cpo science

Timer IIe

Timer ***IIe***™ User's Guide

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Chapter 1: Introduction

Making accurate measurements is the key to many good experiments. The CPO Science Timer IIe uses a precision quartz crystal to make time measurements accurate to within 0.0001 seconds and frequency measurements accurate to 0.1 Hertz. The two photogates (included) allow the Timer to be started and stopped by anything that breaks the light beams.

This booklet will show you how to use the Timer to measure speed, acceleration, the period of a pendulum, the frequency of sound, and many other quantities.

What's New?

The Timer IIe (*enhanced*) and the new photogates feature several improvements over the Timer II kit.

The tilted, console-style case makes reading the display much easier and the metal stand allows a variety of positioning options. The robust, internal electronics have not changed.

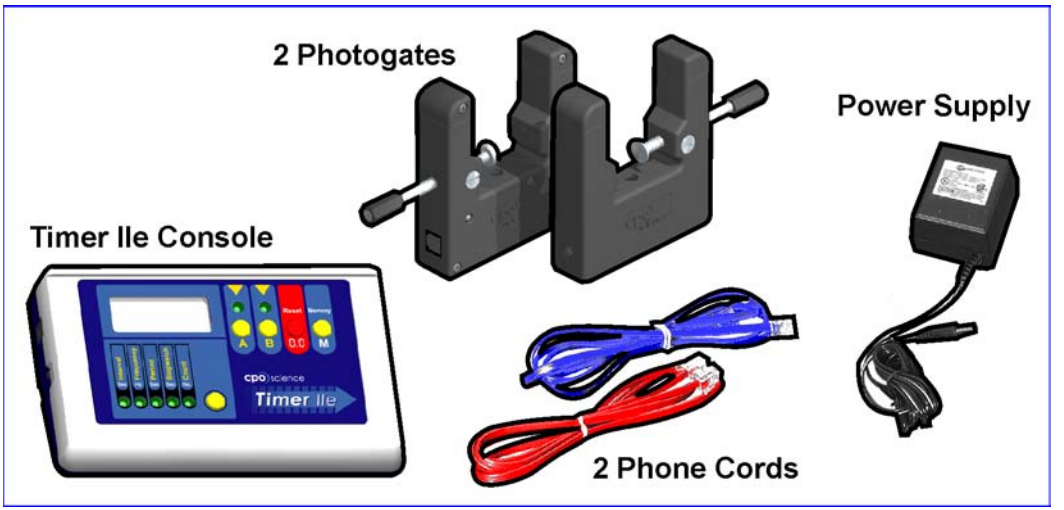
The new photogates feature a rubberized texture for easy, comfortable use and advanced electronics to improve accuracy and reliability.

Chapter 2: Kit Contents

The Timer IIe comes with everything you need to perform accurate experiments. You should have received the following parts. Replacement parts can be ordered using the part numbers given.

Table 1: *What's in the case?*

Quantity	Description	Part Number
1	CPO Science Timer IIe	892-1000
2	CPO Science Photogate	392-1100
1	Wall Mount Power Supply	692-4001
2	Phone cord (1 red, 1 blue)	392-1106, 392-1105
1	Timer IIe User's Guide	692-8101
1	Storage Case (optional)	692-6501
1	9 Volt Battery (not included)	N/A



Chapter 3: Using the Timer

Warnings and Precautions

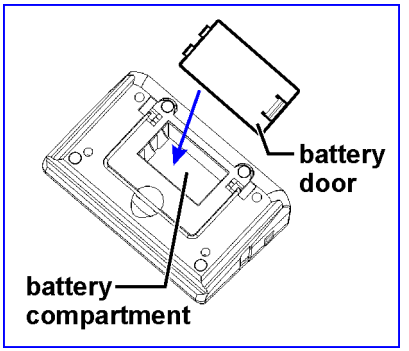
Please make note of the following warnings and precautions:

WARNING: Do not plug any lines from the telephone system in to the inputs. Telephone rings (also present in modems) generate large voltages that can damage or destroy the Timer.

IMPORTANT: Use only the 9V power supply that has the CPO Science name/logo on it with the Timer. Using another supply can damage the Timer or photogates and void your warranty.

