Student Guide

For

Electronic Snap Circuits®

Model SC-300R/500R/750R

Hands-on Program for Basic Electricity and Electronics

Prepared by the Educational Division of

Elenco® Electronics, Inc.

Wheeling, IL 60090 U.S.A.

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THE SNAP CIRCUITS® PROJECT MANUALS

The Snap Circuits® project manuals include lots of useful information in addition to the projects themselves, as listed below. The project manuals summarize much of the lesson in the Student Guide while adding troubleshooting information.

The Model SC-300R contains two project manuals, the Model SC-500R contains three, and the Model SC-750R contains four. Note that the parts lists and information about the parts is spread across all the project manuals. The DO's and DON'Ts of Building Circuits section of the manual with the highest numbered projects is the most thorough.

Much of the text in all chapters is color-coded green and blue so that instructors can easily adapt the course based on the skills and interests of the students. The orange boxes are more advanced material while the brown boxes are considered additional/background material, either can generally be omitted without a significant impact on the course.

First Project Manual contains:

1. Parts List (partial, continued in other manuals)
2. **How To Use It** - brief description of how to make connections and understand the circuit drawings.
3. **About Your Snap Circuits® Parts** - brief description of what each component does (partial, continued in other manuals).
4. **DO's and DON'Ts of Building Circuits** - brief but important guidelines for building circuits (additional guidelines are in other manuals).
5. **Basic & Advanced Troubleshooting** - systematic testing procedure for identifying damaged parts (continued in other manuals).
6. Project Listing
7. Projects 1-101

Other Project Manuals contain:

1. Parts List (partial, continued from first manual)
2. **How To Use It** - brief description of how to make connections and understand the circuit drawings.
3. **About Your Snap Circuits® Parts** - brief description of what each component does (partial, continued from first manual).
4. **DO's and DON'Ts of Building Circuits** - brief but important guidelines for building circuits.
5. **Basic & Advanced Troubleshooting** - systematic testing procedure for identifying damaged parts (continued from first manual).
6. Project Listing
7. Projects 102 and up

Preface

This booklet is an introduction to the exciting world of electronics. Following the "Learn by Doing®" concept, electronics will be easy to understand by using Snap Circuits® to actually build circuits as you learn about them. This booklet emphasizes the practical applications of electronics, without bogging down in mathematics.

Why learn about electronics? Electronics plays an important and increasing role in our everyday lives, and so some basic knowledge of it is good for everyone. Learning about it teaches how to do scientific investigation, and the projects develop basic skills needed in today's world.

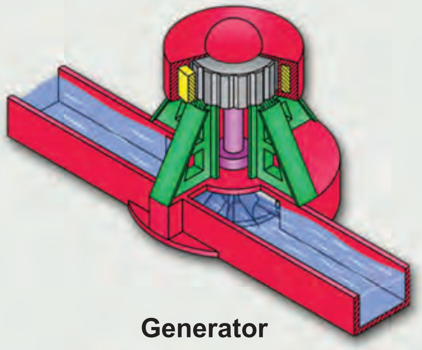
The first pages of the Snap Circuits® project manuals contain a brief description of the parts in Snap Circuits®, along with brief guidelines for building circuits.

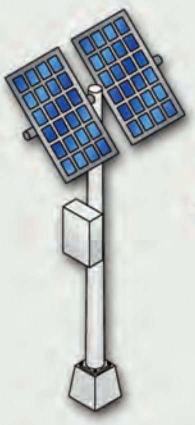
- If you have the **SC-300R** version, you may wish to purchase the **UC-50 Upgrade Kit** to continue to Part II of this manual. The **UC-70 Upgrade Kit** will allow you to continue to Parts II & III of this manual.
- If you have the **SC-500R** version, you may wish to purchase the **UC-80 Upgrade Kit** to continue to Part III of this manual. Upgrade kits can be purchased online: ***www.snapcircuits.net***

CHAPTER 1: BASIC COMPONENTS & CIRCUITS

What is electricity? Nobody really knows. We only know how to produce it, understand its properties, and how to control it. It can be created by chemistry (batteries), magnetism (generators), light (solar cells), friction (rubbing a sweater), and pressure (piezoelectric crystals).


Batteries


Generator


Solar Cells

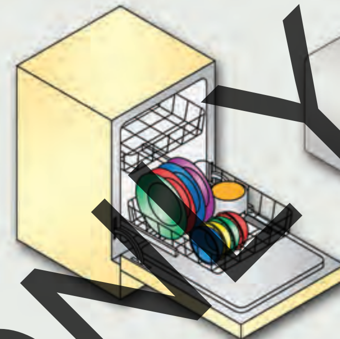

Rubbing a Sweater

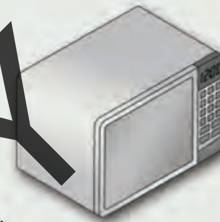

Piezoelectric Crystal

In this section you will learn about basic electrical components and circuits. By building circuits using Snap Circuits®, you will begin to understand the electrical world.

Electricity is energy that can be used to save us effort (electric toothbrushes and dishwashers), heat things (electric heaters and microwave ovens), make light (light bulbs), and send information (radio and television). But electricity can also be dangerous if abused (electric shock).

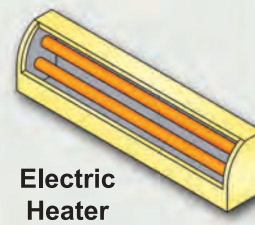

Electric Toothbrush


Dishwasher


Microwave Oven


Light Bulb


Radio


Electric Heater


Television


Electric Shock

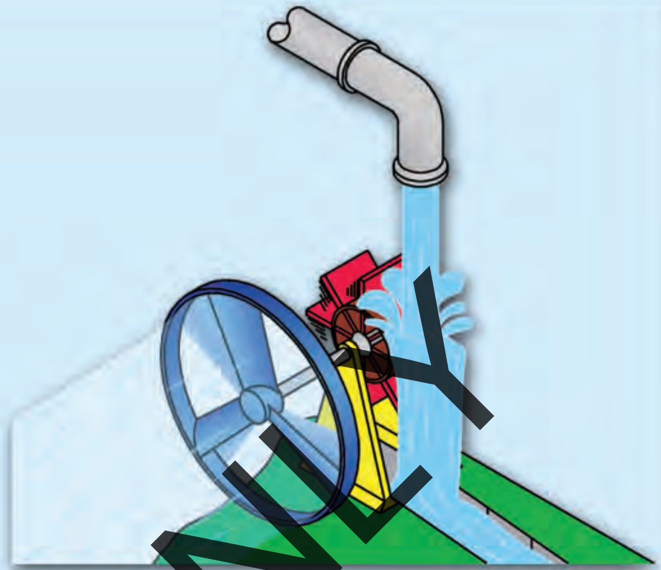
In this chapter you will learn about generators and motors. A generator uses mechanical motion to create electricity and a motor uses electricity to create mechanical motion. This statement may not seem important to you but it is actually the foundation of our present society. Nearly all of the electricity used in our world is produced at enormous generators driven by steam or water pressure. Wires are used to efficiently transport this energy to homes and businesses where it is used. Motors convert the electricity back into mechanical form to drive machinery and appliances. **The most important aspect of electricity in our society** - more important than the benefits of the Internet - **is that it allows energy to be easily transported over distances**.

Note that "distances" includes not just large distances but also tiny distances. Try to imagine a plumbing structure of the same complexity as the circuitry inside a portable radio - it would have to be large because we can't make water pipes so small. Electricity allows complex designs to be made very small.

2-1 Motors

Water flowing under pressure in a pipe or a fast-moving stream can be used to turn a paddlewheel. If the paddlewheel was linked to a fan blade then you could use the water pressure to turn the fan, perhaps to cool yourself on a hot day. If the water was flowing very fast due to high pressure, then you could get the fan moving fast enough it might create a strong airflow like a propeller on a plane.

A similar thing happens in a motor, with electricity instead of water. A motor converts electricity into mechanical motion.

