Chapter 1

Synchronising Sight and Sound with a Colour-Organ Circuit

In This Chapter

- Preparing the project
- Constructing your colour organ
- Playing around with the circuit

One of the great things about theme parks these days is that sometimes the long wait to go on a particular ride is almost as good as the ride itself. One of the best examples is the famous *Indiana Jones Adventure: Temple of the Forbidden Eye* in Disneyland, California. Just outside an ancient temple, you pass by a rickety steam-powered generator that's barely running. The clickity-clickity sound of the generator alternately grows louder and softer as it sputters and threatens. When you're inside the temple, you pass through narrow tunnels and creepy caverns that are lit overhead by lights that appear to be powered by the ancient generator. The lights flicker and dim, grow brighter for a moment, and then flicker and dim again in sync with the generator.

In this chapter, you discover how to build an electronic circuit (called a *colour organ*) that can create this type of creepy lighting, as well as thunderstorm effects or a spooky red heartbeat for the heart of a plastic skeleton or other Halloween prop.

Considering the Colour-Organ Project

The operation of a colour-organ circuit is pretty simple: it converts the volume of an audio input into an output voltage that gets higher as the sound source gets louder. If you connect a light to the output, the light glows brighter when the audio input is louder and dimmer when the input is quieter.

The completed colour organ is shown in Figure 1-1; we house the project in a 130 x 68 x 44 mm box. It has terminals to which you can connect a 12 V power supply, terminals to which you can connect halogen lamps (maximum 12 V/50 watts (W)), an RCA-style audio input connector for connecting a sound source to (maximum 60 W), a knob for adjusting sensitivity and a power switch.

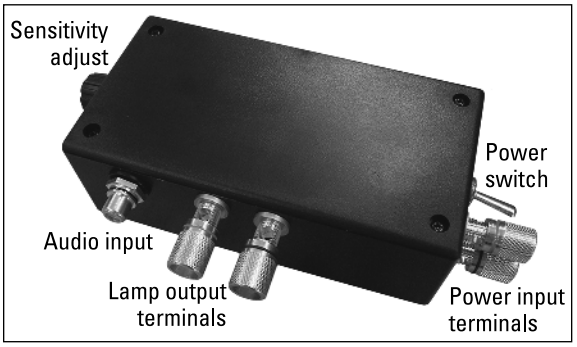

Figure 1-1: The completed colour-organ project.

To keep the project simple, you can do as we do in this chapter and build the electronics using an inexpensive kit – specifically, the snappily named Velleman MK114 Low Voltage Light Organ Minikit. This kit is available on the Internet for under $10; searching for 'Velleman MK114' brings up several sources.

Figure 1-2 shows how you can connect the colour-organ project to create light that varies in brightness with a sound source. Of course you need a source for the sound, such as a portable CD player or other sound system with external speaker outputs that you can tap into.

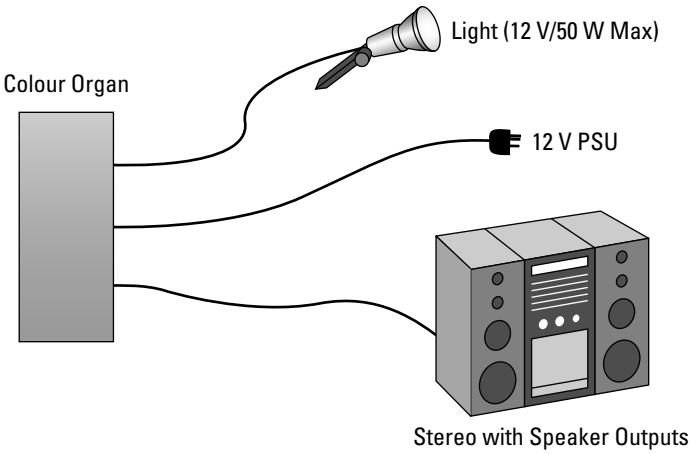

Figure 1-2: Connecting the colour organ to light and sound sources.