Inputs **A** and **B** are for connecting the photogates or the CPO Science Sound & Waves machine. **DO NOT** plug telephone equipment, modems or anything else into the inputs, or you risk damaging the Timer and/or the telephone equipment.

Replacing the 9 V Battery

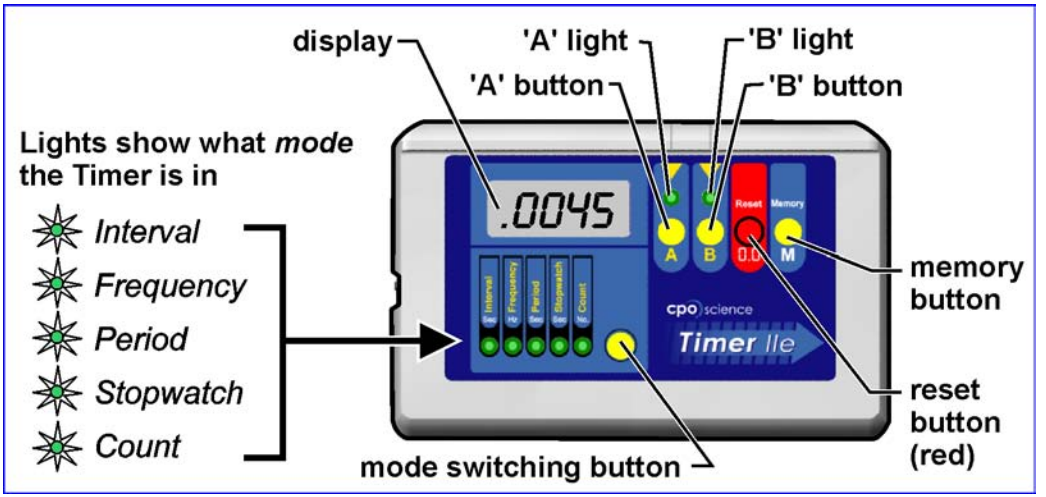


Open the battery compartment by gently pulling back on the latch and removing the compartment door. Remove the old battery. Clip in the fresh 9 V battery and place it inside the battery compartment, then replace the battery door.

If the battery door is difficult to close, do not force it. Check that the battery, clip, and wires are seated properly inside the compartment and try again.

Using the Timer with two photogates can run down the battery quickly. Use the 9 V power supply instead.

The Console



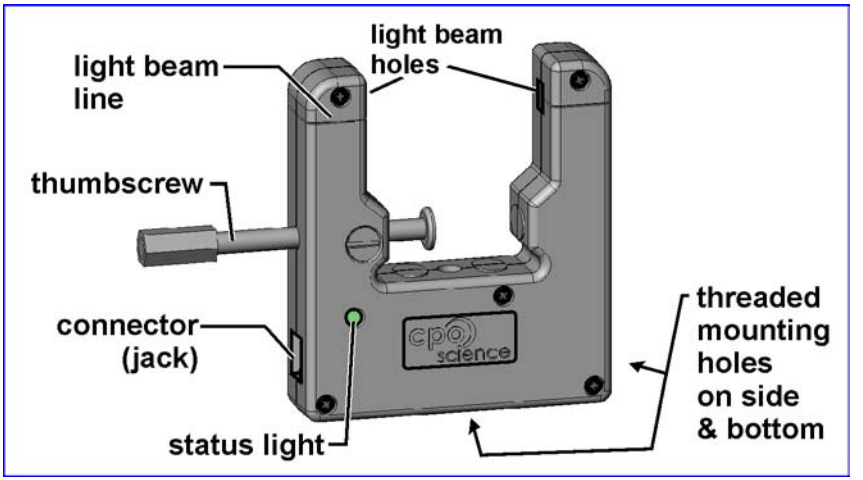
The five buttons control the Timer and the lights tell you what the Timer is measuring and displaying, and its units.

Pressing the mode switching button will change the mode from one of the five modes to the next one, moving left to right and stepping once for each time the button is pressed. The order is: *Interval-Frequency-Period-Stopwatch-Count*. After *Count*, the mode cycles back to *Interval*.