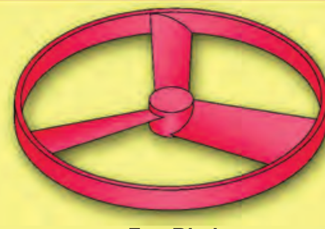


Introducing New Parts

Snap Circuits® includes one motor, shown here with its symbol. Snap Circuits® also includes a fan, which is used with the motor. An electric current in the motor will turn the shaft and the motor blades, and the fan blade if it is on the motor.

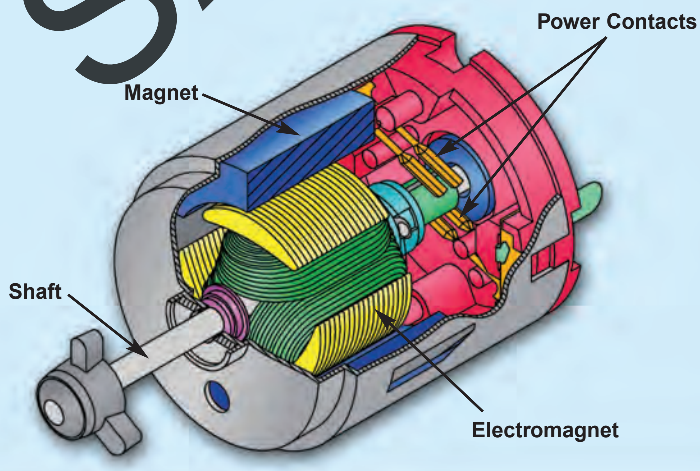
Motor Symbol

Motor (M1)



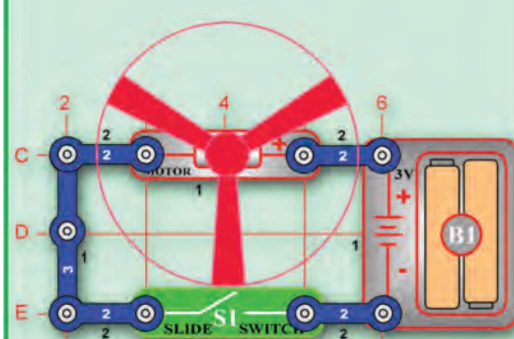
Fan Blade

How does electricity turn the shaft in the motor? The answer is magnetism. Electricity is closely related to magnetism, and an electric current flowing in a wire has a magnetic field similar to that of a very, very tiny magnet. Inside the motor is a coil of wire with many loops, if a large electric current flows through the loops the magnetic effects become concentrated enough to move a small magnet. The motor also has a small magnet, on a shaft. When electricity moves the magnet, the shaft spins. If the fan is on the motor shaft then its blades will create airflow.



Experiments

Consider this circuit (which is project 2):



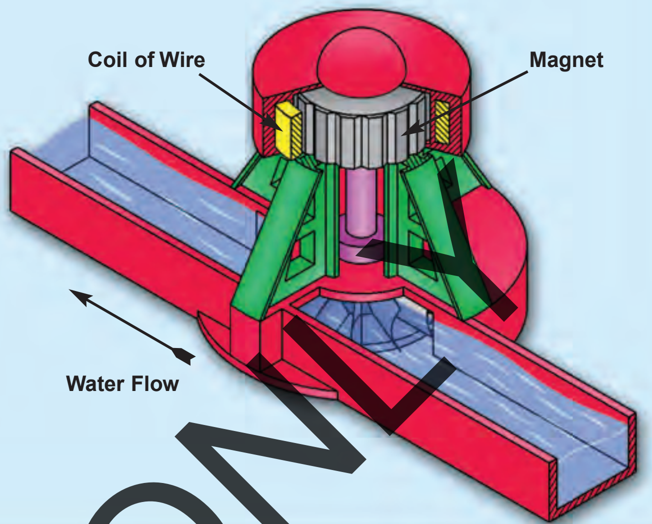
When the switch is on, current flows from the batteries through the motor making it spin. The fan blades will force air to move past the motor. Be careful not to touch the motor or fan when it is spinning at high speed.

Motors are used in all electric powered equipment requiring rotary motion, such as a cordless drill, electric toothbrush, and toy trains. An electric motor is much easier to control than gas or diesel engines.

The electromagnetic effect described above also works in reverse - spinning a magnet next to a coil of wire will produce an electric current in that wire. This is what happens in a **generator**, which uses mechanical motion to create electricity. In an electric power plant, high-pressure water (from a dam) or steam (heated by burning oil or coal) is used to spin a paddlewheel linked to magnets. The magnets create an electric current in a coil of wire, which is used to power our cities.

In theory, you could connect your Snap Circuits® motor directly to the 2.5V lamp and spin the fan blade with your fingers to light the lamp. In reality, it would be impossible for you to spin the motor fast enough to produce enough current to get even a glimmer of light from the lamp.

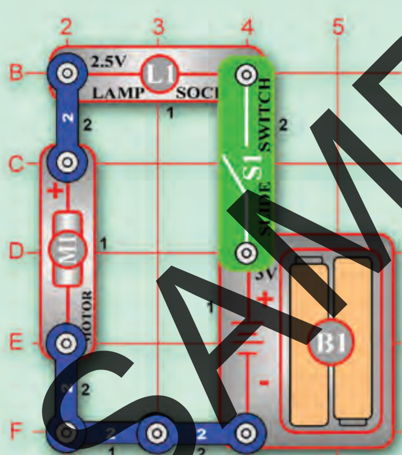
To summarize, **a generator uses mechanical motion to create electricity and a motor uses electricity to create mechanical motion**.



2-2 Motor Circuits

Experiments

Consider this circuit (which is project 5):

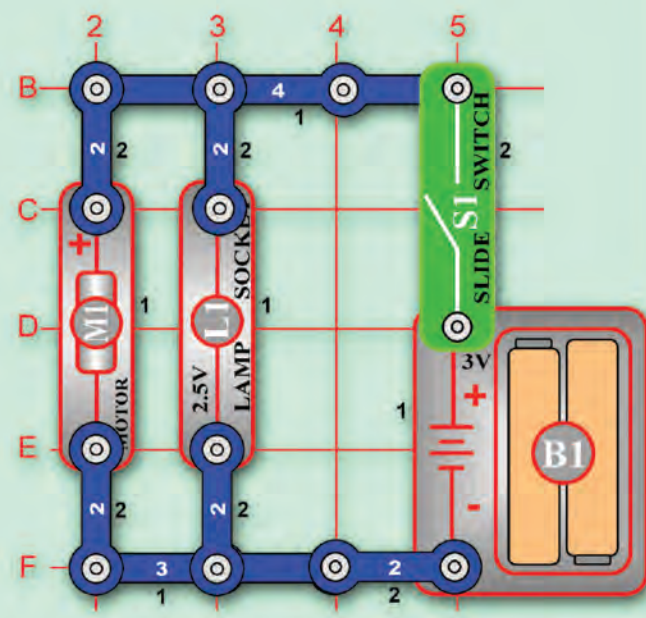


If the switch is on, the lamp will light and the fan will spin.

The lamp and motor are in series, so the voltage from the batteries will get divided between them. In this circuit more of the voltage will be used at the lamp than at the motor.

If the fan was not on the motor then the motor would spin much faster but the lamp would not be as bright. The motor needs more voltage to spin faster, so there is less voltage available to light the lamp.

Consider this circuit (which is project 6):



If the switch is on, the lamp will light and the fan will spin. This circuit has the lamp and motor in parallel, so the full voltage from the batteries would be applied to both. So the fan would spin faster than for the circuit in project 5, which divided the battery voltage between the lamp and motor.

5-7 Microphone

Introducing New Parts

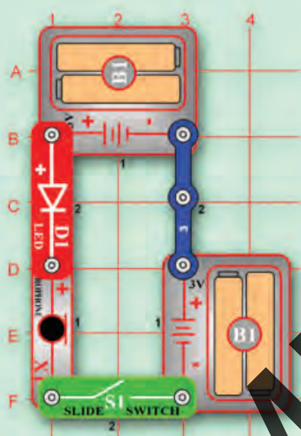
Microphone (X1)

Microphone Symbol

This part acts like a resistor that changes when exposed to sound waves. This change in resistance will change the current through a circuit when sound waves apply pressure to its surface. This action is similar to squeezing a garden hose and watching the water through it decrease. The side with a "+" mark should always be placed toward the higher voltage.

