chapter 1

Building Triggers

in this chapter

- ☑ Making a Wired Remote Trigger
- ☑ Making a Delay Trigger
- ☑ Making an Interval Trigger
- ☑ Connecting the Triggers to a Point-and-Shoot Camera
- ☑ Extending the Remote Switch

One of the first camera hacks I ever performed was the extension of the remote trigger release on my Canon EOS SLR: I extended it to shoot pictures of myself on roller skates from a distance. The hack was so easy I soon learned to make trigger switches as well. Trigger switches and extensions can serve purposes other than self-portraiture. You might want to set up your camera gear in a remote location to photograph birds and other animals in action. Sometimes I would set my camera in my hamsters' cages to capture their daily activities. Another popular remote trigger application is shooting sporting events. Photographers have been known to rig their gear inside hockey rinks and even in goalie boxes, generally using wireless triggers. But nothing is stopping you from running wired camera equipment to the basketball hoop in your yard. Mounting your camera there can render some awesome pictures of your kids playing basketball.

This chapter helps you make trigger switches and extend their ranges. If you have trigger switches from older generation cameras, you may be able to adapt them for use on your new state-of-the-art cameras. This chapter shows you how to make those adapters. Most single-lens reflex (SLR) cameras have a built-in shutter trigger port, and you connect to this port directly. But most point-and-shoot (P&S) cameras lack this nifty feature. On these cameras, you hack the camera itself and wire a trigger port directly to the shutter switch. This trigger port will use the same interface as the one available on SLRs, so if you have both types of camera systems, you can use the same remote trigger switch and extender for all your gear.

Making a Wired Remote Trigger

Most SLRs, even entry-level ones, have a remote shutter release socket so you can shoot pictures without actually touching the camera body. The remote trigger is used often in long-exposure photography, where even a small amount of vibration can introduce blurriness into the image. As steady as your hands are, they are not machines, and, therefore, they are prone to tiny movements that you may not be aware of until you view your picture. With a wired remote trigger release, the camera body can be mounted on a tripod, and you operate the camera through the wired remote trigger.

In astrophotography, exposure can take several minutes. If you had to operate the camera shutter with your hands on your camera's shutter button, they would probably be shaking like mad after five minutes. Holding the shutter button down for a long time is extremely tiring. Fortunately, many remote shutter triggers can be locked in the down position. An older mechanical trigger without the locking feature can be taped instead.

Remote shutter triggers are usually optional accessories for SLRs. They can cost anywhere from five dollars for a mechanical version to several hundred dollars for a super fancy electronic version. In the following sections, you build your own simple remote trigger so you understand how a remote trigger works. This knowledge will help you to build fancier timing triggers and multiple-camera triggers in the later sections of this chapter.

FIGURE 1-1: This picture of the moon was shot with a telescope and a camera. Both the telescope and camera were mounted on their own tripods. Vibration was still a major issue, so a wired remote and mirror lock-up were used.

How Does a Remote Trigger Work?

On most of today's cameras, a remote trigger works simply by closing an electrical circuit to trigger the shutter. This simple concept is shown in Figure 1-2. The wired remote is simply a switch extended from the camera body.

Note This chapter makes extensive use of circuit diagrams. See Appendix B for a list of circuit symbols.

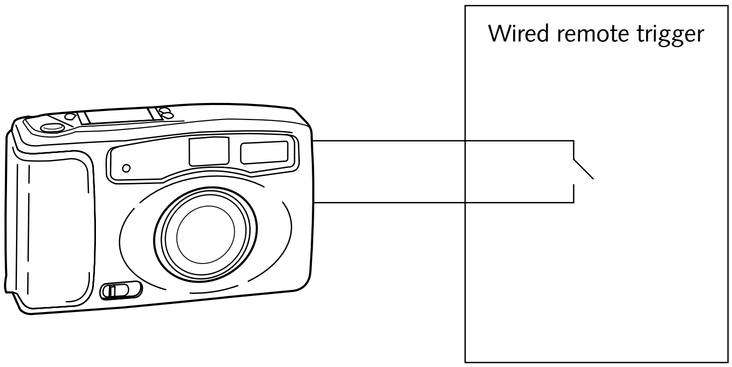


FIGURE 1-2: A schematic of the wired remote shutter trigger

A camera that has auto-focus (AF) capability generally has a two-position shutter trigger. The first position—reached when you press the trigger halfway down—closes the circuit for the auto-focus function. The second position—reached when you press the trigger all the way down—closes the shutter circuit. A wired remote trigger moves these two functions off the camera, as shown in Figure 1-3. Most Canon SLRs use this simple circuit for remote triggering.

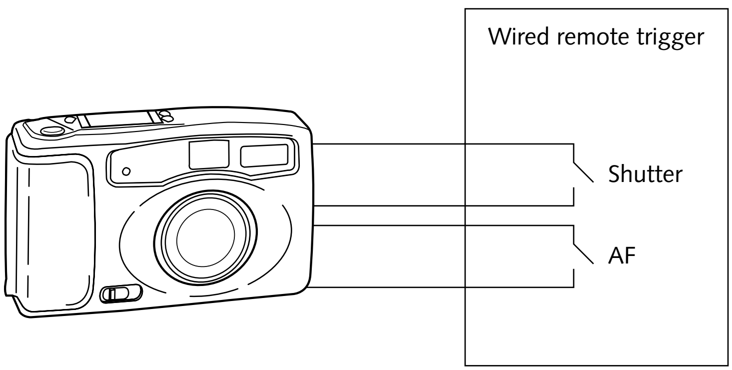


FIGURE 1-3: A schematic of the wired remote shutter trigger with AF function

Nikon SLRs use a slightly more complex circuit. The shutter circuit is simply an open/close circuit, like that shown previously in Figure 1-2. But the AF circuit is an open/close switch along with three 1N4148 diodes wired in series. The Nikon wired remote trigger circuit is shown in Figure 1-4.

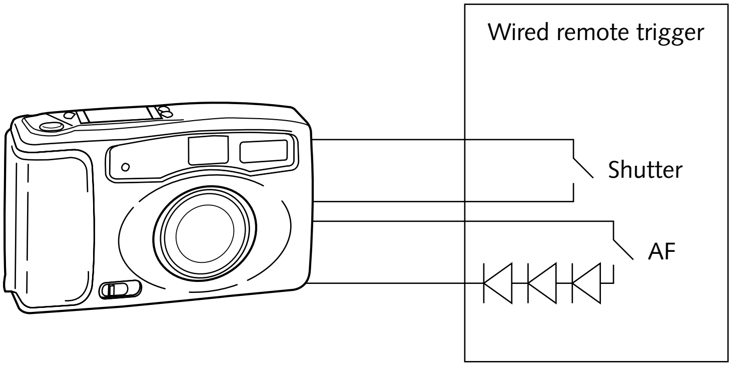


FIGURE 1-4: A Nikon wired remote shutter trigger with AF function

Parts You Need

Your local electronic store carries all of these parts. I prefer Radio Shack because the stores are everywhere. You can also order the parts online from RadioShack.com. I have listed the Radio Shack part numbers for your convenience.

- Mini SPST Momentary Switch (275-1547)
- SPDT Submini Slide Switch (275-409)
- $^{3}/_{32}$" Submini Phone Jack (274-245)
- 20-gauge wire (278-1388)
- Mini Project Enclosure (270-288)

Note A 2.5mm jack is the same size as a $^{3}/_{32}$" jack.

There are many different types of switches (see the “Switch Terminology” sidebar). Each one serves a slightly different purpose. Sometimes, two types of switches can be used for the same purpose. For this project, I chose to use two momentary switches and a slide switch. The normally open momentary switch (see Figure 1-6) is similar to the on-camera shutter button. A normally open momentary switch requires that you hold down the switch to close the circuit. As soon as you let go of the switch, it opens the circuit again.

Canon E3 Connector

The Canon RS60-E3 remote control, used on Canon EOS cameras, is a two-position switch just like the shutter release on the Canon EOS series. Pushing the button down halfway causes the camera to focus, while pushing the button down all the way causes the camera to release its shutter. The wired remote control transmits the signal though a standard 2.5mm (sub-mini) audio head. The contacts on the head are numbered in Figure1-5.

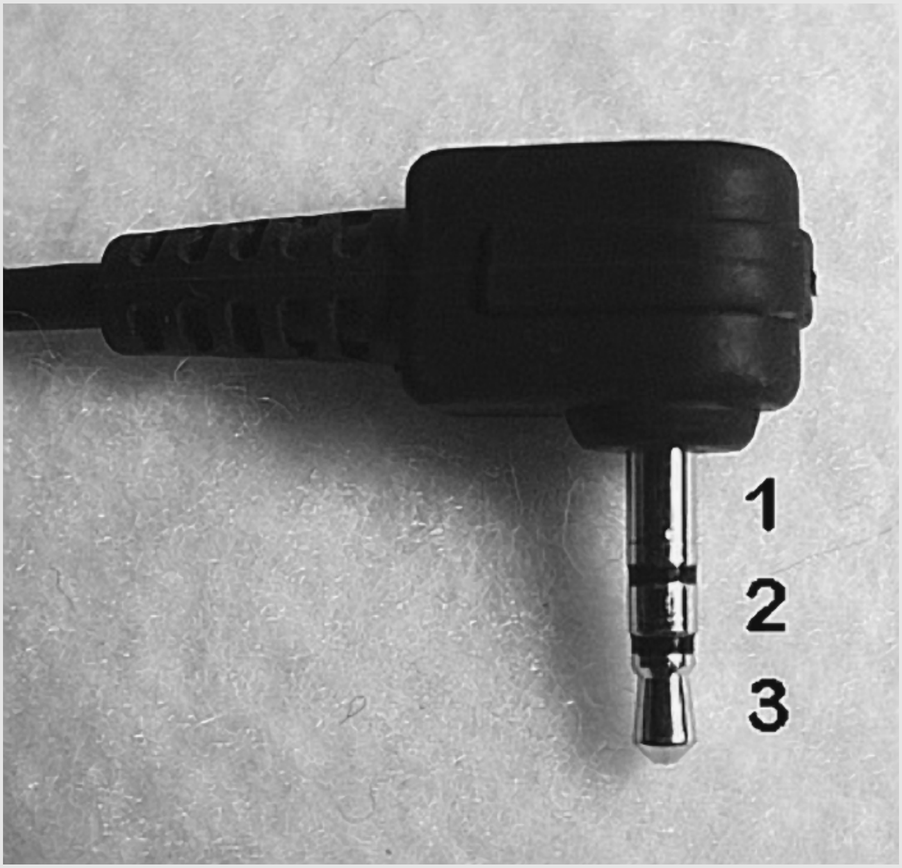


FIGURE 1-5: The E3 connector pins

When the button on the remote control is pushed halfway, contact sections 1 and 2 are shorted together, causing the camera to focus. When the button on the remote control is pushed all the way, all three contact sections are shorted together, causing the camera shutter to be released. Pin 1 is actually the ground connector. Therefore, pin 1 and pin 3 cause the camera to trigger.