Note that the diagram in Figure 1-2 doesn't show the details of how to connect the sound system to the colour-organ circuit and the speakers. The easiest way to connect the circuit to the sound system is simply to replace one of the speakers with the colour organ. That way, the colour organ responds to one of the stereo channels while the speaker plays the sound coming from the other stereo channel (check out the later section 'Putting Your Colour Organ to Work' for more details). For this type of hookup, you need just a single cable that has an RCA connector on one end (to plug into the colour organ) and the proper connector on the other end to connect to the sound system's speaker output.

You also need a suitable recording for your sound source. For example, if you want to use the colour organ to create a thunderstorm effect, you need a recording of thunder. To make a red light flash in sync with a heartbeat, you need a recording of a heartbeat. Many such sound effects are available online, and so you can locate and download one to meet your needs without too much trouble. If you want to customise the sound effect, you can download a free audio editor called Audacity from `www.audacity.sourceforge.net`.

Understanding how the colour organ works

You can design a colour-organ circuit in several different ways. Most of the circuits that drive low-voltage DC lamps rely on a type of transistor, called a *MOSFET* (which stands for 'metal oxide semiconductor field effect transistor'), designed to handle large currents. It has three terminals: source, drain,

and gate. A voltage at the gate above a given threshold allows the drain and source path (called the *channel*) to conduct. The larger the gate voltage, the more the channel will conduct. Conversely, if there is no or too little voltage on the gate, the source is disconnected from the drain. The load is connected between the positive supply and the drain, with the source connected to ground. The gate voltage is derived from the audio input.

The audio input isn't connected directly to the transistor gate, however. Instead, the colour organ uses an *optoisolator* to isolate the audio input from the supply-voltage side of the circuit. This device is a single component that consists of an infrared light-emitting diode (LED) and a photodiode or other light-sensitive semiconductor. Voltage on the LED causes it to emit light, which the photodiode detects and passes on to the output circuit.

The Velleman MK114 kit that we employ in this chapter uses an optoisolator transistor, in which the photosensitive semiconductor is in fact a transistor whose gate is stimulated by light rather than by current. The optoisolator is an integrated circuit (check out Book III, Chapter 1) in a 6-pin DIP package.

Figure 1-3 shows a simplified schematic diagram for the circuit that the Velleman MK114 kit uses. As you can see, the audio input is applied to the LED side of the optoisolator, controlled by a potentiometer (something we describe in Book II, Chapter 2), which lets you adjust the sensitivity of the circuit. The output from the optoisolator is applied to the gate of two MOSFETs (T4 and T5) via the amplifier/logic circuit formed by transistors T1-T3. The load is connected between the positive supply and the drains of the two MOSFETs. Thus, the volume of the audio input controls the current through the output circuit.

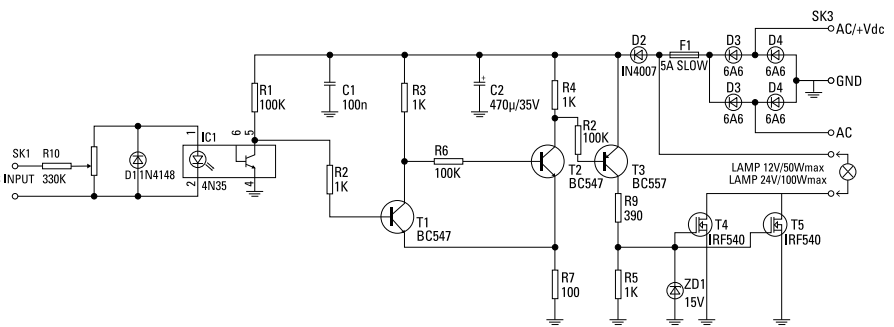

Figure 1-3: A simplified version of the colour-organ circuit. Make sure to follow the detailed schematic diagram that accompanies your circuit.