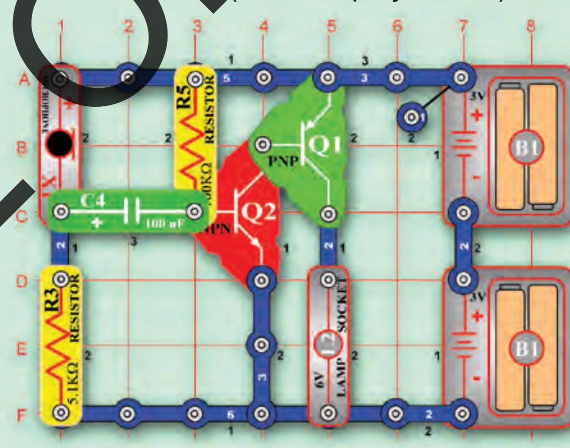
Experiments

Consider this circuit (which is project 273):



If you blow on the microphone, the LED brightness changes.

Consider this circuit (which is project 109):



Current flows through the 100KΩ resistor to turn on the transistors and lamp. Blowing on the microphone diverts current away from the transistors and the lamp shuts off briefly.

Summary

Summary of Chapter 5:

1. The resistance of semiconductors may be controlled by their operating conditions.
2. Semiconductors have a turn-on level (0.7V for silicon), after which the resistance becomes very low in one direction.
3. Transistors have three connection points, called the emitter, base, and collector.
4. The transistor is a current amplifier, it uses a small amount of current to control a large amount of current.
5. When a small current flows into the base and out of the emitter in an NPN transistor, a larger current flows into the collector and out of the emitter. In a PNP transistor, current flows into the emitter and out of the base and collector.
6. A microphone is a resistor that changes when exposed to sound. This change in resistance will change the current through a circuit when sound waves apply pressure to its surface.

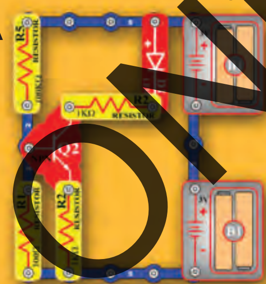
Quiz

Chapter 5 Practice Problems

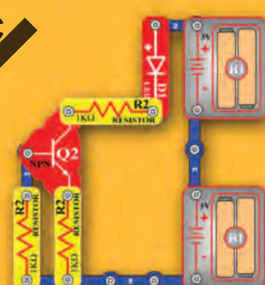
1. In a transistor, the ____________ will have the most current flowing through it.
   A. Emitter C. Collector
   B. Base D. Vacuum tube

2. The following are advantages of transistors except . . .
   A. they can be miniaturized.
   B. they can amplify signals.
   C. their resistance can be changed by adjusting the voltage in the circuit.
   D. it has zero resistance under certain operating conditions.

3. Which circuit will light the LED?

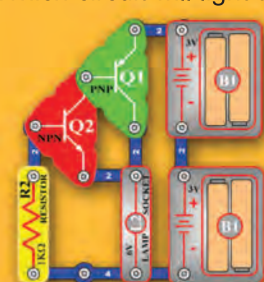
A


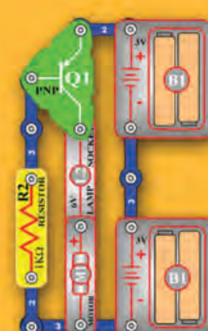
B

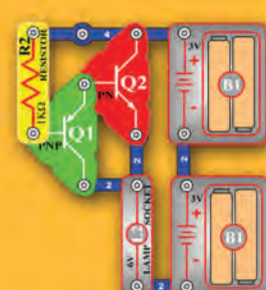

C


D All three.

4. Which circuit will light the lamp?

A


B


C


D All three.

Answers: 1. A, 2. D, 3. B, 4. B

CHAPTER 6: OSCILLATORS & ELECTRONIC SOUND

Learn By Doing®

Your electronic stereo and radio are powered by electricity and play music, so how does electricity make sound? In this chapter you will find out. You will also learn about oscillator circuits, and build some simple ones using snap circuits.

Oscillators are used in all radios, TVs, and electronic communications equipment to set the transmitter or receiver frequency. Different types of oscillators are used as timing references in computers and almost all complex electronic products. It would be hard to count how many oscillator circuits are in your home since there are different types and they can be hard to identify.

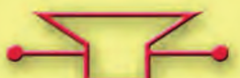
Oscillators can be among the most difficult electronic circuits to design, due to the tight requirements placed on them by today's communications technology. They usually don't use a lot of components, but the way they are arranged is complex and often difficult to analyze. But they are fun to learn about.

6-1 Electronic Sound

Introducing New Parts

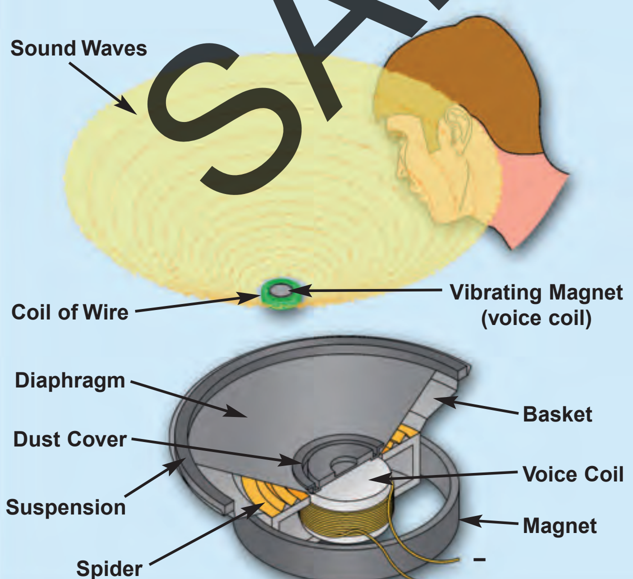
Snap Circuits® includes a speaker:

Speaker (SP)



Speaker Symbol

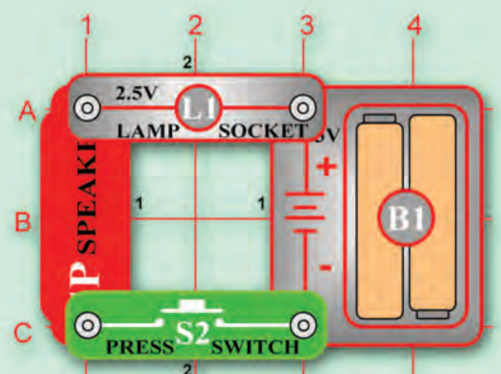
A **speaker** converts electricity into sound. It does this by using the energy of a changing electrical signal to create mechanical vibrations (using a coil and magnet similar to that in the motor). These vibrations create variations in air pressure, called sound waves, which travel across the room. You "hear" sound when your ears feel these air pressure variations.

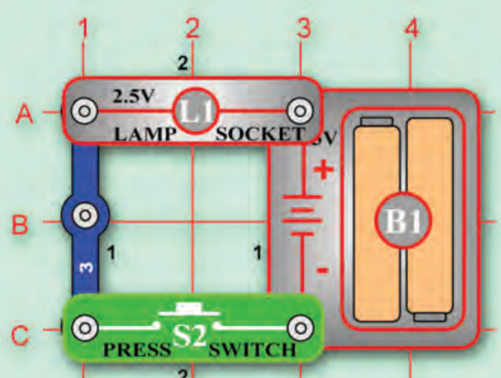


A speaker can only create sound from a CHANGING electrical signal, for unchanging electrical signals it acts like an 8Ω resistor. (An unchanging signal does not cause the magnet in the speaker to move, so no sound waves are created).

Experiments

For example, compare these two mini-circuits:





When you press or release the press switch, you hear static from the speaker. When you hold the press switch down, the speaker is silent and the lamp is not as bright as the circuit without it.

7-2 Integrated Circuit Projects

Integrated circuits are used in most electronic products; there are probably more than a thousand throughout your home. The range and uses of ICs available is hard to imagine.