When you build your own camera interface, you can split the auto-focus and shutter release functions by using two switches (using two independent circuits).

FIGURE 1-6: Momentary pushbutton switches

Although this switch is appropriate as a shutter release for high-shutter-speed pictures, it would be tiring to hold down a momentary switch for a long time (minutes or hours), such as during a bulb exposure. To relieve you from having to hold the button down, most remote triggers have a locking feature that holds the button down for you. I have chosen a slide switch (see Figure 1-7) to simulate that feature in this project. When you begin the exposure, slide the switch to on. When you are done with the exposure, slide it to off.

Note

Bulb exposure is the term that describes what happens when you control the shutter's opening and closing without using the camera's shutter speed timer. It's generally used for a long exposure in astrophotography and night photography.

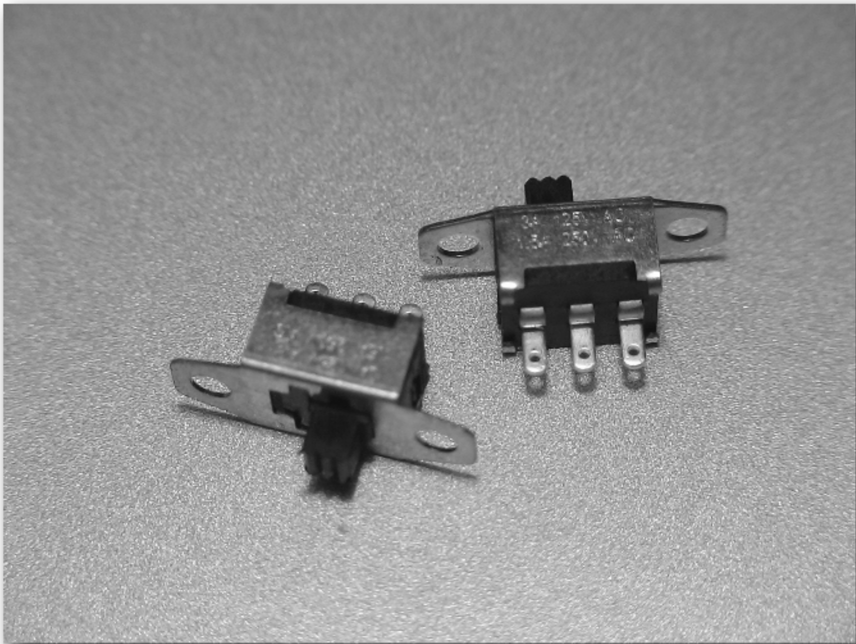


FIGURE 1-7: Slide switches

In this project, I chose a mini–project enclosure (see Figure 1-8) and a bunch of sub-mini parts to fit into it. These small parts help create a small remote trigger. A smaller remote trigger is easy to carry around and doesn't take up too much space in your camera bag. I also chose a plastic case because they are generally easier to work with than metal cases. It's easier to drill and shape plastic than metal.

Most photographers like to have a small, wired remote. I've noticed that there seems to be a general consensus that smaller is better, and there's nothing wrong with that. In fact, I picked a very small project case and a lot of sub-mini parts for this project. But you might consider a bigger box to fit bigger switches for action events. If you have rigged a camera in a hockey arena by the goal box, you probably don't want to miss a shot because you are fiddling for a button on your tiny remote. You might want to rig up a table-size remote where the button is the size of your hand, so that you can pound on the buttons during the excitement of the game.

FIGURE 1-8: A small project box

For interfacing, I chose a 3/32" (2.5mm) stereo phone jack (refer to the "Canon E3 Connector" sidebar), shown in Figure 1-9. This is the same interface that is used on entry-level Canon EOS SLRs, so you can easily attach this wired remote trigger to them. This interface is common on cellular phone earpieces and other electronic components as well. Both female and male versions are common and easy to source. This is the preferred interface method compared to the proprietary interface found on higher-end Canon EOS SLRs, Nikon SLRs, and others. Later in this chapter I show you how to adapt this simple interface to the proprietary interfaces so that you can use the same remote trigger with the more advanced cameras.

You need some electrical wires to make the connections between the switches and the interface jack. You might already have some leftover wires at home. You can even strip them from your old stereo headphones (3.5mm) or your cell phone earpiece (2.5mm). You won't need very much of it, just about a foot or so of wire. I have listed 20-gauge wire in the part list. But any wire between 18 and 22 gauge will work just fine.

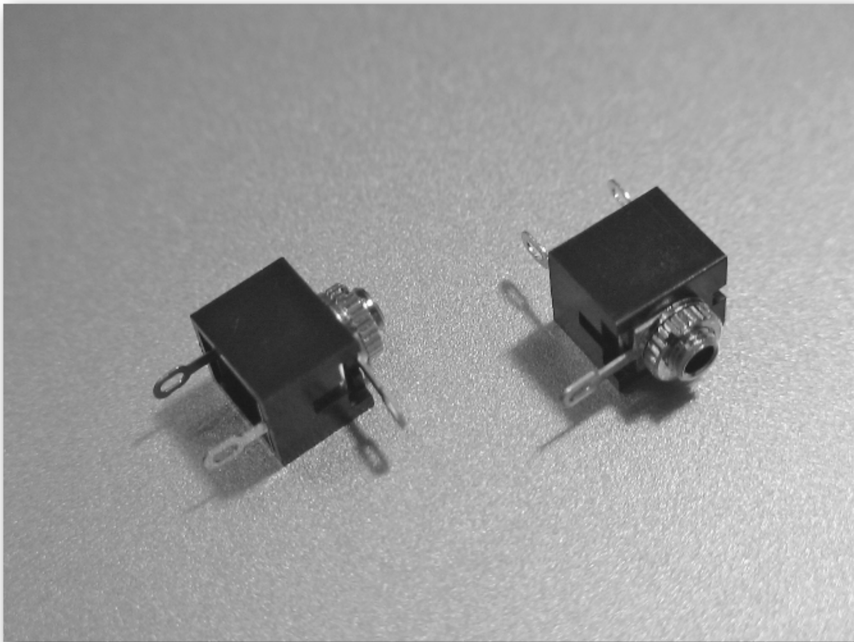


FIGURE 1-9: 2.5mm stereo phone jacks

Tools You Need

Here are the tools you will need to complete this project:

- Drill
- Drill bit
- Small c-clamps
- #1 Phillips precision screwdriver
- Digital multimeter
- Wire stripper
- Solder iron
- 0.032" diameter 60/40 Standard Rosin-Core Solder (64-009E)

Cross-Reference

See Appendix A for information on buying and using soldering irons.

Switch Terminology

Switches come in many different physical forms and types. But common to most physical switches are four types of function. Figure 1-10 shows the schematic of each type of switch.

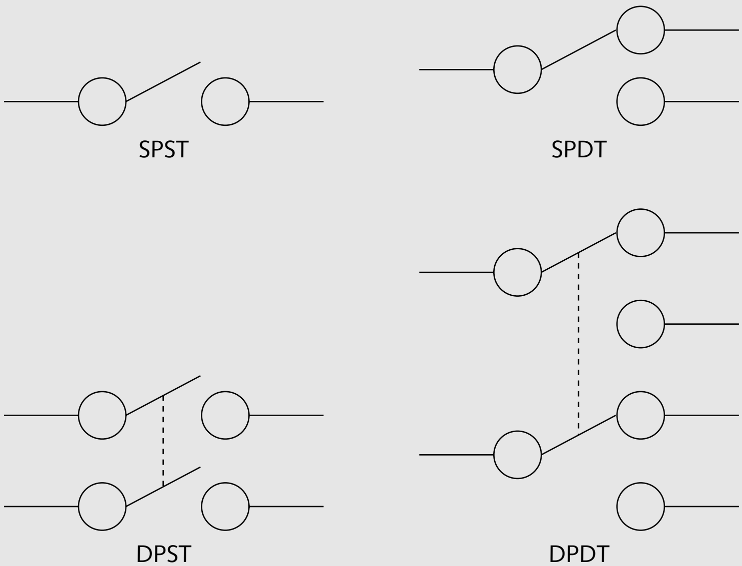


Figure 1-10: Different types of switch circuitry

Single Pole Single Throw (SPST)

Single pole single throw switches are the simplest form of switches. This type of switch is either open or closed. There can be no other position. These switches have two contact pins. Most SPST momentary switches are normally open, meaning that the circuit is open unless you activate it. Some SPST momentary switches are normally closed, meaning that the circuit is closed unless you activate it.

Single Pole Double Throw (SPDT)

A single pole double throw switch has two possible positions. In either position, different circuits are connected. Think of it as a railroad switch, where the train would travel over one railroad track versus another, depending on the position of the switch. In physical form, an SPDT switch has three pins. It is possible to wire up an SPDT switch to act like an SPST switch by simply leaving one of the pins unconnected. Most SPDT switches are toggle or slide switches. SPDT momentary pushbutton switches are more rare.

Double Pole Single Throw (DPST)

A double pole single throw switch is basically a pair of SPST switches. The switch position is connected, so when one circuit is closed, the other is closed as well. When one is open, the other circuit is open too. A DPST switch has four physical pins. It is possible to wire up a DPST switch to function like an SPST switch or an SPDT switch.

Double Pole Double Throw (DPDT)

Double pole double throw switches are two SPDT switches. The positions of the two switches are physically connected; when one physical switch is thrown, both circuit switches change position. A DPDT switch has six pins. It is possible to wire up a DPDT switch into any of the previous less sophisticated switches.

For this project, you need a drill to makes holes in the project enclosures for the switches. A low-power electrical version will work fine. The size of the drill bit depends on the switch size. It's easy to measure with a drill gauge, as shown in Figure 1-11 (see Chapter 18 for information about how to make your own drill gauge). Buy a set of drill bits so that you have many sizes on hand. Buying a set is generally cheaper than buying bits individually. Make sure you have a small c-clamp on hand to secure the enclosure on the workbench—you don't want to hold the enclosure with your hand. The drill bit could bite into the enclosure and the drill will have much more torque than your hand can control, which could lead to serious injury. A precision screwdriver is needed for fastening the enclosure together.

FIGURE 1-11: Drill gauge for measuring the switch diameter

When you are ready to put all the electrical connections together, you need a wire stripper to strip the insulation from the end of the wires. A wire stripper costs a few bucks at the local home improvement store. The soldering iron and solder help you create good electrical contacts between the switch contacts and the wires (see Appendix A for a quick guide to the basics of soldering). You can find soldering irons and solder at Radio Shack.

Drilling the Case

The first step in making your own remote trigger is to drill the project enclosure. Before you do so, use the drill gauge to measure the hole required by the switch. Poke the switch through the holes in the gauge until you find the right size. Then mount the right sized drill bit onto the drill.