Getting your equipment together

Other than the Velleman kit itself (see the preceding section), you can purchase most of the materials you need to build the colour-organ project at your local Maplin shop or any other supplier of electronic components. The following table lists all the materials you need.

Quantity	*Description*
1	Velleman MK114 Low Voltage Light Organ kit, available from Quasar Electronics (`www.quasarelectronics.co.uk`) and other online suppliers
1	130 x 68 x 44 mm plastic enclosure (Quasar Electronics part WCAH2853)
4	M3 x 10 mm female-female Hex standoffs (to provide a little room between the board and the enclosure)
8	M3 x 6 mm screws
1	RCA-style chassis socket (Quasar Electronics part 755.280UK, or similar)
1	Control knob (Quasar Electronics part KB0295)
1	5 A rated single pole, single throw (SPST ON-OFF) toggle switch (Quasar Electronics part 785.660UK, or similar)
2	4 mm plug sockets/screw terminal, panel mount, Red (Quasar Electronics part 780.030UK, or similar)
2	4 mm plug sockets/screw terminal, panel mount, Black (Quasar Electronics part 780.030UK, or similar).
35-45 cm	0.8 mm diameter stranded wire
1	PSU (Power Supply Unit) 12 V DC 50 W or 12 V AC 50 VA. (This may be a wall wart type or bench power supply. Alternatively, use a 12 V car or motorcycle battery with suitable cabling. However, please be very careful to guard against short circuits if you do use a battery.)

To assemble the colour-organ project, you require the following tools:

- Drill with a range of bits
- Hobby vice
- Magnifying goggles
- Phillips screwdriver
- Pliers
- Small flat-edge jeweller's screwdriver
- Solder

- Soldering iron, preferably with both 20- and 40-W settings
- Wire cutters
- Wire strippers

Building the Colour Organ Project

When you have your tools and materials at the ready, as we describe in the preceding section, you can start to build your colour-organ circuit.

Assembling your colour organ

Here are the steps for constructing this project:

1. **Assemble the Velleman MK114 kit.**

   The kit comes with simple but accurate instructions. In essence, you just mount and solder all the components onto the circuit board. Pay special attention to the colour codes for the resistors and the orientation of the diodes and electrolytic capacitor. Do not fit the detachable rotor shaft to the potentiometer at this time (see step 4).

   Figure 1-4 shows the completed MK114 kit.

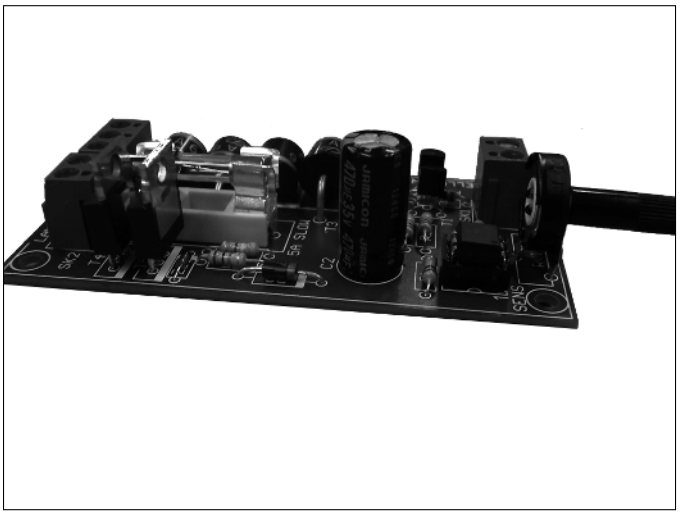

Figure 1-4: The assembled Velleman MK114 kit.

Mount the circuit board in a good hobby vice and use a crocodile clip or masking tape to hold the components in place while soldering.

2. **Drill all the mounting holes in the project box except the hole for the sensitivity control on the left side of the box.**

   Figure 1-5 shows the orientation of the approximate location of the mounting holes.