Table 2: *Timer Buttons and Indicators*

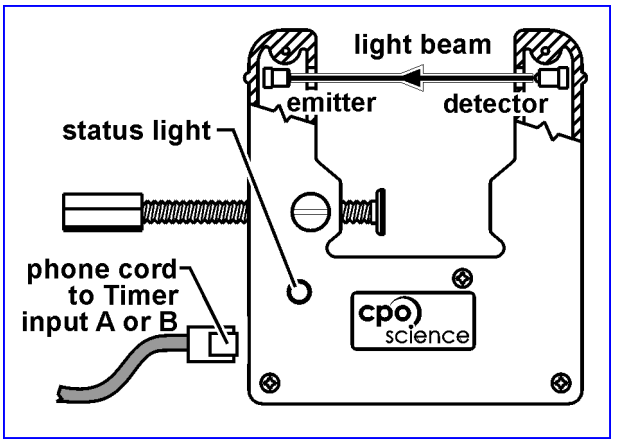
Feature	Function
Mode Button:	The mode button switches the Timer between its five different functions (or modes).
Mode Lights:	The five lights tell you which function the Timer is in.
“A” Button:	The “A” button switches the “A” light on and off, and starts and stops the stopwatch.
“A” Light:	The “A” light indicates what the Timer is displaying or doing relative to input A.
“B” Button:	The “B” button switches the “B” light on and off.
“B” Light	The “B” light indicates what the Timer is displaying or doing relative to input B.
The Reset (0.0) Button:	The reset button initializes the Timer back to zero, or begins a new measurement. It also erases any value in memory.
The Memory (M) Button:	The memory button allows you to display the previous time interval measurements in interval mode.

The Photogate



The photogate uses an invisible beam of infra-red light to start and stop the Timer. The photogates connect to inputs **A** and **B** with two telephone cords. When the photogate is working properly, the status light will be lit when the Timer is turned on. If there is nothing obstructing the light beam, the status light will be green. The status light changes to red when you interrupt the light beam. The Timer can work with either one or two photogates connected.

For convenience we refer to the photogate plugged into input **A** as photogate A. and the one connected to input **B** as photogate B. It does not matter which color wire you use. The wires are electrically identical and the different colors allow you to indentify quickly which is photogate A and which is photogate B.



The versatile C-clamp design allows the photogates to be used on many different experiments.

Overtightening the thumbscrew can flex the photogate body enough that the light emitter and reciever twist out of alignment, causing the photogate to malfunction. Loosening the screw will fix the problem.
ONLY TIGHTEN THE THUMBSCREW GENTLY.

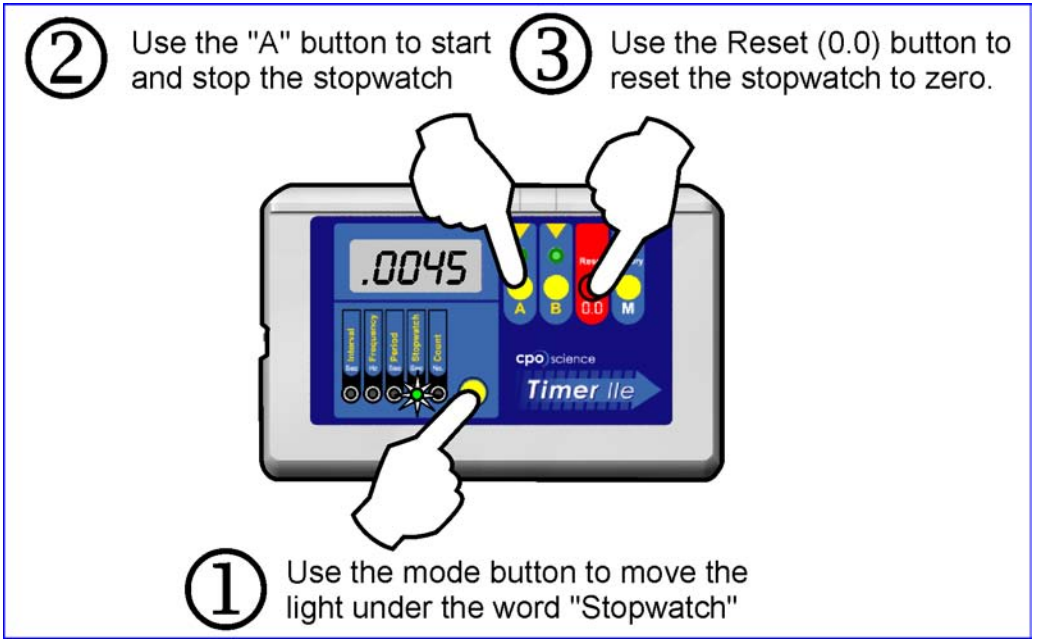
The photogates connect with ordinary telephone cords. You can get replacements (or longer ones) from almost any hardware or office supply store.