Before actually starting to drill, use the c-clamp to secure the project box onto the workbench (see Figure 1-12). My workbench has several holes over the surface for drill bits to drill through. If your workbench doesn't have the same facility and you don't want accidentally to drill into it, I suggest you place a block of wood between the project box and the workbench. With a wood block in between, when you drill through the project box, you'll drill into the wood block instead of your workbench.

FIGURE 1-12: The project box is secured onto the workbench

After drilling all of the holes for your enclosure, test fit each jack and switch in the enclosure. This step is your chance to make sure the project box is drilled to your satisfaction, so you can make any additional modification as needed.

Soldering the Wires

When you are done drilling the enclosure, you can start soldering the parts together. Wire up the switches based on the conceptual circuit diagrams presented in the "How Does a Remote Trigger Work?" section. When you are ready to solder the interface jack, refer to the "Canon E3 Connector" sidebar for an overview and solder the connection to match the pin-out. Follow the instructions in Appendix A if your soldering skills are rusty.

After you have soldered all of the wires and contacts, you should test out your trigger before actually fitting everything together. No matter how confident you are about your result, you may find that the trigger is defective. I don't know how many times I put something together, whether it's an electrical project or an internal computer component upgrade, thinking it's perfect, but after tightening the last screw, it fails to work. So, before all the switches and wires and the jack are in the project box, plug it into your camera. Verify that all the switches are working as expected. If everything works properly, you can move to the next step. Otherwise, pull out your digital multimeter (see Figure 1-13) and test all of the connections.

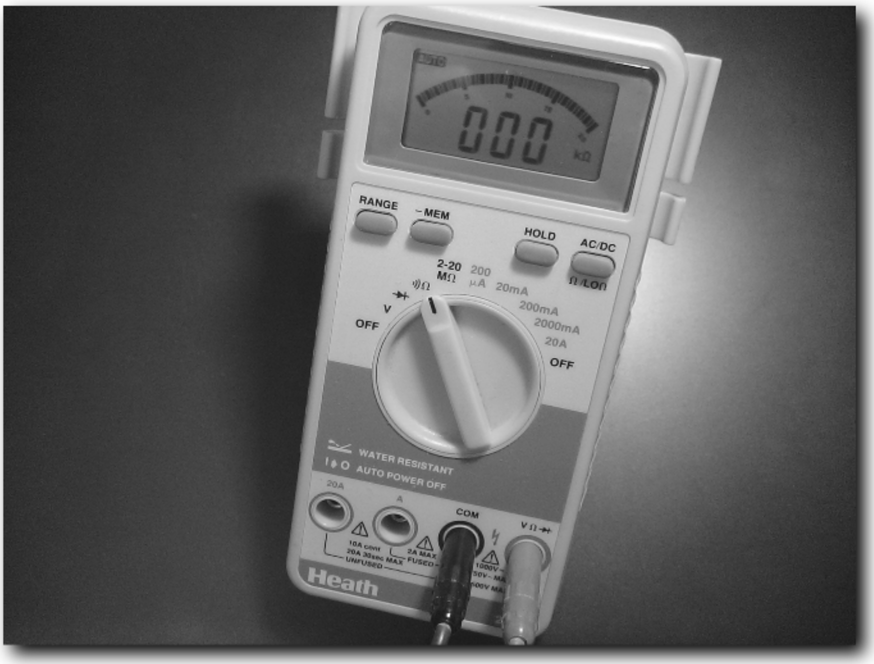


FIGURE 1-13: A digital multimeter

Canon N3 Connector

The Canon N3 shutter release trigger connector, found on higher-end Canon EOS cameras, has three connector pins. The male connector is designed onto the camera body, while the female connector is designed for shutter release trigger accessories. Unlike the E3 connector (refer to the "Canon E3 Connector" sidebar), which is a standard 2.5mm sub-mini connector used in the audio world, the N3 connector, shown in Figure 1-14, is proprietary, made by Canon. Neither the male nor the female connector can be sourced from anywhere. Your best bet is to buy an accessory or cable adapter (such as the T3 to N3 adapter), and then cut the N3 heads off for your project.

FIGURE 1-14: The N3 connector is the circular port on the right. The circular port on the left is a PC terminal for triggering flashes and strobes.

The pin-out for the Canon N3 connector (looking at the N3 connector on the camera) is listed as follows:

- Top - ground
- Left - shutter
- Right - focus

What this pin-out means is that if you short the right pin and the top pin, the camera focuses (in AF mode). If you short the left pin and top pin, the shutter releases.

Note A digital multimeter is a multi-purpose electronic measurement tool. The digital multimeter can measure voltage, resistance, and current. Using the resistance mode, you can check for bad connections in your circuit.

Fitting the Pieces Together

After you've successfully tested the circuits, you can carefully fit everything into your project box. You may have to bend the circuit wires to fit the box. Try to bend them at sleeved unsoldered locations to prevent breaking the soldered contact points. Once everything is fitted into the project case, use a #1 Phillips precision screwdriver to fasten the screw and the case covers together. At this point, you need to test your finished trigger once again. As careful as you were putting the case together, it is possible for a fragile soldering contact to break loose. You don't want to wait and find out that your remote trigger is not working when you are out in the field.

Making a Delay Trigger

You are probably already familiar with a delay trigger. You use one whenever you place your digital camera in front of a group of people, set the 10-second timer, and run into the scene yourself. Or whenever you want to shoot a self-portrait, such as that shown in Figure 1-15. Most decent cameras on the market have pretty good built-in self-timers. It's practically an industry standard to set them to 10 seconds. There are two reasons you might want to make a delay trigger yourself: First, you can make one in case your camera doesn't come with a self-timer; second, the built-in 10-second timer is either too short or too long for your needs.

I learned to build a delay trigger because I found through experience that the 10-second delay timer is simply not long enough for me to set up a perfect shot. As my photographic experience increases over time, my taste for the "perfect" shot also increases. I found myself taking from several minutes to several hours just to perfectly set up a scene and all the models. When I have to join the scene myself, the setup time for each shot far exceeds the 10 second allowance.

Just recently, I visited the Villa Riviera building in Long Beach, California, and I had a chance to shoot some wonderful environmental portraits of my girlfriend and me. I had to set up my Canon EOS D30 digital SLR on the other side of the courtyard. For each shot, I set the 10-second timer, ran to the other side of the courtyard, and tried to pose before the timer went off. Each time I failed. After taking five unsuccessful frames, I finally gave up.

Without my further rambling, let's start making a delay trigger.

FIGURE 1-15: A self-portrait using the 10-second timer delay

Parts You Need

Here are the parts you will need to complete this project:

- 555CN Timer IC (276-1723) or TLC555 Low-Power CMOS Timer (276-1718)
- SPDT Micromini 5VDC Relay (275-240)
- Pushbutton normally closed Momentary Switch (275-1548)
- 4.7K ohm 1/2W 5% Carbon Film Resistor (271-1124)
- 2200μF Electrolytic Capacitor
- 0.01μF Polyester Film Capacitor (272-1065)
- Heavy-duty 9V Battery Snap Connector (270-324)
- SPST Submini Slide Switch (275-409)
- Stereo 3/32" Submini Phone Jack (274-245)
- 6" Matching Solderless PC Board (276-170)
- Project case
- 9-volt battery

Tip These are all fairly basic electronics parts, so they can be found easily at your favorite electronics store. I bought them all at Radio Shack, either locally or online. For your convenience, I have listed their Radio Shack part numbers.

The 555 timer chip has been a popular integrated circuit (IC) ever since its invention (see the "555 Timer Chip" sidebar later in the chapter). All circuits that require some kind of timing have this chip. Because of their popularity, there are tons of supplies from multiple manufacturers, which drives the cost down. Currently, they cost about a buck fifty each. Pick up a few spares for circuit testing purposes. When you put your prototype together, it's likely not going to work correctly the first time. The extra chips can help you determine if it's a bad chip or if it's your circuit at fault.

The SPDT Micromini Relay looks like a black block, which is not very elegant. Its operation is also not elegant—it emits loud clicking noises. The noise is good for testing, but in normal operation, it can get annoying. I had originally wanted to use the SPST Reed Relay (275-233), which has a fast response, a compact size, and a lower cost. And best of all, no loud clicks! Unfortunately, the reed relay is simply an open/close circuit switch, whereas the Micromini Relay is a two-position switch. Because the 555 timer defaults to a signal high during countdown, a simple open/close switch wouldn't have worked without a more complex circuit. For the purpose of learning, you wire up the two-position relay in reverse, or negative, logic to work as a delay trigger.

Note

A relay was chosen as the trigger mechanism because it enables circuit independence. Thus, the switch is on the camera's circuit, independent of the timer circuit you create. This independence ensures that the circuit works with most, if not all, cameras. Using an independent circuit also means that you won't ever fry your camera's circuitry with your timer circuit.

The 555 timer circuit changes state on a circuit open rather than a circuit closed signal. Therefore, you use an interesting normally closed pushbutton switch in this project, because the normally closed pushbutton keeps the circuit energized all the time, preventing the 555 timer from changing states. When you push the button, it breaks the circuit, causing the chip to change state and the timer to start.

The resistor and the first capacitor in the list are the components that will control the time delay. See the "Circuit Diagram" section later in the chapter for a more detailed description.

Note

Resistors are available in limited values. The resistor value you need may not be available off the shelf. Instead, you can make different resistor values by combining multiple resistors in series and in parallel. When resistors are connected in series, add up the resistor values to obtain the total resistor value. For parallel resistors, add up the reciprocals of the resistance values, and then take the reciprocal of the total to calculate the total resistor value.

The heavy-duty 9-volt battery connector is very useful for connecting a battery source to your project. It can be used with a 9-volt battery or with a battery holder from Radio Shack. The Radio Shack AA battery holders are available in a variety of configurations that can hold from one AA battery to eight AA batteries. Each battery holder has a 9-volt battery connector so that it can be connected to your project.

The slide switch is used to turn the circuit on and off. The sub-mini phone jack is used to connect to your camera. Your finalized circuit is transferred to the solderless PC board. Although it is described as solderless, you actually solder parts onto this circuit board. A 9-volt battery powers the timing circuit.

The following list includes additional parts you'll want to pick up. Although they will not make it into your finalized circuit, they are necessary for prototyping and testing. Without them, you might spend a lot of time putting a circuit together that doesn't work.

- 5mm yellow LED (276-021)
- 100 ohm 1/4W 5% Carbon Film Resistor 5-pack (271-1311)
- AA Battery Holder (270-383)
- 4 AA batteries

The yellow LED is a visual indicator for you to see if your circuit works. In this project it simulates the camera trigger visually. Without this indicator, you would be in the dark about whether the timing circuit works or not. The resistors work with the LED and provide the necessary current-limit to prevent the LED from burning out. See the "Make Your Own Infrared Emitter" sidebar in Chapter 16 for more information on the lack of LED resistance. The AA battery holder and the four AA batteries power the LED.