Although Snap Circuits® contains only five IC modules, more than half of the projects use at least one. There are many more examples of using the parts described in the preceding chapters, such as the microphone and photoresistor. Here is a short description of each, the project manuals explain them in more detail:

Suggested Projects: 38, 51, 58, 61, 81, 83, 119, 158, 178, 202, 237, 238, 242, 245, 250, 255, 272, and 297.

Project 3: Uses the music IC with the whistle chip as a vibration sensor.

Project 4: Uses the music IC with the whistle chip as a vibration sensor.

Project 10: Combines the sound effects of the music and space war ICs.

Project 15: Uses the music IC as a doorbell.

Project 16: Uses the music IC as an alarm.

Project 17: Makes one of the alarm IC siren sounds.

Project 18: Makes one of the alarm IC siren sounds.

Project 19: This is the standard circuit using the space war IC.

Projects 20-21: This uses the photoresistor with the space war IC.

Projects 22-26: Uses the photoresistor and music IC to control the alarm IC siren sounds.

Projects 27-31: Uses the whistle chip and music IC to control the alarm IC siren sounds.

Projects 32-33: Uses the whistle chip and music IC to control the space war IC.

Projects 34-35: Uses the motor and music IC to control the space war IC.

Projects 36-37: Uses the motor and alarm IC to control the space war IC.

Projects 38-39: Uses the alarm IC to control the music IC. An example of a periodic (repeating) signal.

Projects 40-44: Uses the motor and music IC to control the alarm IC siren sounds.

Project 45: Uses the photoresistor, music IC, and alarm IC to control an LED.

Project 46: Makes one of the alarm IC siren sounds.

Project 51: The alarm IC uses the photoresistor to sense reflections from a lamp.

Project 52: The alarm IC uses the photoresistor to sense reflections from a lamp.

Project 53: Sound and light controlled by the alarm IC.

Project 54: Uses the alarm IC to control the space war IC.

Project 58: Uses the music IC to control the alarm IC, with additional control from the whistle chip and photoresistor. Also shows how some parts can be used as wires.

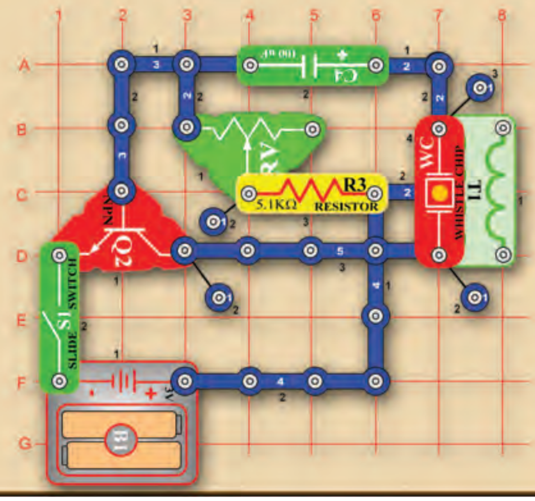
Project 60: Uses the alarm and space war ICs to control the motor.

Projects 61-65: The alarm IC makes sound with the whistle chip; loudness is controlled by the photoresistor.

Project 66: Uses the space war IC in a mind-reading game.

Experiments

Consider this circuit:



The whistle chip makes a sound like a dripping faucet; use the adjustable resistor to make it drip faster or slower. Although the sound may seem to be nearly continuous, the transistor is only activating for about 1/100 second for each drip.

Other Snap Circuits® using the transformer in an oscillator: 347-351, 399-408, 419-424, 447-452, and 458-465.

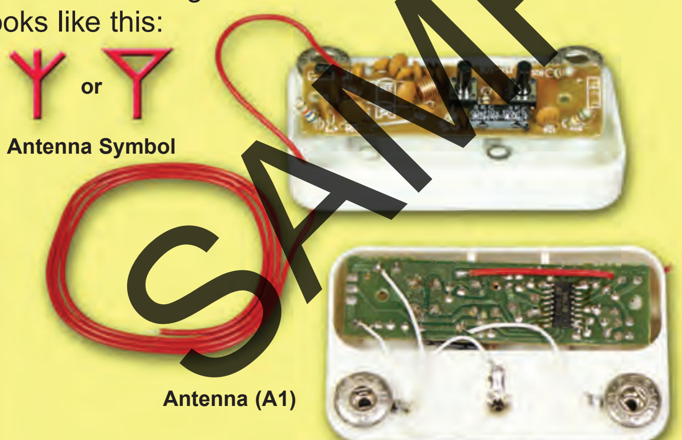
9-5 More About FM Radio

FM • 88 • 92 • 96 • 100 • 104 • 108 MHz
AM 540 • 650 • 800 • 1000 • 1300 • 1700 kHz

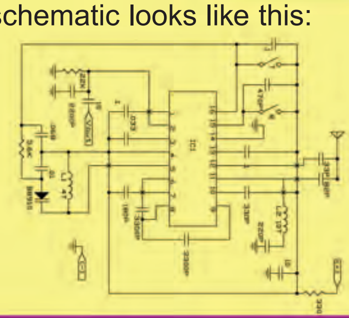
In sections 8-4 and 8-5 you learned about AM (Amplitude Modulation) and FM (Frequency Modulation) radio, and built some AM radio circuits. You may want to review those sections now.

Introducing New Parts

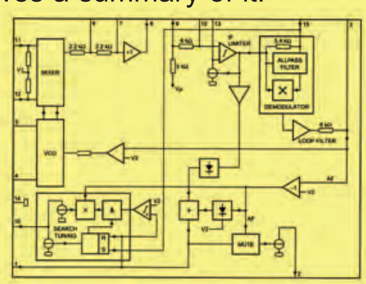
Snap Circuits® includes an FM module, which contains an integrated FM radio circuit. The inside looks like this:



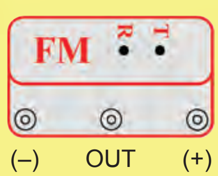
Its actual schematic looks like this:



This circuit is actually much more complex than it appears here, since it is built around an integrated radio circuit. A schematic of the circuitry within this part would be too large to show here, but this block diagram gives a summary of it:



Its Snap Circuits® connections are like this:

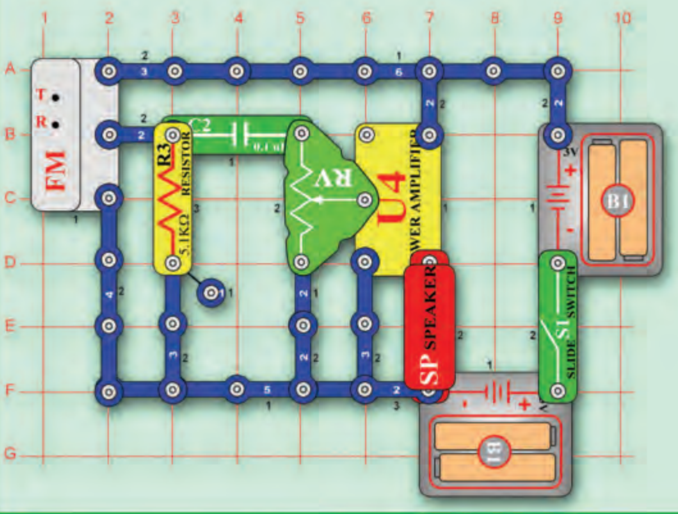


FM Module:
(+) - power from batteries
(–) - power return to batteries
T - tune up
R - reset
OUT - output connection

The antenna (Y) is a loose wire that should always be left unconnected and spread out for best radio reception.

Experiments

Consider this circuit (which is project 307, or a variation of it):



Turn on the switch (S1) and press the R button. The R button resets the frequency to 88MHz (the beginning of the FM band). Now press the T button and the FM module scans for an available radio station.

When a station is found, it locks on to it and you hear it on the speaker. Adjust the volume using the adjustable resistor (RV). Press the T button again for the next radio station. The module will scan up to 108MHz (the end of the FM band), and stop.

Snap Circuits® project 316 is a variant of this circuit without a volume adjustment. Project 306 is a variant of the AM radio circuits discussed in section 8-5.

9-6 When Wires Are Not Wires

In section 8-3 you learned that the AM antenna (Snap Circuits® part A1) has inductance due to its magnetic affects at AM radio frequencies, and that at low frequencies it acts like an ordinary wire. At FM radio frequencies (88-108MHz) a long wire has enough inductance to become an antenna, and one is used like this on the Snap Circuits® FM module.