Computer data cables have the same (RJ-11) connectors and look like telephone cords but are wired differently inside.
USING A DATA CABLE WILL DAMAGE THE PHOTOGATES.

Stopwatch Mode

The Stopwatch function is the simplest of the different modes. In Stopwatch mode the Timer measures in seconds and is accurate to one hundredth (0.01) of a second from 0.01 to 59.99 seconds. After one minute the display switches to *minutes:seconds* format and the display is accurate to whole seconds. The stopwatch can measure times up to 199 minutes and 59 seconds (199:59)

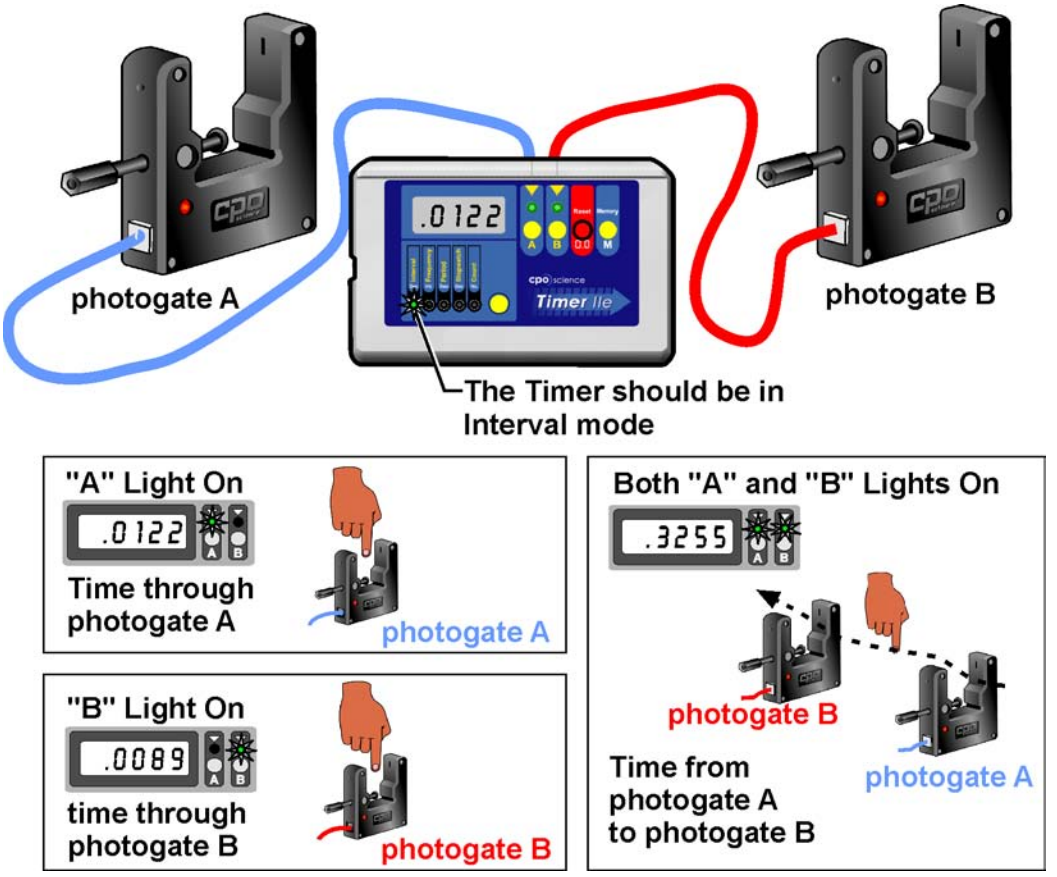
The diagram below shows the steps to using the stopwatch mode..



Interval Mode

In Interval mode, the Timer uses one or two photogates to electronically start and stop up to three stopwatches.