555 Timer Chip

The 555 timer chip is one of the most useful integrated circuits (IC) in existence. Introduced in the 1970s as the IC Time Machine, it provided circuit designers and hobbyists with an inexpensive commercial electronic timer. Today, 555 timer chips are available from many manufacturers and are readily available at your local electronic store. Information about the 555 timer chip is also widely available on the Internet. My favorite is the National Semiconductor LM555 Timer specification sheet that is downloadable at `www.national.com/ds/LM/LM555.pdf`.

555 timer chips are available in a bipolar and a CMOS version (see Figure 1-16). The CMOS version is typically rated to operate from 3 to 18 volts. The bipolar version operates from 4.5 to 16 volts. The bipolar version also requires more current than the CMOS version, which makes the CMOS timer chips the perfect candidate for low power to very low power applications. On the other hand, the bipolar chip can handle considerably greater current for high-power applications.

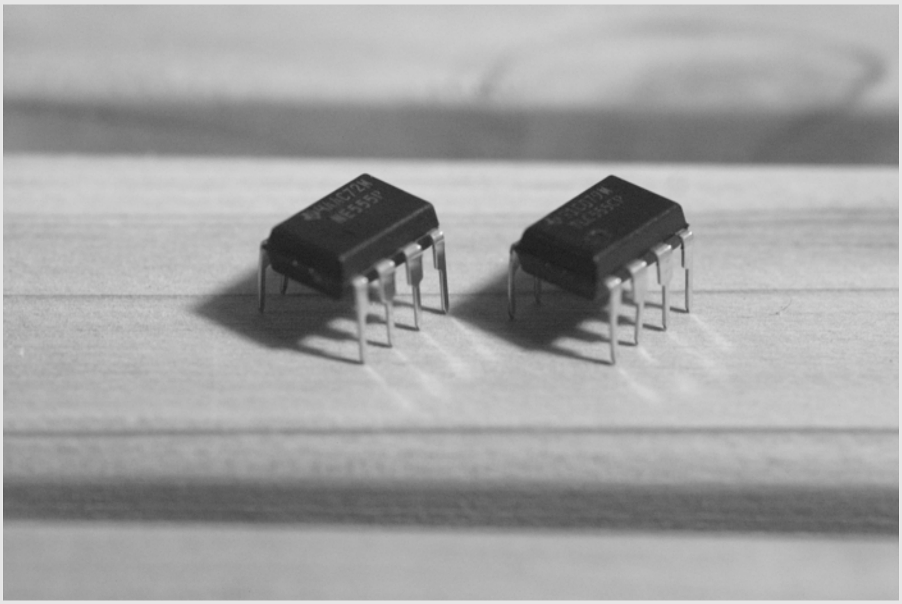


Figure 1-16: A bipolar timer chip and a CMOS timer chip look identical. The only way you can tell a difference is by reading their packaging and specification sheet.

Continued

Continued

The 555 timer chip has limitations on the values that can be used for R1, R2, and C (see circuit diagrams). The resistor values cannot be less than about 1 kilo-ohm and should not be greater than about 1 mega-ohm. A resistor with resistance less than 1 kilo-ohm results in excessive currents in the circuit, while a resistor greater than 1 mega-ohm does not pass enough current through the circuit. Capacitor values should be between 100 pF and about 10µF. If you follow these rules, the slowest pulses that can be accurately produced have a frequency of around 1 pulse every 10 seconds (0.1 Hz).

The packaging of the 555CN Timer IC (276-1723) mentions "Times microseconds through hours." I suspect that the newer 555 IC design has done away with resistor and capacitor value restrictions.

Tools You Need

Here are the tools you will need to complete this project:

- Breadboard (276-174)
- Solderless Breadboard Jumper Wire Kit (276-173)
- Digital multimeter
- Needle-nose pliers
- Soldering iron
- 0.032" diameter 60/40 Standard Rosin-Core Solder (64-009E)

The breadboard is a piece of white plastic with a lot of tiny square holes (see Figure 1-17). These holes allow you to insert electrical wire and component leads. The holes are connected via different patterns of rows and columns. Figure 1-18 shows the connection pattern. The breadboard is an essential part for prototyping and testing your design.

When working with breadboards, a pair of needle-nose pliers is a must. You really want to use the small type with a long nose. This tool helps you insert wire leads and component leads into the breadboard sockets.

Circuit Diagram

The delay timer circuit is shown in Figure 1-19. It is a fairly simple circuit that is based entirely on the monostable operation shown in the LM555 specification sheet (refer to the "555 Timer Chip" sidebar). The circuit is unchanged, but a few minor components have been added. A battery was added to the circuit to power the timer chip. A switch was added to turn the circuit on and off. A normally closed pushbutton switch was added to start the timer. A relay was added to provide independent triggering of the camera through the timer circuit. And a camera was added to show how to interface the circuit to the camera.

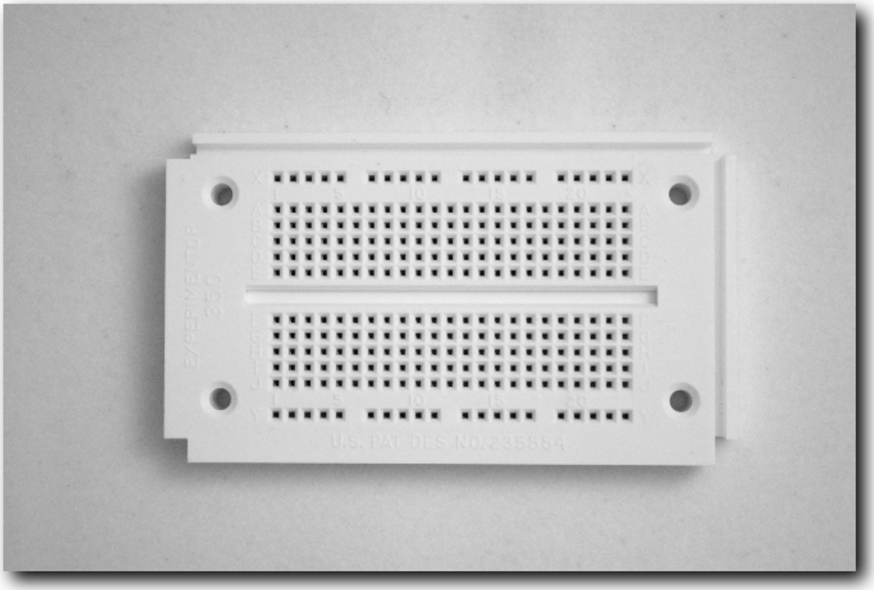


FIGURE 1-17: A breadboard

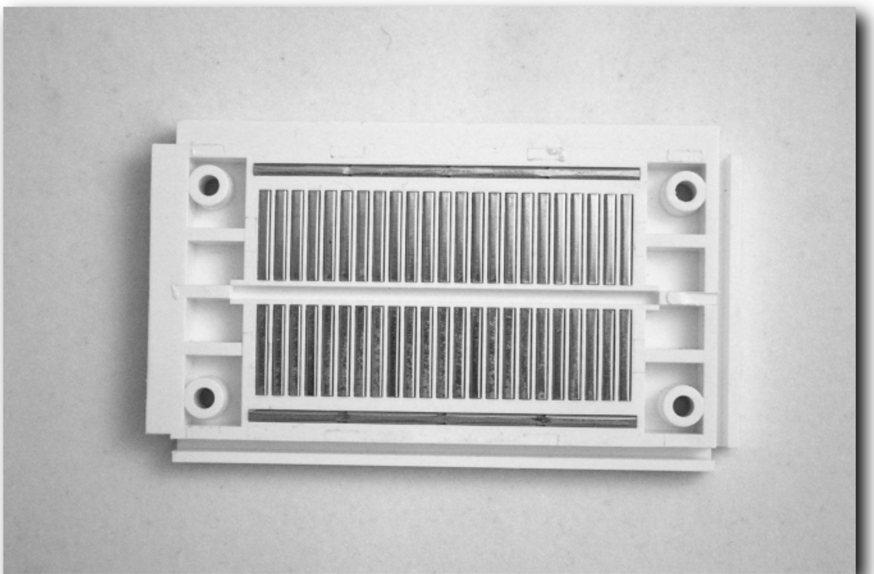


FIGURE 1-18: The bottom of the breadboard shows the electrical connections. When you buy a breadboard, a label covers the bottom to insulate the metal contacts from other potential electrical contacts. I pulled the label off my breadboard to show you the pattern underneath.

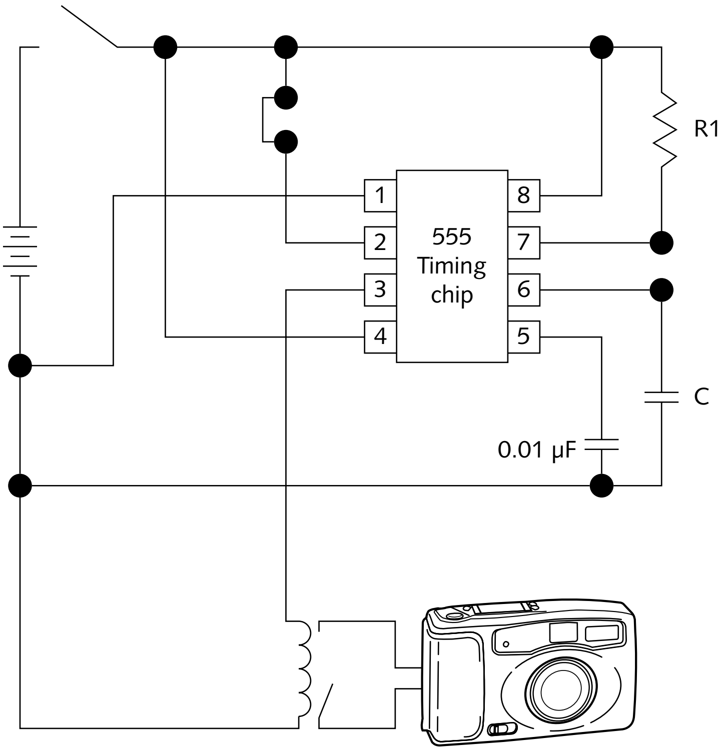
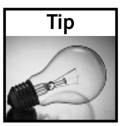


Figure 1-19: The delay timer circuit



Some resources have mentioned that the 0.01μF capacitor may not be needed with a CMOS timer chip. Based on my experience, the capacitor is required for both the bipolar and CMOS timer chips. Without it, the bipolar chip does not work at all, and the CMOS chip becomes extremely speedy. I have noticed a ten-fold speed-up in frequency.