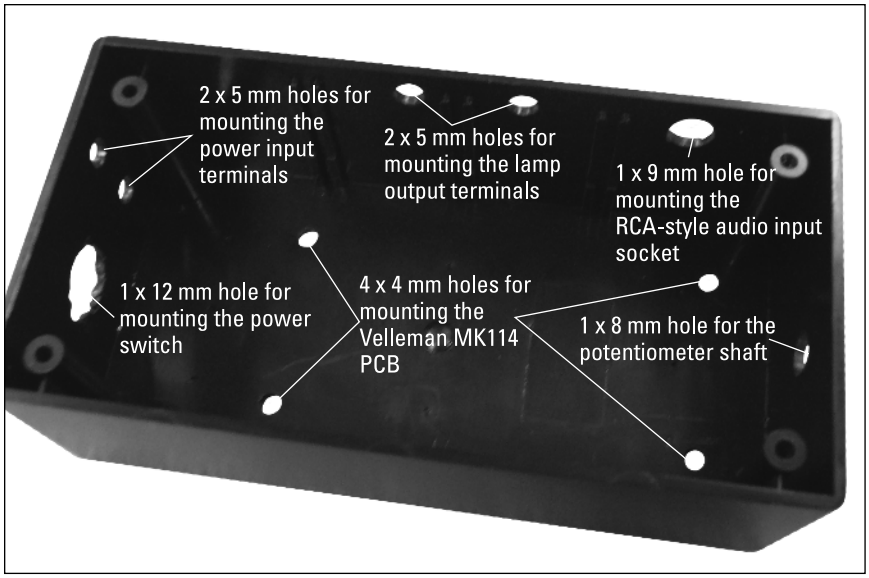

Figure 1-5: Drill the holes as indicated in this photo.

Use the assembled circuit board to determine the exact drilling locations for the four holes that mount the circuit board. The position of the other holes isn't critical, with the exception of the hole for the potentiometer knob. Don't drill that hole until Step 4.

3. **Mount the four standoffs for the MK114 circuit board.**

   Use M3 screws through the four 4 mm holes in the bottom of the box to secure the standoffs in place.

4. **Drill the hole for the circuit board's potentiometer.**

   Position the circuit board, without the potentiometer rotor shaft fitted, on the four standoffs to determine the exact position for the 8 mm hole.

Thinking inside the (project) box

In the steps that follow, you assemble all the parts into the project box. Use Figure 1-6 as a guide for the proper placement of each part.

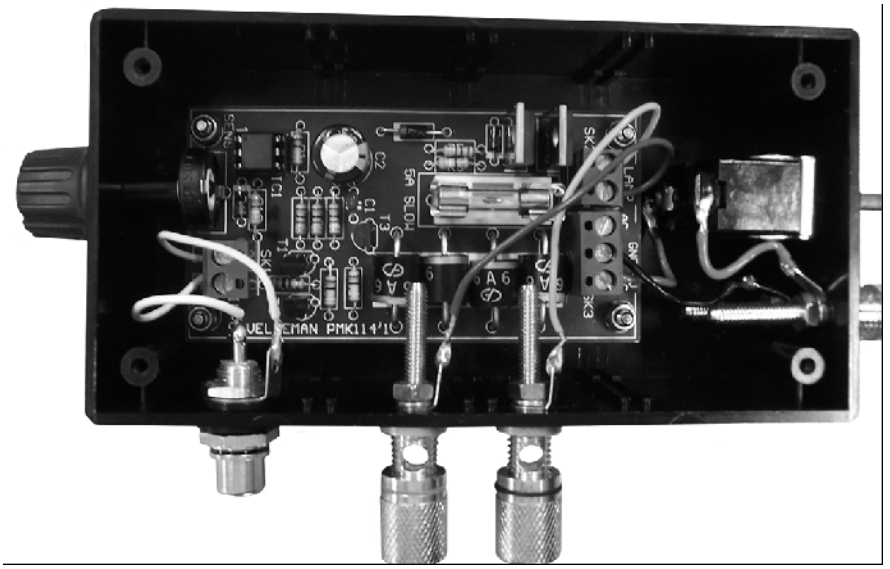

Figure 1-6: How the parts go together inside the project box.

