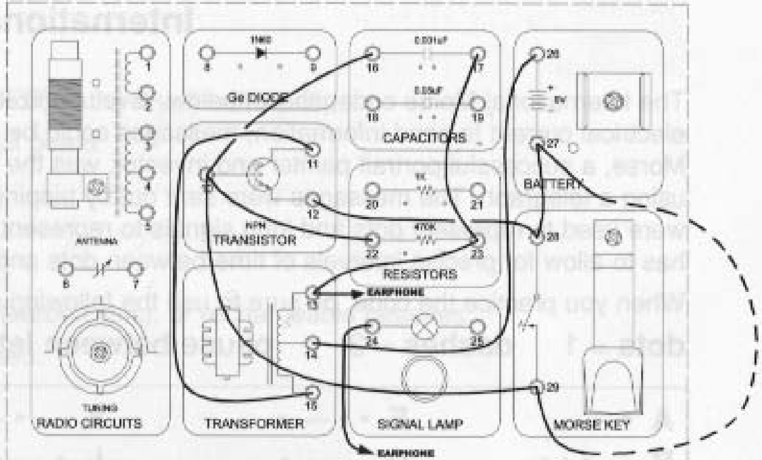
Wiring Checklist

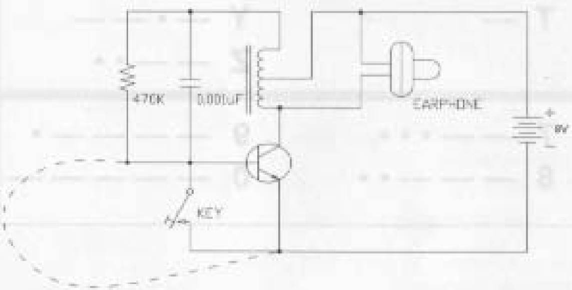
- 10 to 18
- 12 to 27
- 23 to 26
- 13 to 17 (dashed line)
- 10 to 22
- 13 to 19
- 10 to 16 (dashed line)
- 11 to 15
- 14 to 26

Circuit Project 10 Burglar Alarm

Build your own security system that detects "burglars" in your room...or wherever! This circuit is an audio frequency oscillator that may be used as a trip wire detector. The feedback oscillator won't produce a signal as long as the "closed wire circuit" is really closed (attached at both ends and not "broken"). However, if the "closed wire circuit" is broken or disconnected, the alarm will go off in the earphone.

First, connect the circuit shown without the closed wire circuit. You will get an alarm until you will press the key. Pressing the key acts as a "closed wire circuit," so the alarm should stop when you press the key. Now set the trip wire wherever you need it—at a door, or a window. If anyone walks in and "breaks" the wire, the alarm will immediately go off.





Wiring Checklist

- **10** to **16** **10** to **22** **10** to **29**
- **11** to **15** **12** to **28** **13** to **23**
- **14** to **26** **17** to **23** **27** to **28**
- **27** to **29** (dashed line)

International Morse Code

The International Morse code, shown below, revolutionized communication in the nineteenth century. Before the use of electrical current to send information, messages could be delivered no faster than the fastest horse. In 1836, Samuel Morse, a successful portrait painter and inventor, was the first to demonstrate how messages could be sent over wires using a telegraph. The messages were sent out by tapping a special code for each letter of the message—short signals were used to represent dots and long signals to represent dashes. To use Morse code properly, the message sender has to allow for precise intervals of time between dots and dashes, and between letters and words.

When you practice the code, be sure to use the following units of time:

dots = 1 **dashes** = 3 **pause between letters** = 3 **pause between words** = 7

A •—	F ••—•	K —•—	P •——•	U ••—
B —•••	G ——•	L •—••	Q ——•—	V •••—
C —•—•	H ••••	M ——	R •—•	W •——
D —••	I ••	N —•	S •••	X —••—
E •	J •———	O ———	T —	Y —•——
				Z ——••
1 •————	3 •••——	5 •••••	7 ——•••	9 ————•
2 ••———	4 ••••—	6 —••••	8 ———••	0 —————

Battery Installation Instructions

1. Attach a 9-volt battery (006p, VS332, or equal, NOT SUPPLIED) to the 9-volt battery clip.
2. Push the battery into the battery holder mounted on the circuit board.
   - Do not mix old and new batteries.
   - Non-rechargeable batteries are not to be recharged.
   - Do not use rechargeable batteries.
   - Do not mix different types of batteries: alkaline, standard (carbon zinc), or rechargeable batteries.
   - Only batteries of the same or equivalent type are to be used.
   - Remove exhausted batteries from the unit.
   - The supply terminals are not to be short-circuited.
   - To prevent corrosion and possible damage to the product, it is recommended to remove the battery from the lab if it will not be used for more than two weeks.

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