By changing R1 and C, you can vary the trigger timing. The delay time is calculated by the following formula:

$$T = 1.1 \times R1 \times C$$

T is in seconds, R1 is in ohms, and C is in farads. With the 4700 ohms resistor and the 2200μF capacitor picked for this project, the timer delays 11.37 seconds before triggering the camera.

Resistor Color Code

Resistor values are color coded onto the resistor bodies. There are generally three to four bands on each resistor. From the resistor end where the band is closer to the lead, the first color band signifies the first digit in the resistor value. The second color band represents the second digit in the resistor value. The third color band indicates a multiplier for the two digits. The fourth band (if it exists) determines the tolerance defined by the manufacturer for that particular resistor. The possible values for each band are shown in Table 1-1.

Note If you read the "555 Timer Circuit" sidebar, you are probably wondering how I got away with using a 2200µF capacitor. My experience has shown that although timing isn't truly accurate by violating the rules, the 555 timer chip still works. And it still produces a frequency on par with the calculation. For camera triggering, I wouldn't worry so much about accuracy or precision. But if you really need an extremely accurate and precise timer, you need to design a more complicated circuit with all the right parts.

I picked the SPDT Micromini 5VDC Relay because of its double throw characteristic (refer to the "Switch Terminology" sidebar). The 555 timer chip outputs high during the delay and outputs low when the delay elapses. That is exactly the opposite of what you want. You want the circuit to output high after the delay elapses. A simple single throw relay would not work. Fortunately you can emulate that characteristic by wiring up a double throw relay, as shown in Figure 1-20.

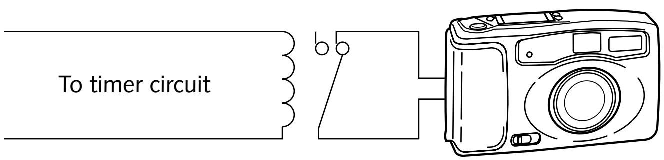


Figure 1-20: The SPDT Micromini 5VDC Relay circuit

This delay timer is a very basic circuit that gets the job done, but it doesn't do it particularly well, especially considering that the trigger is on until the normally closed button is pressed. But the knowledge you gained by building this circuit can start you thinking, and later you can build more advanced and elegant timing circuits.

Table 1-1: Resistor Band Color Chart

First and Second Color Band		*Third Color Band*		*Fourth Color Band*	
Band Color	***Value***	***Band Color***	***Multiplier or Divisor Value***	***Band Color***	***Tolerance***
Black	0	Black	×1	Gold 5%	5%
Brown	1	Brown	×10	Silver 10%	10%
Red	2	Red	×100	None 20%	20%
Orange	3	Orange	×1,000		
Yellow	4	Yellow	×10,000		
Green	5	Green	×100,000		
Blue	6	Blue	×1,000,000		
Violet	7	Silver	÷100		
Gray	8	Gold	÷10		
White	9				

Prototyping the Circuit

With the circuit worked out, your first task is to prototype the circuit on a breadboard. Typically, I like to use the top row as the positive power source and use the bottom row as the negative ground. These two rows are linked across the entire breadboard, making them easy to access for the rest of the circuits.

The first thing you should do is find a nice spot in the middle of the breadboard for your timer chip. It needs to be inserted horizontally with the pins above and below the trench (see Figure 1-21). This gives each pin its own contact strip and keeps the pins from shorting each other.

Caution

Use a chip puller to remove ICs from the breadboard or chip sockets, or use a screwdriver to pry them off. Pulling them off with your fingers forcefully could be dangerous. I've had their tiny legs embedded in my flesh before.

Now wire up the rest of the circuit using jump wires, and attach electronic components as needed. The needle-nose pliers will do wonders on the breadboard compared to your fingers. When working with tiny electronic components, your fingers are big columns from a Greek temple. Use the needle-nose pliers to thread the jumper wires and leads on the prototype circuit. When you are done wiring everything, you'll see a circuit that looks like Figure 1-22.

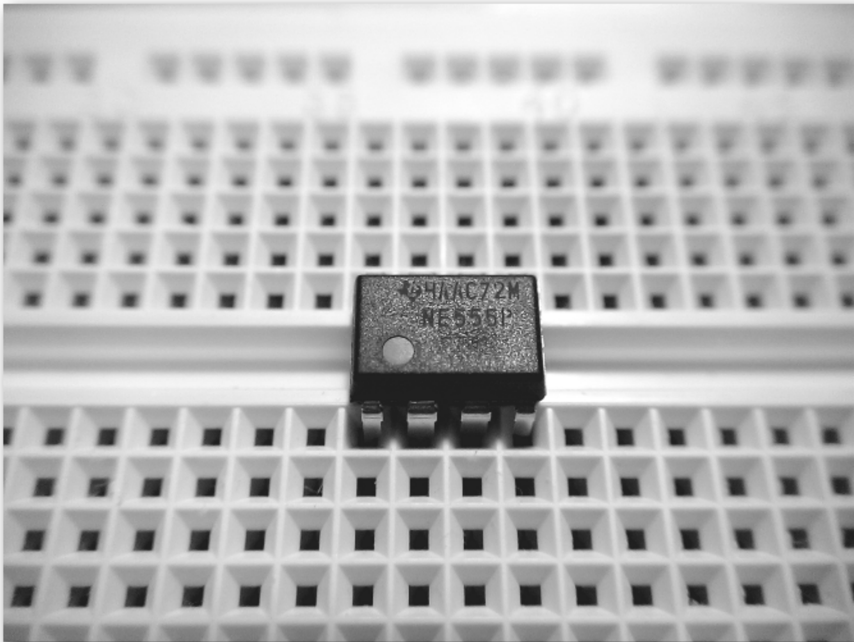


FIGURE 1-21: The timer chip inserted in the breadboard

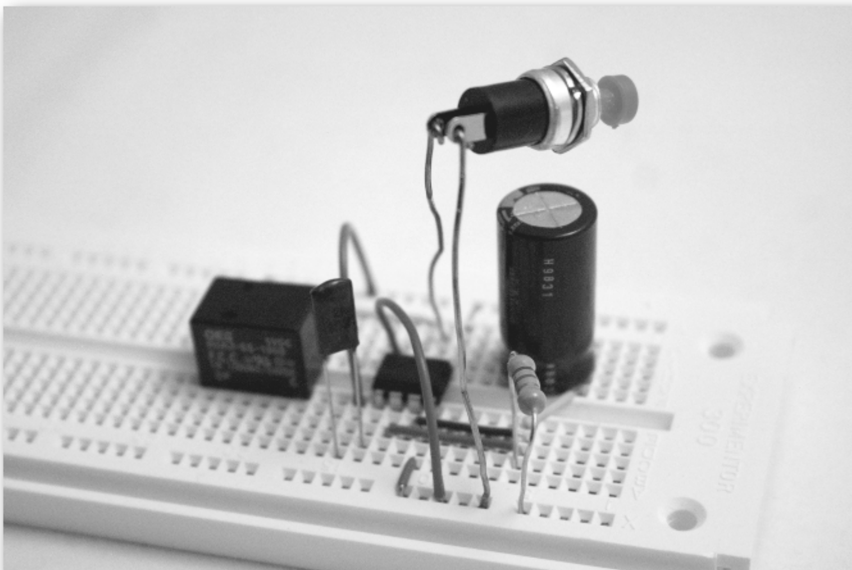


FIGURE 1-22: The delay timer prototyped on a breadboard

At this point, you are probably pretty excited about the circuit you just put together. It's time to insert the testing circuit. In place of the camera, wire up the AA battery holder, the resistor, and the LED in series (see Figure 1-23). This series of electrical components will give you a visual indicator of the trigger mechanism. Plug in a 9-volt battery to power the timing circuit and insert four AA batteries to power the LED.

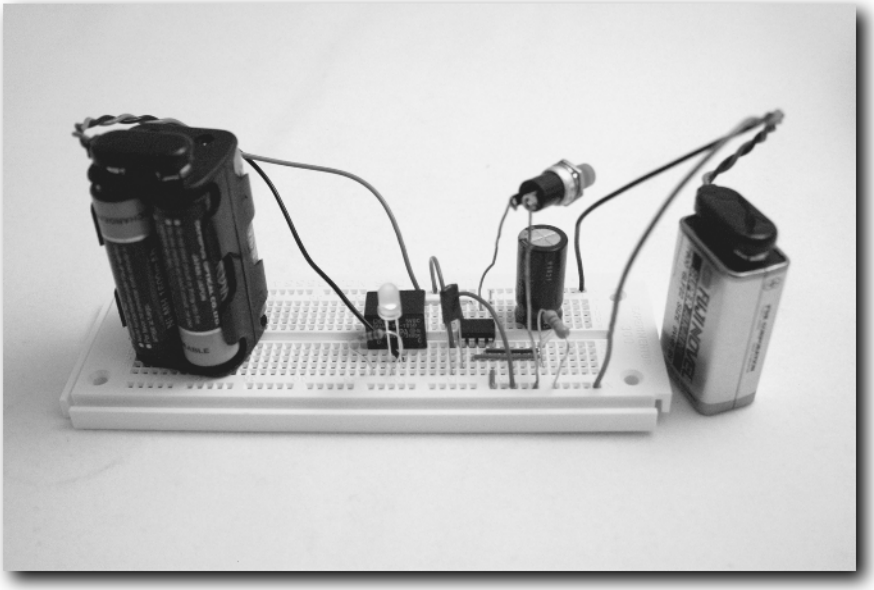


FIGURE 1-23: The breadboard with the testing circuit installed

Once wired, the LED stays on. This is normal because you have wired the relay in reverse. This is also the non-elegant portion of the design that I mentioned earlier. When you push the button, the LED should turn off. You'll hear the relay click. The LED will stay off for 11.37 seconds. Then it will turn back on again. The turning on is what causes the camera to trigger when you finally wire it to your camera.

Because this circuit is not elegant, you will have to set your camera to one-shot mode. Otherwise, when the light turns on and stays on, the camera will continue to fire off pictures.

Soldering the Wires

A breadboard circuit is perfect for prototyping and testing. But it's easy for the circuit to get screwed-up because a lead comes loose. After you have tested the prototype circuit, you can memorialize your design by soldering everything to a PC board. I have found that Radio Shack has made a 6" Matching Solderless PC Board (276-170) that is perfect for this purpose. This PC board matches the breadboard exactly so that you don't even have to rewire your circuit for

Resistor Characteristics

Metal Foil: Low tolerance. Very low temperature coefficients. Long stability.

Metal film: Low tolerance (nominally 0.1 to 1 percent). Low temperature coefficients. Long stability. Thin film is more stable from temperature changes than thick film.

Carbon film: High temperature coefficient. Tolerance nominally 2 to 10 percent.

Carbon: Very high temperature coefficient.

Composition: Tolerance nominally 5 to 20 percent. Tolerance becomes higher over time through aging and humidity.