1. **Prepare and mount the power switch.**

   Cut two 3.5 cm lengths of wire and strip 5 mm of insulation from both ends of each. Remove the screws from the two switch terminal posts and solder a wire to each terminal through the resulting holes.

   Remove the top mounting nut and ON-OFF indicator plate from the switch and push the switch lever/mounting thread through the 12 mm mounting hole from inside the box. Orientate the switch body so that the terminals are at the top and the bottom. (You may need to bend the terminals slightly to get the switch to fit in this orientation.) Reattach the indictor plate and mounting nut and secure the switch by tightening the nut with needle-nose pliers.

2. **Mount the black power socket.**

   Remove the mounting nut, washer and terminal tab from the treaded shaft of one of the black 4 mm plug sockets. Push the treaded shaft

through the lower of the 5 mm holes adjacent to the toggle switch. Replace the terminal tab, washer and mounting nut. Secure in place by tightening the nut with needle-nose pliers.

Cut a 3.5 cm length of wire and strip 5 mm of insulation from each end. Solder one end of the wire to the terminal tab.

3. **Mount the red power socket.**

   Remove the mounting nut, washer and terminal tab from the treaded shaft of one of the red 4 mm plug sockets. Push the treaded shaft through the upper of the 5 mm holes adjacent to the toggle switch. Replace the terminal tab, washer and mounting nut. Secure in place by tightening the nut with needle-nose pliers.

4. **Connect the switch to the red power socket.**

   Solder the wire from the top terminal of the switch to the terminal tab of the red power socket already fitted.

5. **Mount the black lamp output socket.**

   Remove the mounting nut, washer and terminal tab from the treaded shaft of the remaining black 4 mm plug socket. Push the treaded shaft through the right-hand 5 mm hole on the long edge of the case. Replace the terminal tab, washer and mounting nut. Secure in place by tightening the nut with needle-nose pliers.

   Cut a 9 cm length of wire and strip 5 mm of insulation from each end. Solder one end of the wire to the terminal tab.

6. **Mount the red lamp output socket.**

   Remove the mounting nut, washer and terminal tab from the treaded shaft of the remaining red 4 mm plug socket. Push the treaded shaft through the left-hand 5 mm hole on the long edge of the case. Replace the terminal tab, washer and mounting nut. Secure in place by tightening the nut with needle-nose pliers.

   Cut a 9 cm length of wire and strip 5 mm of insulation from each end. Solder one end of the wire to the terminal tab.

7. **Prepare the RCA-style phono jack.**

   Cut two 6.5 cm lengths of wire and strip 5 mm of insulation from both ends of each. Solder one of the wires to the centre terminal of the RCA-style phono jack and the other to the ground terminal tab.

   At this point you have finished with the soldering iron, so you can turn it off.

8. **Mount the RCA-style phono jack in the 9 mm hole in the project box.**

   Remove the mounting nut, terminal tab and lock washer from the jack. Pass the wire connected to the centre terminal of the phono jack through the 9 mm hole and insert the threaded end of the phono jack into the hole. Slip the lock washer, the ground terminal and the nut over the wire connected to the centre terminal, and thread them onto the threaded part of the jack. Tighten with needle-nose pliers.

Wiring up your circuit

In this section, you attach wires to the MK114 circuit board.

Don't mount the circuit board to the standoffs quite yet. You have an easier time connecting the wires if the circuit board is loose. After the wires are all connected, you mount the board.

1. **Connect the wire from the bottom terminal of the toggle switch to the +V terminal of block SK3 on the Velleman MK114 circuit board.**

   Use a small, flat screwdriver to tighten the terminal. Make sure that you connect the wire securely.