AM Antenna (A1)

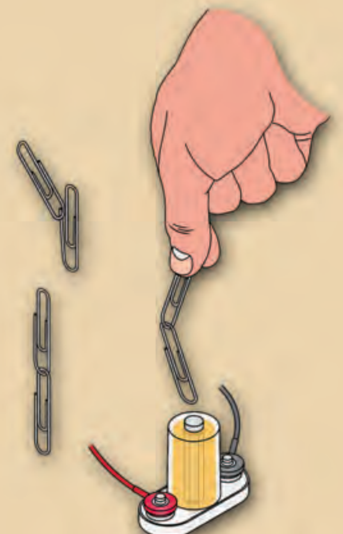
FM Antenna Wire

The entire FM radio circuit comes as a complete module, instead of coming as individual parts that you could build and experiment with. This was necessary because at FM frequencies the snap wires connecting your parts on the base grid are long enough to have enough inductance to change the performance of the circuit. The output signal to the power amplifier IC (U4) is at much lower frequency (audio, 300-3000Hz).

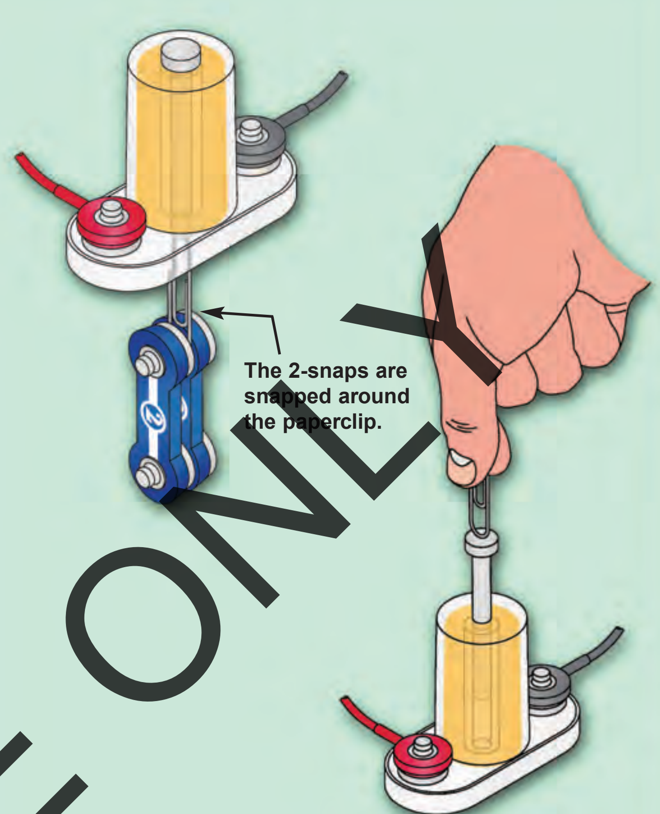
At microwave frequencies (>1000MHz) circuit design becomes very complicated since every component or interconnection has some amount of capacitance and inductance. Components and the spaces between them must be as small as possible for circuits to perform properly.

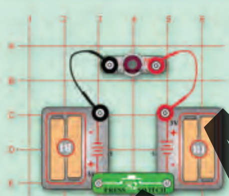
If you don't have a compass, you can make one using metal paperclips. Slide two paperclips together, using their loops.

Hold the paperclips just above the electromagnet, without them touching the iron core rod. Press the switch and watch how the lower paperclip is attracted to the rod. It will point toward it like a compass.



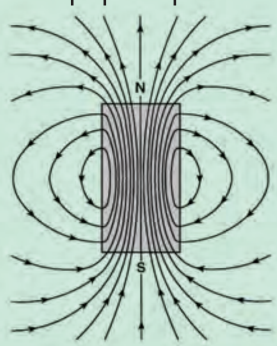
Use the paperclips to pick up things.

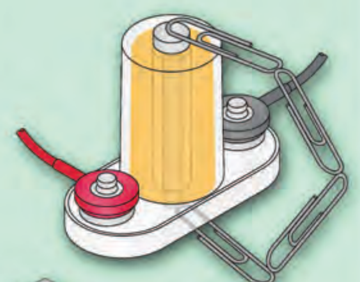


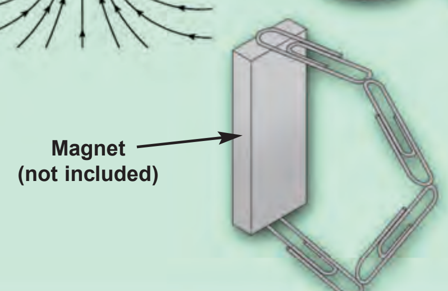


Snap Circuits® includes some paperclips, use the electromagnet to pick up some. Release the switch to drop them.

The magnetic field created by a magnet occurs in a loop. You can see this using the electromagnet and paperclips:



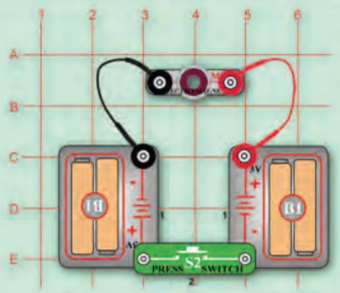




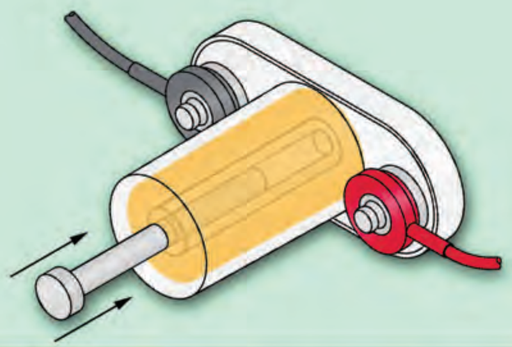
Materials made of iron concentrate their magnetic effects at both ends. The center of the material is magnetically neutral because the attraction from each end is the same.

The magnetic field created by the electromagnet works the same way. It is strongest at both ends but neutral in the center. But the electromagnet is hollow - so iron at one end will be sucked into the middle.

Experiments



Use the same simple circuit but lay the electromagnet on its side with the iron core rod sticking out about halfway. Press the switch to see the rod get sucked into the center.



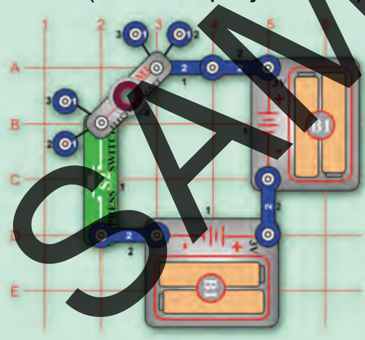
A lighter iron object will move better. Straighten out a paperclip, and bend it in half.

Place it on one side of the electromagnet and press the switch to see it sucked inside. Hold the switch and gently pull it out to see how much suction the electromagnet has.

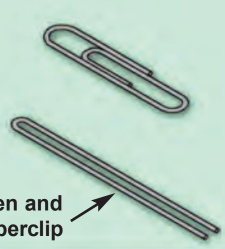
Try sucking in other thin iron objects, like nails.

Experiments

This circuit will use electromagnetism to defy gravity. Mount the electromagnet on the base grid using this circuit (which is project 664).



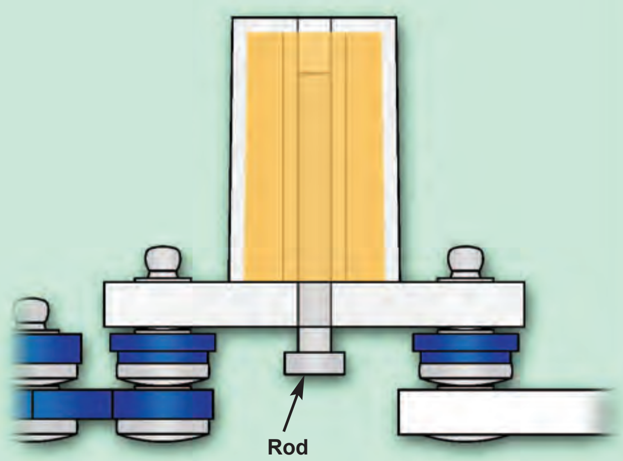
Bend a paperclip as shown, and drop it into the electromagnet. Press the switch to suspend the paperclip in mid-air.