Because resistors can change characteristics over time, you can place a variable resistor in series with a fixed resistor for precise timing applications. The variable resistor can be adjusted and calibrated for different conditions.

the PC board. Simply transfer all of the wires and components from the breadboard to this PC board and you're done.

Just make sure you test your finalized circuit again with the visual indicator. It's easy to make mistakes even if you are just transferring the circuit from one medium to another. And there could be bad solder connections.

Putting It Together

Once you are happy that the circuit is working correctly on the new PC board, mount it into a project case. The project case helps prevent damage to the components on the circuit board. (And if you drop it, parts won't scatter all over the floor.)

Making an Interval Trigger

In this section you use the 555 timer chip to make an interval trigger. The interval trigger is far more interesting than the delay trigger because it can help you document the changing environment around you. You can take sequential pictures of flowers that bloom in one night. You can shoot a sequence of changing cloud formations. Or you can shoot the motion of the stars.

Most camera manufacturers make interval triggers for their high-end SLRs. For example, Canon makes a TC80N3 Timer Remote Control for EOS cameras that has an N3 connector (refer to the "Canon N3 Connector" sidebar). Because the lower-end EOS Rebel-series of cameras uses the E3 connector (refer to the "Canon E3 Connector" sidebar), the Rebel-series cameras can't connect to the TC80N3 Timer Remote Control. But you can make an interval timer yourself.

The delay trigger in the previous section is the cornerstone to understanding the capability of the 555 timer chip. Therefore, a lot of tips and notes in the previous section apply to the interval trigger as well. For the interval trigger, I will present only pertinent information that differs from the previous section. Unless you are already extremely familiar with the 555 timer chip, I suggest that you thoroughly review the previous section.

Parts You Need

Here are the parts you will need to complete this project:

- 555CN Timer IC (276-1723) or TLC555 Low-Power CMOS Timer (276-1718)
- SPDT Micromini 5VDC Relay (275-240)
- 4.7K ohm 1/2W 5% Carbon Film Resistor (271-1124)
- 100 ohm 1/4W 5% Carbon Film Resistor 5-pack (271-1311)
- 0.01µF Polyester Film Capacitor (272-1065)
- 4700µF Electrolytic Capacitor (272-1022)
- SPST Submini Slide Switch (275-409)
- Stereo $^{3}/_{32}$" Submini Phone Jack (274-245)
- Heavy-duty 9V Battery Snap Connector (270-324)
- 9-volt battery

Capacitor Characteristics

Capacitors come in different types. Each type has different characteristics appropriate for different applications. Some capacitors have a lower tolerance and are good for accurate and precise timing applications. Others are more tolerant and thus less accurate and precise. In most cases, timing doesn't need to be overly accurate and precise for general-purpose camera triggering. Of course, if you are building a mission-critical camera trigger, stick with the best parts.

Metal film: Film capacitors include polycarbonate, polystyrene, polyester, and polypropylene. All of these film types are excellent for timing applications.

Tantalum: Tantalum capacitors have high dielectric absorption characteristics and high leakage. Therefore they are not suitable for timing applications. Use them only for non-critical situations.

Electrolytic: Electrolytic capacitors suffer from loose tolerances, poor stability, and high leakage. They are also not suitable for critical timing applications.

Ceramic: Ceramic capacitors are highly unstable and should also be avoided for timing applications.

Note

Refer to the section "Making a Delay Trigger" for information on these parts.

The following parts are used for testing the prototype:

- 5mm yellow LED (276-021)
- AA Battery Holder (270-383)
- 4 AA batteries

Tools You Need

Here are the tools you will need to complete this project:

- Breadboard (276-175)
- Solderless Breadboard Jumper Wire Kit (276-173)
- Needle-nose pliers
- Digital multimeter
- Soldering iron
- 0.032" diameter 60/40 Standard Rosin-Core Solder (64-009E)

The tools listed basically mirror the tool list from the "Making a Delay Trigger" section, so I won't go into further detail here.

Circuit Diagram

The interval timer circuit is shown in Figure 1-24. It is a fairly simple circuit based entirely on the astable operation shown in the LM555 specification sheet (refer to the "555 Timer Chip" sidebar). The circuit was unchanged, but a few minor components were added. A battery was added to the circuit to power the timer chip, a switch was added to turn the circuit on and off, a relay was added to provide independent triggering of the camera through the timer circuit, and a camera was added to show how to connect the circuit to the camera.

By changing R1, R2, and C, you can vary the interval and trigger timing. The interval timing is the delay between each trigger. For overnight exposure, depending on how many images you want to capture, you can set it from seconds to minutes to hours. The interval time is calculated by the following formula:

$$T1 = 0.693 \times (R1 + R2) \times C$$

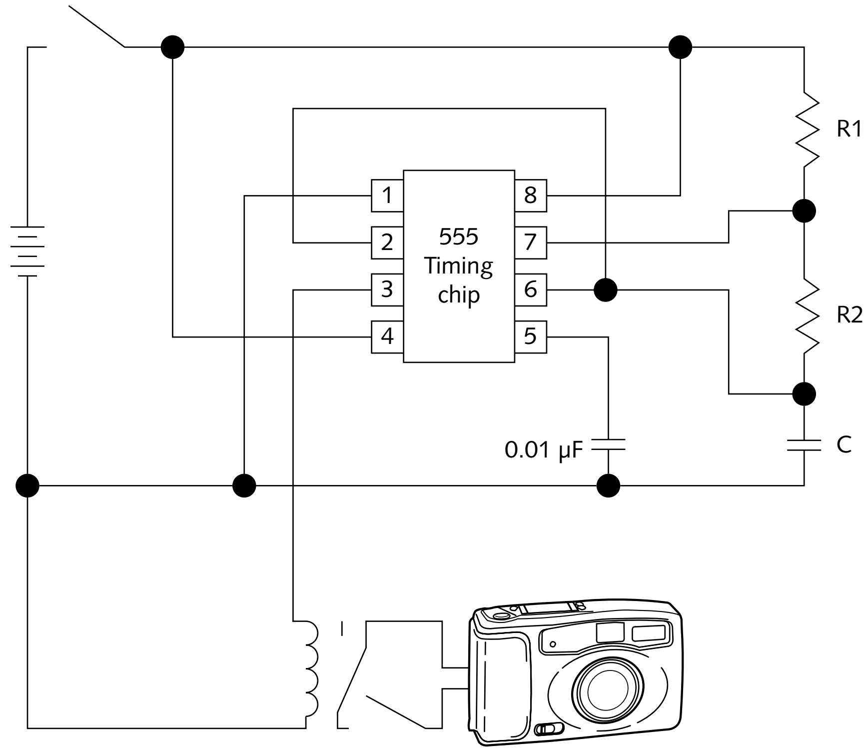


FIGURE 1-24: The interval trigger circuit diagram

The triggering timing determines how long to hold the camera button down. This could range from a few milliseconds to a second or two, depending on the camera. I usually set it to 1 second just to be safe. The trigger timing is calculated by the following formula:

$$T2 = 0.693 \times R2 \times C$$

T1 and T2 are in seconds, R1 and R2 are in ohms, and C is in farads. For my project, I set R1 to 18800 ohms (four 4700 ohms resistors wired in series), R2 to 300 ohms (three 100 ohms resistors wired in series), and C to 4700µF. With these values, the interval of the timer is 62.210 seconds and the trigger time is 0.977 seconds. These values are close enough to 1-minute intervals and holding the camera trigger down for 1 second.

To put the interval trigger together, follow the steps from the sections "Prototyping the Circuit," "Soldering the Wires," and "Putting It Together."

You'll need to refer to the "Making a Delay Trigger" section when you wire up the interval trigger (see Figure 1-25). Remember to test your circuit with the LED, as shown in Figure 1-26.

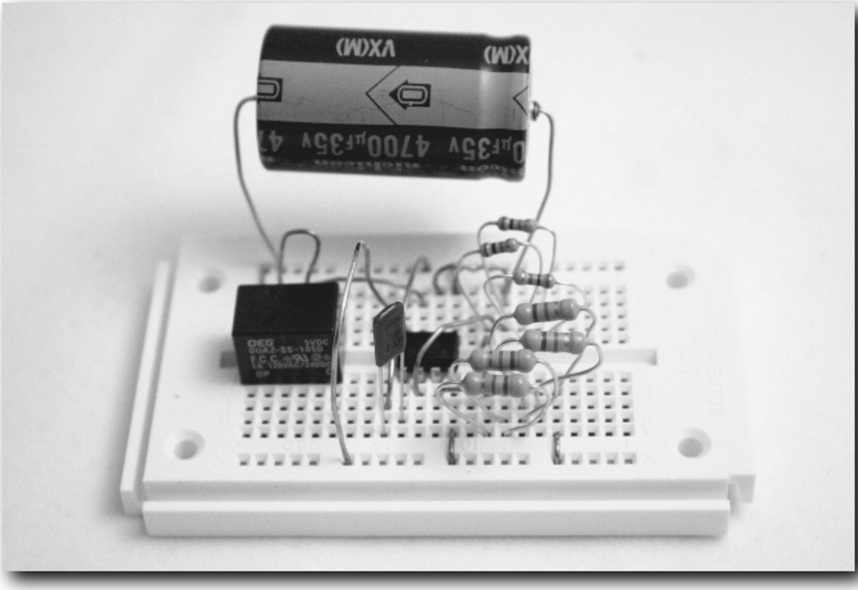


FIGURE 1-25: The delay timer prototyped on a breadboard

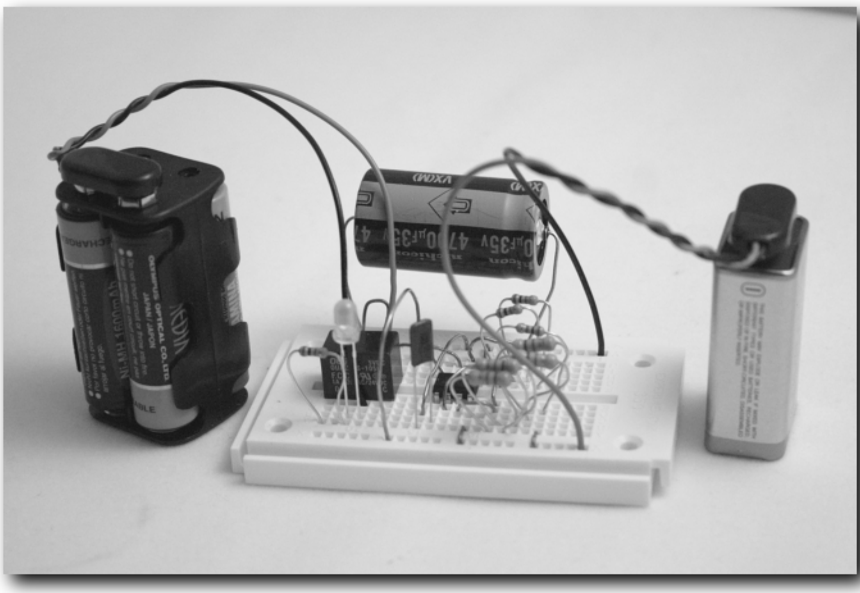


FIGURE 1-26: The breadboard with the testing circuit installed

Connecting the Triggers to a Point-and-Shoot Camera

As you learn in the rest of this chapter, it's fairly easy to connect your trigger to an SLR because SLRs already have trigger ports—you just have to build adapters to make the connection work. But most P&S cameras do not come with any trigger ports at all. Fortunately, it is possible to modify most P&S cameras so that you can connect any wired triggers you build. On most P&S cameras, the shutter button is simply a circuit closure switch, so it is a straightforward task to wire a trigger interface to the button circuit.