The time measurements are much more precise because the light beam can respond much faster than your finger. Using the photogates, the Timer can measure to one ten-thousandth (0.0001) of a second. The pictures below show how the two photogates can be connected and how the lights control the display of time measurements made with the three stopwatches.



Interval Mode Behaves like Three Stopwatches

The Timer in interval mode works like it has three stopwatches.

Stopwatch A starts when the light beam is broken in photogate A and stops when the light beam is unbroken again. *Stopwatch A measures the time interval during which the light beam is broken in photogate A.*

Stopwatch B starts when the light beam is broken in photogate B and stops when the beam is unbroken. *Stopwatch B measures the time interval during which the light beam is broken in photogate B.*

Stopwatch AB is controlled by both photogates. Breaking the beam in photogate A starts the stopwatch and breaking the beam in photogate B stops it. *Stopwatch AB measures the time interval between photogate A and photogate B.*

The Timer can use all **three stopwatches simultaneously,** allowing you to measure up to three time intervals at once. The lights (and buttons) allow you to choose which of the three stopwatches to show on the display.

The A and B lights do not have to be on for the Timer to record measurements.

The (A) and (B) **lights** and the (A) and (B) **buttons** control how the Timer displays the results from the three different stopwatches you can use. The buttons toggle the lights on and off. The lights tell you which of the three stopwatches is being displayed.

Try It With One Photogate

Connect a photogate to the input jack (socket) behind the (A) button using one of the telephone cords. You should see the status light on the photogate come on. Put the Timer into Interval mode by pressing the mode button until the Interval light comes on. Push the (A) button to turn on the (A) light. When the (A) light is on, the display shows measurements made with the photogate connected to input A.

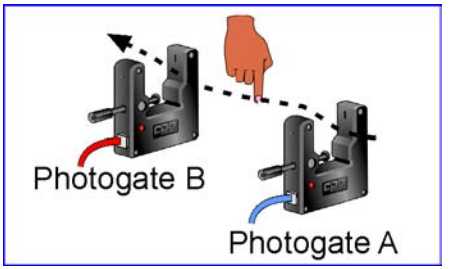
Put your finger across the light beam and watch what happens to the display. The display should start counting as soon as your finger breaks the beam and should stop as soon as you finger is removed from the beam. Once your finger is removed the display shows the time during which the beam was broken.

Note that when you break the light beam of the photogate with your finger the status light changes from green to red. When you remove your finger, the status light changes back to green.

Try It With Two Photogates

With both photogates connected you can measure the time it takes to pass between photogates A and B. The following demonstration shows how.

Set the Timer to Interval mode with two photogates connected. Use the A and B buttons to turn both the A and B lights on. Press reset to clear the Timer (be sure the light beams are not blocked when pressing reset).



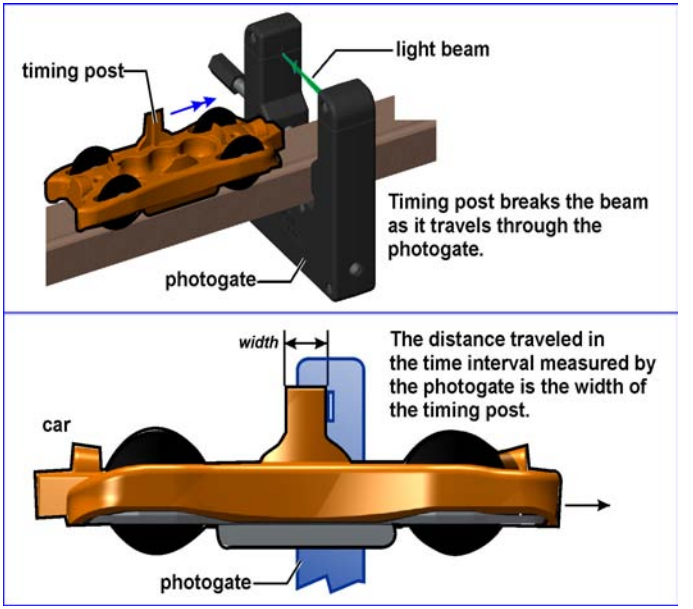
Pass your finger through photogate A first, then B. The display should start counting up the moment you break the beam in photogate A and stop when you break the beam in photogate B.