2. **Connect the wire from the bottom (black) power supply input 4 mm plug socket to terminal block SK3 on the Velleman MK114 circuit board.**

   If using an AC power supply, connect the wire to the unoccupied terminal marked AC. If using a DC power source, connect the wire to the middle terminal, marked GND.

   Use a small, flat screwdriver to tighten the terminal. Make sure that you connect the wire securely.

3. **Connect the wire from the red lamp output 4 mm plug socket to terminal block SK2 on the Velleman MK114 circuit board.**

   The wire connects to the SK2 terminal adjacent to SK3.

   Use a small, flat screwdriver to tighten the terminal. Make sure that you connect the wire securely.

4. **Connect the wire from the black lamp output 4 mm plug socket to terminal block SK2 on the Velleman MK114 circuit board.**

   The wire connects to the SK2 terminal nearest the circuit board mounting hole.

   Use a small, flat screwdriver to tighten the terminal. Make sure that you connect the wire securely.

5. **Connect the two wires from the RCA-style phono jack to terminal block SK1 on the Velleman MK114 circuit board.**

   Connect the wire from the centre of the jack to the SK1 terminal nearest the potentiometer and the wire from the tab to the SK1 terminal nearest the PCB mounting hole.

   Use a small, flat screwdriver to tighten the terminals. Make sure that you connect the wires securely.

6. **Mount the MK114 circuit board on the standoffs.**

   Position the circuit board over the standoffs and use the remaining four M3 screws to secure it in place.

7. **Attach the rotor shaft to the potentiometer.**

   Slide the potentiometer's detachable rotor shaft through the 8 mm hole and engage the slotted end with the centre of the potentiometer until it clicks in place.

8. **Attach the knob to the potentiometer shaft now protruding from the box.**

   Use a small, flat screwdriver to tighten the screw on the side of the knob.

9. **Place the lid on the project box and secure it in place with the screws provided.**

   Now you really are done!

Putting Your Colour Organ to Work

When you've completed the colour organ, you can use it to make interesting sounds and lighting effects. To do that, you have to connect it to lights and a sound system:

1. **Connect a 12 V halogen lamp to the colour organ's lamp output terminals.**
2. **Connect a speaker-level audio input to the RCA-style phono connector.**
3. **Connect your power supply to the power input terminals.**

   If using a DC supply, the red terminal is positive and the black terminal is negative. If using an AC supply, the polarity is unimportant.

4. **Turn on the colour organ.**
5. **Play the sound.**
6. **Turn the knob on the colour organ to adjust the sensitivity.**

7. **If the light never comes on, try increasing the output volume on the stereo.**

The colour organ can handle only 50 W on the output circuit, and so be careful not to overload the circuit.

The easiest way to connect the colour organ to the sound system is to replace one of the speakers with the colour organ. The type of cable you need to do that depends on how the speakers connect to the sound system:

- If they connect with simple post connectors, you need a cable with bare wire on one end and an RCA plug on the other end.
- If they connect with RCA connectors, you need a cable with RCA plugs on both ends.

When you use the colour organ in this way, remember that the colour organ responds to one channel of the stereo recording while the speaker plays the other channel. In most cases, you don't notice much difference, but in some stereo recordings the sound on the left channel is very different from the sound on the right channel. This difference can affect the quality of the sound, and it can also prevent the light from flashing in perfect sync with the sound, because the light is responding to a different sound source from the one you're hearing through the speakers.

In some cases, you can use this situation to improve the effect you're trying to achieve with the colour organ. For example, in a real thunderstorm, the lightning flashes well before the thunder is heard. To reproduce this effect, all you need is a sound recording of a thunderstorm in which the thunder is heard on the left channel before it's heard on the right channel. Then, if you connect the colour organ to the left channel and the speaker to the right channel, the light flashes before the sound is heard.

Play around and have fun!