In this section I demonstrate how to interface to the shutter button on my Sony DSC-P92 digital camera. The modification will be presented on a conceptual level so that you can apply it to any P&S camera.

Cross-Reference

Chapter 16 covers in detail how to take the Sony DSC-P92 case apart, so refer to that chapter before getting started.

Parts You Need

Here are the parts you will need to complete this project:

- $^3/_{32}$" Submini Phone Jack (274-245)
- Wires

The $^3/_{32}$" (2.5mm) sub-mini phone jack is the standard trigger port on the entry-level Canon EOS SLRs. The earlier projects in this chapter use this interface because it is common and easy to find the parts. In this project you again use this connector.

Tools You Need

Here are the tools you will need to complete this project:

- #1 Phillips precision screwdriver
- Digital multimeter
- Soldering iron
- 0.032" diameter 60/40 Standard Rosin-Core Solder (64-009E)
- Drill
- Drill bit
- Drill gauge

The Sony DSC-P92 case has four tiny machine screws that must be unfastened with your #1 Phillips precision screwdriver. After getting inside the camera and finding the shutter button's wire and connector, you use the digital multimeter to determine the pin-out. Then you use the soldering iron and solder to add your own trigger port.

Taking the Camera Apart

Follow the instructions presented in Chapter 16 to take apart the Sony DSC-P92. If you are working with another camera, take care to find all the screws you need to remove. When you take the case apart, make sure you do so slowly and avoid breaking any ribbon cables. Surface mount ribbon cables in today's digital camera are nearly impossible to fix at home.

1. After taking the back cover off, remove the ribbon cable connector that links the back cover and the circuit board (see Figure 1-27).

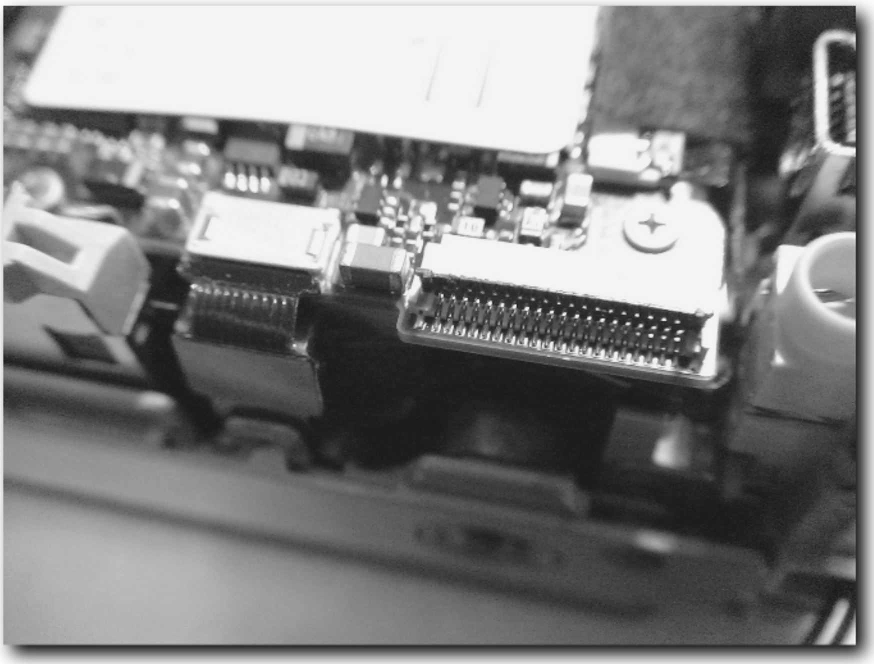


FIGURE 1-27: The ribbon cable connectors on the bottom of the Sony DSC-P92

2. Notice that there is another smaller ribbon cable connector. Remove that as well, using either a small flat blade screwdriver or your fingernails.
3. Next, look at the top of the digital camera, where the power button and the shutter button are located (see Figure 1-28). Note that two tabs are securing the circuit board in the picture—one tab is above the shutter button and the other to the left.

FIGURE 1-28: Two tabs are around the shutter button.

4. Pull those tabs slightly, and the circuit board will come loose.
5. With the circuit board freed from the tabs, separate the circuit board and camera internals from the front cover as shown in Figure 1-29.

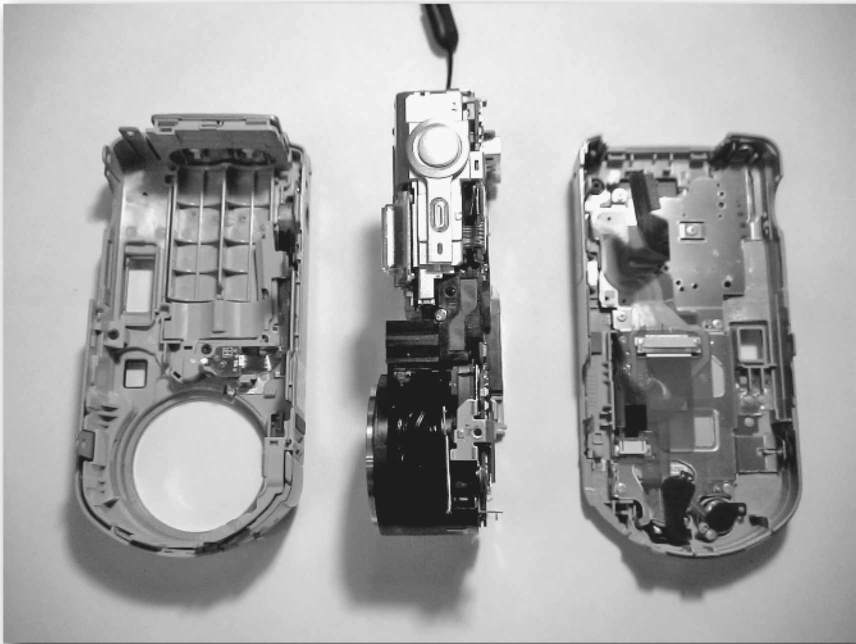


FIGURE 1-29: The camera internals separated from the front and back cover

Looking for the Shutter Switch

With the camera internals separated from the front and back cover, look for the shutter button and examine how it is attached to the camera. On the Sony DSC-P92 digital camera, the shutter button is attached to the camera's internal frame by a tab, as shown in Figure 1-30. Another tab is on the other side, but after you free the tab you see in the Figure 1-31, the whole shutter button panel comes loose.

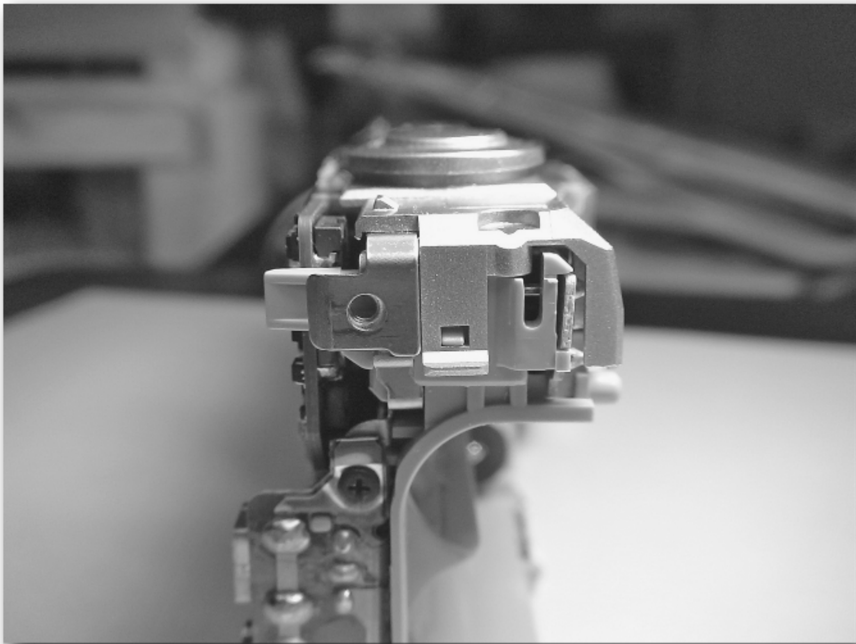


FIGURE 1-30: The shutter button panel is held to the camera internal by two tabs. One tab is shown in this picture; the second tab is on the other side.

Free the tab to remove the shutter button panel, as shown in Figure 1-31. Don't pull it off just yet because the panel is attached to the circuit board by an orange ribbon cable to the left. If you pull the panel off hastily, you might break that cable, and it is nearly impossible to repair.

Note also in Figure 1-31 that the flash capacitor is beneath the shutter button panel. It is still charged with very high voltage. Notice that the capacitor leads are on the right, protruding from the circuit board. Don't touch them or you might get a nasty surprise. I did accidentally touch both pins with my right thumb once. It gave my thumb a little shock that felt like a numbing vibration.

Tip

Use electrical tape to cover the two leads while you are working on the camera to prevent accidental electrical shock.

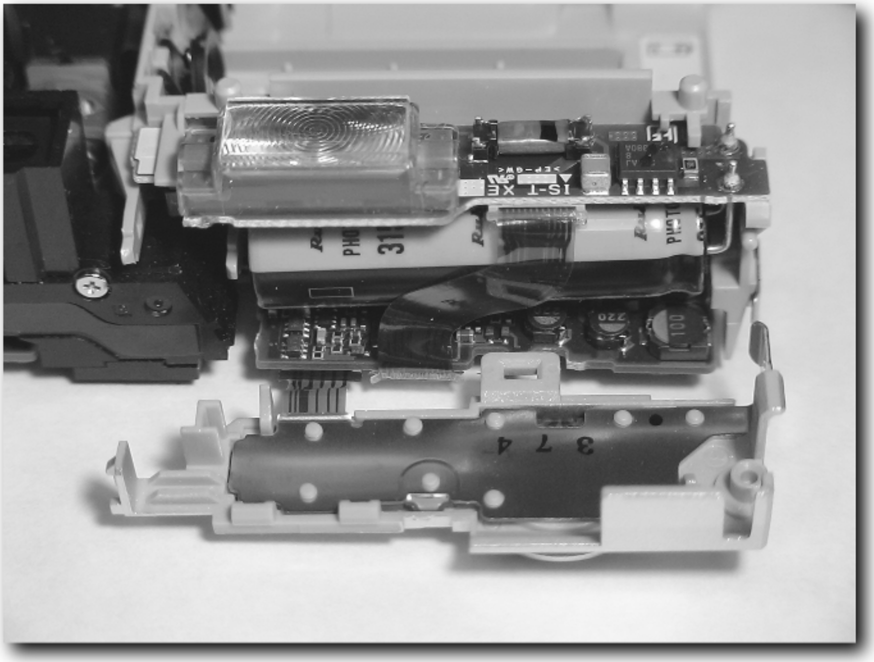


FIGURE 1-31: The shutter button panel freed to reveal the flash capacitor

Shown from the other side, the ribbon cable connector looks like Figure 1-32. Use a small flat-head screwdriver or your fingernails to pry the ribbon cable connector loose and detach the shutter button panel.