Measuring Speed and Acceleration

The Timer can be used in Interval mode to measure the speed of objects of a known size, such as a marble or a car with a “flag.” Ensure the full diameter of the ball or full width of the flag passes through the light beam.

In the case of the car: as the front edge of the flag breaks the light beam, the Timer begins the stopwatch for that photogate. The stopwatch is halted when the flag exits the beam. The average speed through the photogate can be calculated:

$$speed = \frac{distance}{time}$$



In this situation, the distance traveled is equal to the width of the flag, and the time is measured by the Timer. Just divide the width of the flag by the time recorded by the Timer for that photogate to get the speed. Don't forget to keep track of units.

Acceleration

To measure the acceleration of an object you can use two photogates.

$$acceleration = \frac{\Delta speed}{time} = \frac{speed_B - speed_A}{time}$$

The change in speed can be found by calculating the speed of the object at each photogate (as shown above) and taking the difference. The time between photogates is recorded by the Timer in Stopwatch AB. Remember to keep track of units.

Measuring Frequency

The Timer can measure the frequency of anything that breaks the light beams in the photogates regularly, or the frequency of signals applied to the inputs, such as from the Sound and Waves machine. The highest frequency that can be measured is 19,999 Hz and the lowest is 0.1 Hz. For very low frequencies (<100 Hz) it is more accurate to use period mode, measure the period (T) , and invert ($f = 1/T$).

Some other uses for frequency mode

Frequency mode can be used to measure:

- the angular speed of a rotating gear
- the frequency of a vibrating string
- the RPM of the CPO Science Electric Motor or Ripcord Generator

Measuring Period

The Timer can measure the period of signals which are connected to the inputs. The photogates can provide the signals (such as with the Pendulum) or the Sound and Waves experiment can provide the signals.

The Timer measures period in seconds and can measure the period of the signal in input A or the period of the signal in input B.

Period Updates Every Other Cycle

You will notice that the period only updates every *third time* the Pendulum crosses the light beam. This is because the Timer averages over two periods before updating the display. The averaging technique corrects for errors that occur when the photogate is not placed at the exact center of the swing.

A Pendulum Crosses Twice Per Cycle

You will also notice that the Timer measures the half period of the Pendulum. This is because the pendulum breaks the light beam twice per cycle. The Timer does not know it is "seeing" a pendulum; all it knows is the period of the breaking of the light beam.

Using Count

The Timer has a counting feature that counts whenever anything breaks the light beam, or sends a signal. There are two independent counters: A and B. The counters can each count up to 19,999. The Reset button has a double action for count mode. Pressing Reset once causes the counter to stop counting and freezes the display. This is useful for counting things within a fixed time interval. Pressing Reset again will reset the counter back to zero.

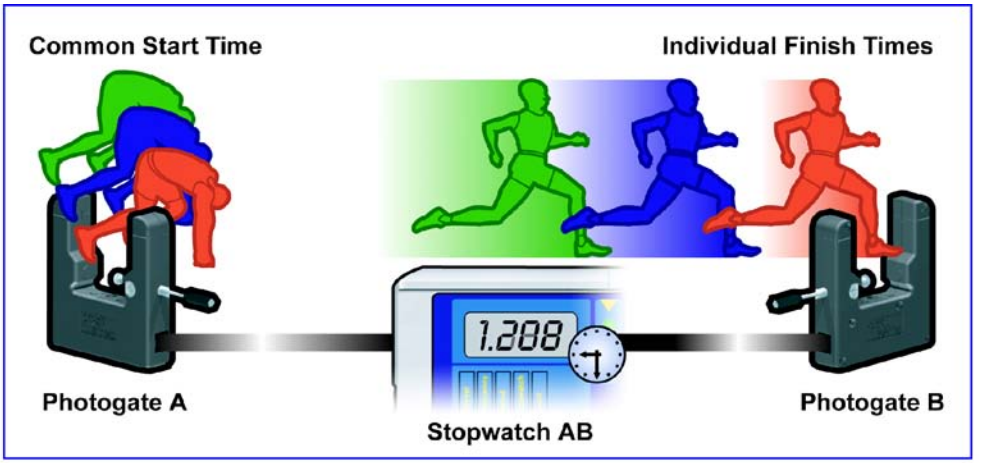
Advanced Functions: The Memory Button

You may have noticed that you do not have to press RESET to start a new time measurement. The Timer automatically resets each stopwatch as soon as something breaks the light beam again. If you do not press RESET, the Timer remembers the last time measurement for each of the three stopwatches (A, B, AB). Holding down the memory button lets you see the last values.