Straighten and bend paperclip

Add two more 1-snaps under the electromagnet to make it higher, and try it again.

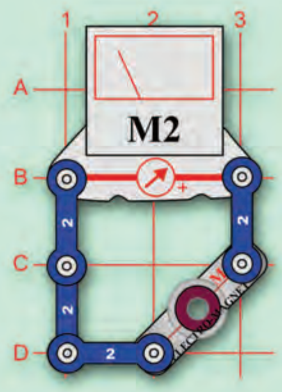
You can also make your electromagnet tower shorter (one 1-snap on each side) and place the iron core rod under it. Then you can suspend the rod in mid-air.



All of the preceding circuits used electricity to create magnetism. But most electricity is made using magnetism, by steam-driven generators in power plants operated by your electric company. These spin a magnet to create a current in a wire.

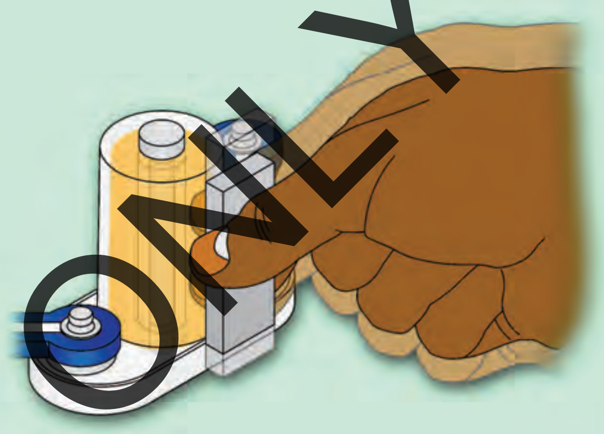
Experiments

If you have a magnet available (Snap Circuits® does not include one), consider this mini-circuit:



Set the meter (M2) to the LOW (or 10mA) setting and place the iron core rod in the electromagnet. This circuit has no batteries and won't do anything by itself.

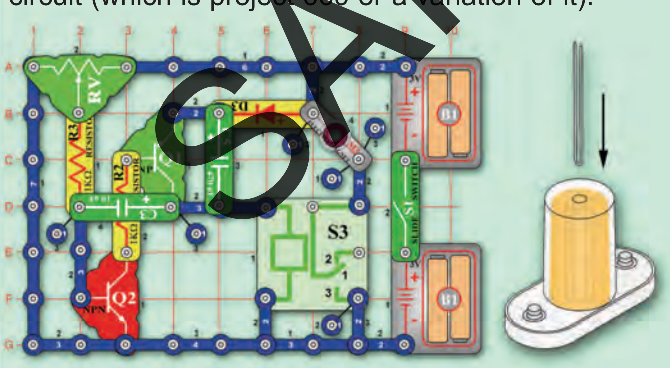
Move your magnet up and down next to the electromagnet. The meter deflects to show that you created an electrical current in the circuit.



12-4 Electromagnetic Oscillators

Experiments

Snap Circuits® will now give you a more dramatic demonstration of how electricity can control magnetic fields in ways ordinary magnets can't. Consider this circuit (which is project 669 or a variation of it):



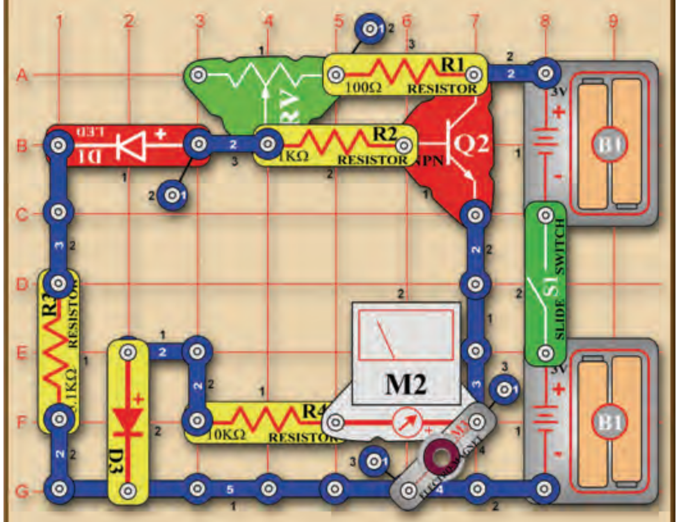
Straighten and bend a paperclip as shown, and drop it into the electromagnet. Set the adjustable resistor (RV) control lever to the right, and the paperclip gets sucked into the electromagnet. Set the lever to the left and it falls. Now slowly slide the lever until you find a spot where the paperclip is bouncing up and down!

The transistors make an oscillator that turns the electromagnet current on and off. If the oscillator frequency is just right, the paperclip bounces up and down.

For another demonstration, replace the bent paperclip with the iron core rod. Slide two paperclips together using their loops and dangle one above the rod without touching it. Slide the adjustable resistor control lever around to see the lower paperclip vibrate as the magnetic field changes.

Experiments

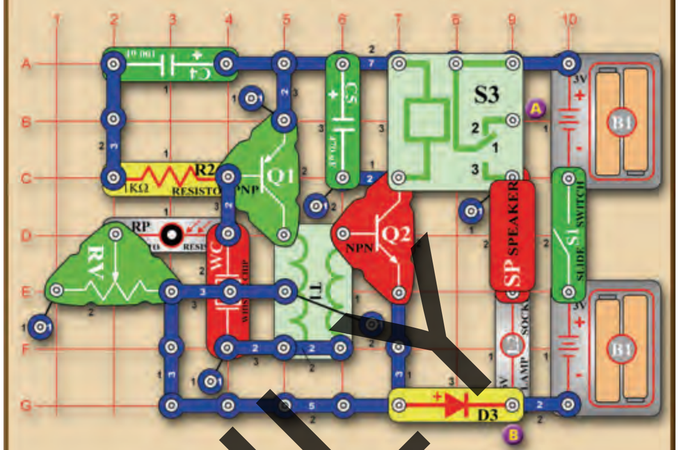
Consider this circuit (which is project 666):



Set the meter to the LOW (or 10mA) scale and drop a bent paperclip into the electromagnet. Move the adjustable resistor control lever to adjust the height of the paperclip above the table. The meter shows how the current changes as you adjust the paperclip height.

Experiments

Consider this circuit (which is project 683):



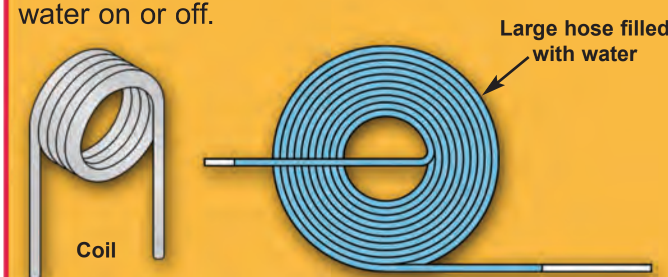
Connect the electromagnet to points A & B using the jumper wires. Hold the electromagnet one inch above the table and drop a bent paperclip into it. Slide the adjustable resistor control lever around and watch the paperclip vibrate. Covering the photoresistor (RP) stops the vibration. You can control the height and frequency of the vibration.

Replace the bent paperclip with the iron core rod. Slide two paperclips together using their loops and dangle one above the rod without touching it. Slide the adjustable resistor control lever around to see the lower paperclip vibrate as the magnetic field changes.

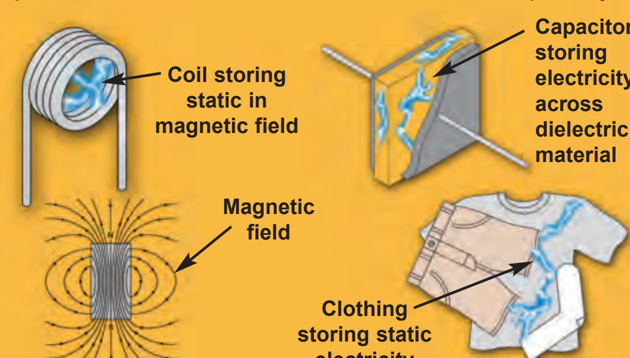
Other paperclip vibration circuits: 667, 668, and 670-682.