Determining the Shutter Button Pins

Figure 1-33 shows the shutter button panel detached from the camera. The ribbon cable is sticking out on the bottom left. The orange portion of the ribbon cable is the insulated section, while the silver leads are actually electrical contacts. The power button has one position, and the shutter button has two positions. So altogether there are three switches on this button panel, which matches the number of electrical contacts as well—considering that each switch requires two wires.

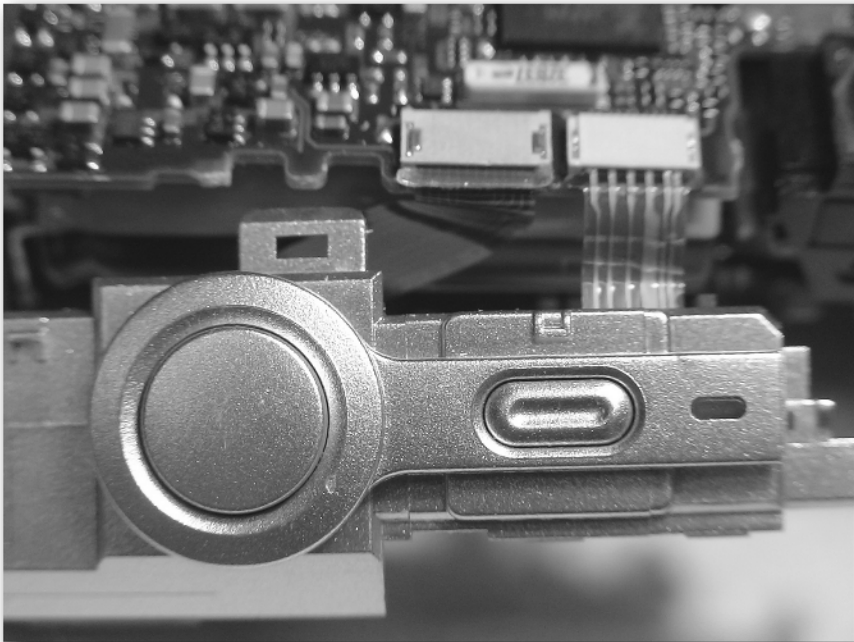


FIGURE 1-32: The shutter button panel and its ribbon cable connector

You need to use a digital multimeter to determine which electrical contacts are associated with each button. You need a friend for this task—one of you probes the electrical contacts, while the other person pushes down one of the buttons. Turn the digital multimeter on and set it up to measure resistance (ohms). Press and hold one of the buttons. Make sure you test each of the two positions on the shutter button separately.

Place the positive and negative test leads on two different electrical contacts. Try different combinations of electrical contacts until you see zero resistance (a closed circuit). The two contacts that showed the zero resistance are the right contacts for the button that was pressed. On the Sony DSC-P92 digital camera, the shutter button is associated with the third and fifth contacts (counting from the left in Figure 1-33).

Soldering the Trigger Interface

After you have determined the pins for different button functions, you need to solder the 2.5mm ($^{3}/_{32}$") stereo jack to the pins. The best way is to first solder thin wires onto the pins, and then solder the wires to the stereo jack. Because the contact pins are extremely small and thin, soldering wires to it is a multi-step process. Start by heating the contact pin. Then flow a tiny bulb of solder onto the contact pin. Be careful that you don't heat the adjacent pins or short them out by flowing solder onto them.

FIGURE 1-33: The button panel is detached from the camera.

Next, tin the thin wire (see the instructions in Appendix A). Heat the thin wire and use it to transfer heat to the tiny bulb of solder. When both the soldering bulb and wire are heated, the solder melts, flowing onto the thin wire. Remove the soldering iron. When the solder cools to a solid form, an electrical contact is made.

Tip

Use wires that are long enough for you to locate the stereo jack wherever you want on the camera body. The following section discusses wire length in more detail.

Strip the other end of the wire. Insert the un-insulated wire end through the contact pin on the 2.5mm stereo jack. Make sure the wire is connected to the correct pin (refer to the "Canon E3 Connector" sidebar for the correct connection). Wrap the wire around so that it is temporarily secured on the pin, as shown in Figure 1-34. While the wire is still secure on the pin, use the soldering iron to apply heat to the wire and the contact pin at the same time. Place the end of the solder wire on the wire and the contact. When they get hot enough, the solder melts and flows onto both the wire and the contact. Remove the soldering iron. When the solder cools down, the connection is complete.

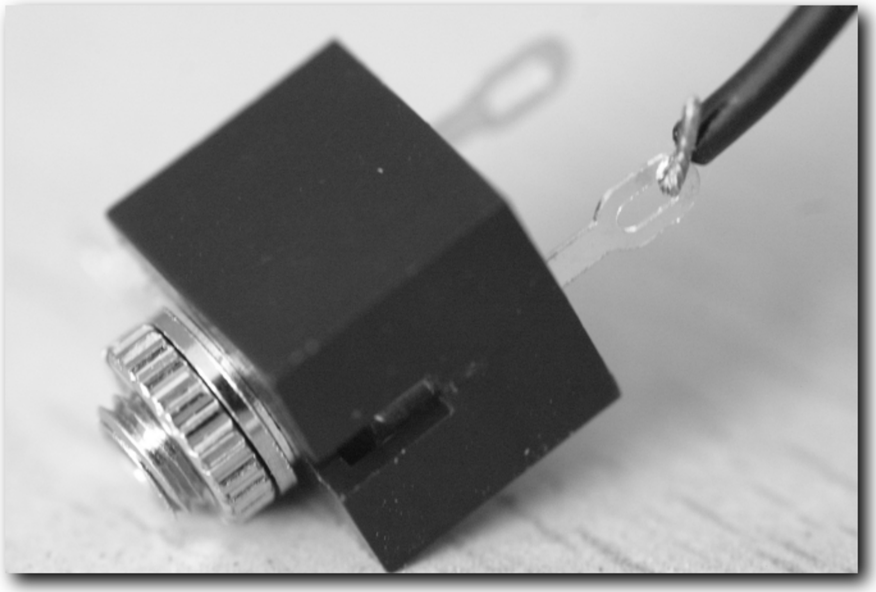


FIGURE 1-34: The exposed wire wrapped on the contact pin

Perform this step for each of the Canon E3 connector functions: shutter trigger and auto-focus. If the camera doesn't have auto-focus capability, you can ignore this step.

Modifying the Camera Case

In this step, you want to mount the 2.5mm stereo jack on the camera itself, if possible. The advantages of mounting the trigger jack securely are, first, that it is convenient to access and, second, that there are no loose wires that could break as a result of wear and tear. But it's not always possible to mount the stereo jack on the camera. With today's miniaturization of digital cameras, the internal electronics are already crammed in a very small package. In this situation, where your camera is already crammed with parts, all you can do is drill a tiny hole for the wires to pass through and dangle the trigger port outside. Tie the wires into a knot on both side of the hole to prevent excess wear and tear on the camera internals (see Figure 1-35).

Tip

You can also twist the wires together into a braid, as shown in Figure 1-36. When two wires are braided together, the result is called a twisted-pair. The advantage is that when the wires are braided together, they become more durable.

FIGURE 1-35: Wires tied into a knot

However, if you manage to find space to mount the stereo jack on your camera, make sure the jack still fits when a stereo plug is inserted into it. Once you're satisfied that your plan will work, use a drill gauge to determine the diameter of the stereo jack. Drill a hole in the camera case just slightly bigger than the stereo jack. The stereo jack is secured from the outside with a bolt. Make sure you don't drill a hole that is bigger than the bolt. After drilling the hole, insert the stereo jack through the hole from inside the camera body. Secure it with the bolt from the outside, as shown in Figure 1-36.

FIGURE 1-36: Secure the stereo jack with the bolt supplied. In this picture, the stereo jack was secured to the drill gauge. But the idea applies to the camera body as well.

Reassembling the Camera

When you reassemble the camera, route the wires around so they won't be crushed. Crushed wires have the potential to deteriorate and short out over time. Route them so they won't get caught and interfere with the camera's operation. Put the camera back together in the reverse order used to take it apart. Don't forget to plug in all the ribbon cables that you unplugged.

Extending the Remote Switch

The wired remote trigger switches you can buy from the manufacturers have a fairly short wire. It might be anywhere from three feet to, at most, six feet long. And unless you had a particular need in mind when you built your own trigger switch, you probably built one with a fairly short cable as well.

Sometimes you'll wish the trigger switch had a longer cable. You might want a longer cable because you want to shoot some self-portraits. Figure 1-37 is a self-portrait that I shot years ago using a homemade extended cable. Running back and forth between the scene and the camera can be extremely inconvenient, especially if the scene is far away. You might want to shoot wildlife. Some wild animals are very sensitive to the presence of humans. By setting up the camera in a remote location, you won't scare them away. Or you might want to take pictures of a hazardous environment, where your physical presence could be a danger to your life. It's better to wire up a remotely triggered camera than to put your life in danger.

FIGURE 1-37: A self-portrait shot with an extended cable. Did you spot the cable? If I hadn't pointed it out, you probably would have never noticed it.

If you have followed the instructions in this chapter and built a remote trigger and interface based on the simple 2.5mm or 3.5mm stereo phone jack, you are in good shape. You can easily buy 3.5mm stereo extension cables at Radio Shack or even build them yourself. Converters for 2.5mm and 3.5mm stereo jacks are also readily available so you can easily convert them back and forth. Figure 1-38 shows these parts.

FIGURE 1-38: An extension cable, a 2.5mm to 3.5mm adapter, and a 3.5mm adapter to 2.5mm adapter

If you build your triggers using proprietary interfaces rather than a popular interface, I suggest you build stereo adapter cables for your proprietary trigger. That way you will be able to build your extension from over-the-counter parts. Otherwise, you will always have to build custom cables.