12-5 The Anti-Capacitor

Coils of wire like those in the electromagnet, antenna, transformer, relay, and motor can store electricity in a magnetic field. Electricity is needed to set up the magnetic field, and is released into the circuit when the magnetic field collapses. A coil of electricity is like a long garden hose – the water doesn't start or stop immediately when you turn the water on or off.

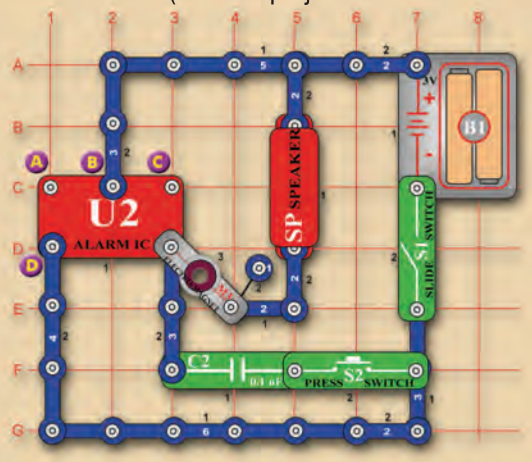


Coils store energy in a magnetic field while capacitors store energy as an electric charge across a material (an electric field). Coils and capacitors have opposite effects on a circuit, but it depends on their construction and the frequency.



Experiments

Consider this circuit (which is project 535 in most manuals):



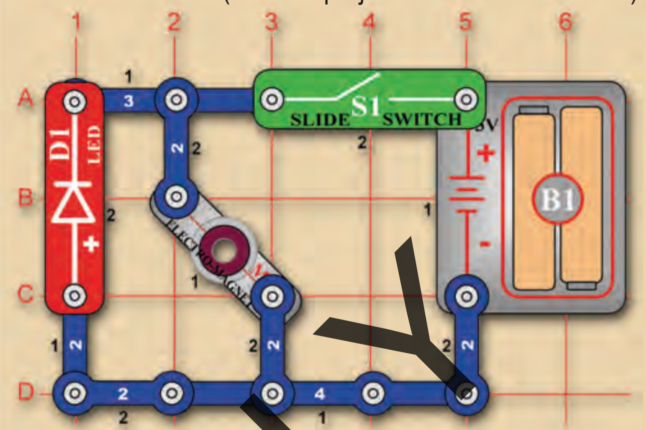
Turn on the slide switch (S1) and the familiar siren sound is badly distorted. The distortion occurs because the electromagnet opposes some of the siren frequencies more than others. You can test it with and without the iron core rod.

Now push the press switch (S2) and the siren sounds more normal. The 0.1μF capacitor counteracts the electromagnet effects.

Now use a jumper wire to connect points A & B, and test the effects using a different alarm sound. Then move the jumper wire to points B & C, then A & D.

Experiments

Consider this circuit (which is project 531 in most manuals):



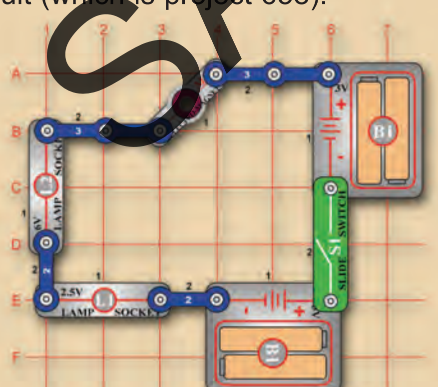
Place the iron core rod in the electromagnet and turn the switch on and off. When the switch is turned off the energy from the electromagnet's magnetic field discharges through the LED.

If you remove the iron core rod then the LED will not flash as brightly, because less energy is stored in the magnetic field.

Snap Circuits® projects 530, 532, 533, and 534 are similar circuits showing that the antenna, transformer, and relay store energy in magnetic fields. Project 529 shows the fan blade storing energy as mechanical motion.

Experiments

The electromagnet is a long wire wrapped in a coil. For constant or slowly changing voltages, its magnetic properties can be ignored and the resistance of the wire is about 25 ohms. Consider this circuit (which is project 658):



The iron core rod isn't needed, because the voltage changes slowly. Notice how lamp L2 takes longer to get bright while lamp L1 gets bright initially but becomes less bright as L2 turns on. Why?

Incandescent lamps like these are made with a high-resistance filament that gets hot enough to glow. The current is higher when a lamp is cold than when the filament has heated up (and has more resistance). This is why bulbs only burn out when you first turn on the light.

Lamps L1 and L2 have low resistance at first because the filaments are cold. The resistance increases as the filaments heat up, and L1's filament heats up faster than L2's.

The resistance of the electromagnet lowers the current, so the filaments don't heat up as fast. Compare this circuit to project 152, which will turn on the lamps faster.

Snap Circuits® projects 656 and 657 are variations of project 658.

Here are some highlights from projects PC1-PC73:

Project PC1: Shows that a tone consists of one strong frequency and many multiples of it at lower amplitudes. It also shows that adding capacitance to an oscillator (lowering the tone of the sound) widens the spacing in oscilloscope mode and lowers the frequency spacing in FFT mode.

Projects PC4-PC7: Shows how the alarm IC makes different siren sounds by changing characteristics of the signal.

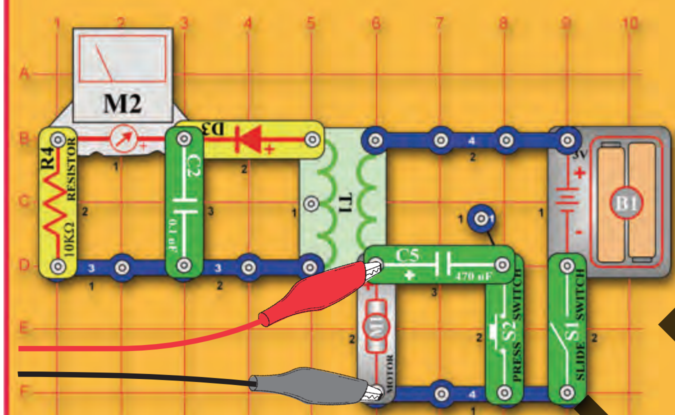
Project PC10: This is an example of modulation (see section 8-4) and filtering.

Project PC12: View the voice signal from a radio.

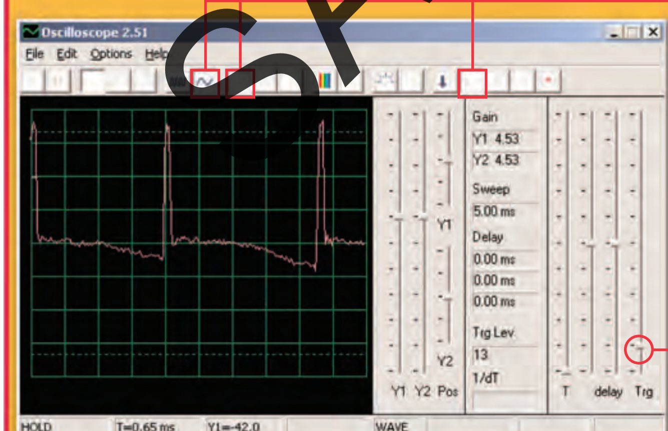
Project PC14: Shows what your voice looks like, and some sound patterns you can make.

Experiments

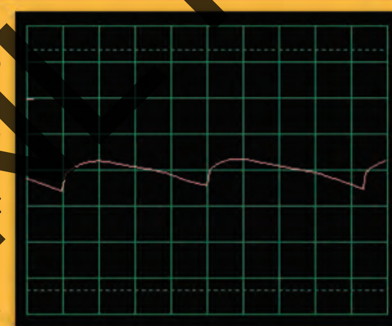
Use Winscope to take a closer look at this circuit (project 523, which you studied in section 10-1):



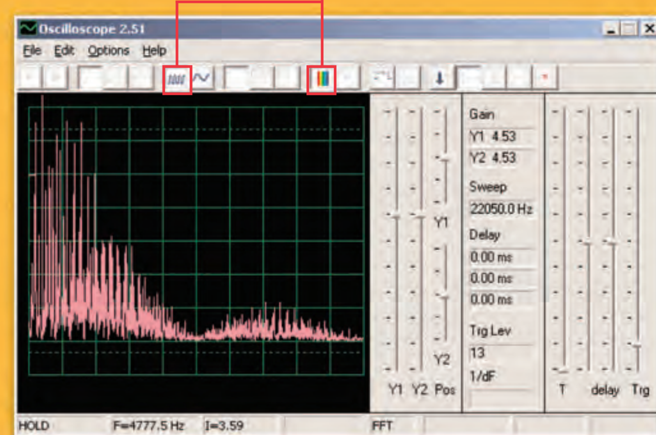
Place the fan on the motor and turn on the slide switch (S1). As the motor spins it connects/disconnects sets of electrical contacts that keep the magnetic field from a coil spinning the shaft. This creates an electrical disturbance which crosses the transformer and moves the meter. Use the Winscope settings shown here to view the disturbance.



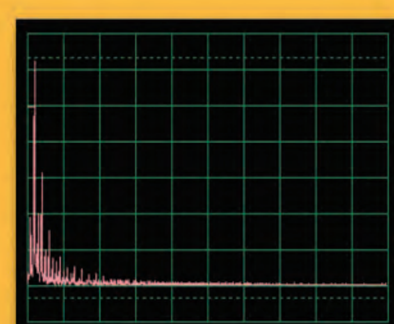
Push the press switch (S2) to connect the 470μF capacitor across the motor.
This filters out most of the disturbance, as you can see with Winscope (use the same settings).



Now change Winscope to FFT mode and change the horizontal scale to compare the frequency spectrum. Press the switch to add the capacitor. This filters out most of the high frequency energy from the disturbance.



Press switch pressed, same Winscope settings.



SUMMARY OF COMPONENTS (continued)

Schematic Symbol	Part	Function	Quantity
	Meter	To measure how much current is flowing in a circuit.	1 SC-500R & SC-750R only
	Transformer	Inductor used to change the AC voltage without wasting power.	1 SC-500R & SC-750R only
	FM Module	Module containing an FM receiver and amplifier circuit.	1 SC-500R & SC-750R only
	Diode	Block current flow in one direction.	1 SC-500R & SC-750R only
	7-Segment	A group of seven LEDs that can display one letter or number.	1 SC-500R & SC-750R only
	Recording IC	Module to record and play music or talking.	1 SC-500R & SC-750R only
	Relay	An electronic component that uses magnetism to open or close a mechanical switch.	1 SC-500R & SC-750R only
	SCR	A controlled diode used as an electronic switch.	1 SC-500R & SC-750R only
	Solar Cell	Uses light to produce a voltage that can power a circuit.	1 SC-750R only
	Electromagnet	Inductor that acts like a magnet when a current flows through it.	1 SC-750R only
	Vibration Switch	Connect or disconnect power to a circuit when shaken.	1 SC-750R only
	Two-spring Socket	Easy connection of other electrical components to Snap Circuits®.	1 SC-750R only
	Computer Interface	View the electrical signals in a circuit.	1 SC-750R only

Additional / replacement parts may be ordered at www.snapcircuits.net or by calling Elenco® at 847-541-3800.

DEFINITION OF TERMS (also see Summary of Components pages 132-134)

AC	Common abbreviation for alternating current.
Alternating Current	A current that is constantly changing.
AM	Amplitude modulation. The amplitude of the radio signal is varied depending on the information being sent.
Ampere (A)	The unit of measure for electric current.
Amplify	To make larger.
Amplitude	Strength or level of something.
Analogy	A similarity in some ways.
Anode	The side of a diode that current flows into.
Antenna	Inductors used for sending or receiving radio signals.
Audio	Electrical energy representing voice or music that can be heard by human ears.
Base	One of the connection points on a transistor.
Battery	A device which uses a chemical reaction to create an electric charge across a material.
Blackout	When part of a city is cut off from the power plants supplying it with electricity.
Capacitance	The ability to store electric charge.
Capacitor	An electrical component that can store electrical pressure (voltage) for periods of time.
Cathode	The side of a diode that current flows out of.
Circuit	An arrangement of electrical components to do something.
Clockwise	In the direction in which the hands of a clock rotate.
Coil	A wire that is wound in a spiral.
Collector	One of the connection points on a transistor.
Color Code	A method for marking resistors using colored bands.
Conductor	A material that has low electrical resistance.
Counter-Clockwise	Opposite the direction in which the hands of a clock rotate.
Current	A measure of how fast electricity is flowing in a wire or how fast water is flowing in a pipe.
DC	Common abbreviation for direct current.
Diaphragm	A flexible wall.
Digital Circuit	A wide range of circuits in which all inputs and outputs have only two states, such as high/low.
Digital Electronics	Using a series of numbers to represent an electrical signal.
Diode	An electronic device that allows current to flow in only one direction.
Direct Current	A current that is constant and not changing.
Disc Capacitor	A type of capacitor that has low capacitance and is used mostly in high frequency circuits.
Electric Charge	An electrical attraction/ repulsion between materials.
Electrical Power	A measure of how much energy is moving in a wire.
Electricity	An attraction and repulsion between sub-atomic particles within a material.
Electrolytic Capacitor	A type of capacitor that has high capacitance and is used mostly in low frequency circuits. It has polarity markings.
Electromagnetic	Involving both electrical and magnetic effects.
Electronics	The science of electricity and its applications.
Emitter	One of the connection points on a transistor.
Farad, (F)	The unit of measure for capacitance.
Feedback	To adjust the input to something based on what its output is doing.
Filament	A high-resistance wire used in incandescent light bulbs.

DEFINITION OF TERMS (also see Summary of Components pages 132-134)

Pitch	The musical term for frequency.
Polarity	Markings indicating which direction a device is positioned in, usually (+) and (–).
Printed Circuit Board	A board used for mounting electrical components. Components are connected using metal traces "printed" on the board instead of wires.
Receiver	The device which is receiving a message (usually with radio).
Resistance	The electrical friction between an electric current and the material it is flowing through.
Resistor	Components used to control the flow of electricity in a circuit.
Schematic	A drawing of an electrical circuit that uses symbols for all the components.
Semiconductor	A material that has more resistance than conductors but less than insulators. It is used to construct diodes, transistors, and integrated circuits.
Series Circuit	When electrical components are connected one after the other.
Short Circuit	When wires from different parts of a circuit (or different circuits) connect accidentally.
Silicon	The chemical element most commonly used as a semiconductor.
Solder	A tin-lead metal that becomes a liquid when heated to above 500°F. It makes a strong mounting that can withstand shocks.
Speaker	A device which converts electrical energy into sound.
Static Electricity	A naturally occurring build-up of electrical charge between materials, usually at high voltage.
Switch	A device to connect ("closed" or "on") or disconnect ("open" or "off") wires in an electric circuit.
Transformer	A device which uses coils to change the AC voltage and current (increasing one while decreasing the other).
Transistor	An electronic device that uses a small amount of current to control a large amount of current.
Transmitter	The device which is sending a message (usually with radio).
Tungsten	A highly resistive material used in light bulbs.
Tuning Capacitor	A capacitor whose value is varied by rotating conductive plates over a dielectric.
Voltage	A measure of how strong an electric charge difference between materials is.
Volts (V)	The unit of measure for voltage.
Watt (W)	The unit measure for electrical power.

FOR FURTHER READING (all of these are available through Elenco® Electronics, Inc.)

Basic Electricity, 736 pages, ISBN 0-7906-1041-8, Sams 61041

Basic Electricity & DC Circuits, 928 pages, ISBN 0-7906-1072-8, Sams 61072

Basic Solid-State Electronics, 944 pages, ISBN 0-7906-1042-6, Sams 61042

Beginning Electronics Through Projects, 236 pages, ISBN 0-7506-9898-5, Sams 67102

Modern Electronics Soldering Techniques, 304 pages, ISBN 0-7906-1199-6, Sams 61199

Schematic Diagrams, 196 pages, ISBN 0-7906-1059-0, Sams 61059

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