Make two successive measurements of the time through photogate A and then look at both. Holding down the memory button with the A light on shows the last value for the time through photogate A. Holding down the memory button with the B light on shows the last value for the time through photogate B. Holding down the memory button with both A and B lights on shows the last value for the time from photogate A to photogate B.

Advanced Functions: Timing Multiple A to B Events

The Timer can keep track of elapsed time from photogate A to photogate B where there may be multiple passes through photogate B. As long as there has been no reset, the A-to-B stopwatch will show the time between the last break of photogate A and the last break of photogate B. This means you can break photogate B multiple times and get increasing elapsed times between A and B. The analogy with a marathon race illustrates how this property of the Timer is useful. Everyone starts through photogate A at the same time. The Timer displays each individual runner's time as they pass through photogate B.



Chapter 4: Technical Information

The CPO Science Timer has the following technical specifications:

Time reference:	20 MHz quartz crystal, 0.4 microsecond internal resolution, 0.0001 second display resolution
Input voltage:	9 V DC/500 mA minimum (center tip positive)
Power source	Supplied 9 V DC power supply or 9 V battery
Sensor Inputs:	Two TTL falling edge triggered inputs using RJ-11 connectors
Interval:	Gate A, Gate B, and Interval A-to-B photogate timing with 0.0001 second resolution, three independent memories, and 19,999 second range
Frequency:	Dual channel plus frequency differences (A, B, A-B, B-A) to 19,999 Hz with 0.1 Hz resolution
Period:	Dual channel (A or B) period measurement to 19,999 seconds with bi-period averaging
Stopwatch:	0.01 second resolution to 59.99 seconds and 1 second resolution to 199 minutes, 59 seconds (199:59)
Count:	Dual channel (A or B) counters to 19,999 each channel
FCC Compliance:	This equipment has been tested and found to comply with the limits for a class A digital device, persuant to part 15 of the FCC rules. These rules are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. The equipment generages and uses radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications.

Power Sources

Using two photogates drains batteries quickly; two photogates in continuous use can drain a 9 V battery in just a few hours. It is better to use the AC adapter if you are using both photogates.

The first sign of a low battery is that the photogates will not work properly.

If the battery is low, the status light will not come back on after the light beam is unbroken. Either replace the battery with a fresh one or switch to using the AC adapter.

Troubleshooting

Table 3: *Troubleshooting the Timer*

Symptom	What to Do
Nothing happens when you slide the switch to the "On" position	Move the switch back and forth a few times. If you are using the battery, try using the AC adapter - you may need to replace the battery. If you are using the power supply, try using a battery - the outlet may not be working. Try the power supply from another Timer unit.
An error is displayed when using photogates	Press Reset after making sure all the light beams are unbroken and the status light is green for each photogate. Check the battery - a weak battery can cause errors. Sometimes bright lights or sunlight can trigger the detector. Try shading the photogate with your hand or repositioning it.

Technical Details: The Error Display

The error display is how the Timer signals that there has been a measurement fault. Different causes can create measurement faults in each of the five modes. In almost every case pressing RESET (with all light beams unbroken) will fix the problem. Sometimes new batteries are needed. In very few cases the measurement capacity of the Timer has been exceeded.

A disconnected photogate or low batteries are the most common faults. The Timer senses whether a photogate is connected by the presence of a light beam signal whenever the RESET button is pressed. **Pressing** RESET with the light beam blocked will cause a **fault**. The fault can be corrected by pressing RESET again with the light beam unblocked. It is possible (but highly unlikely) that the time interval exceeded the maximum of 19,999 seconds (5 hours, 33 minutes).

Frequency measurements are good up to 19,999 Hz. Higher frequencies will either generate an error (HI-F) or result in an erratic measurement.

Period measurements are limited to 19,999 seconds, after which the Timer will generate an error.

Stopwatch measurements are limited to 199 minutes and 59 seconds. Longer time intervals will result in an error.

The counter can only count up to 19,999, after which the Timer will give an error.

Software Updates and Website Information

You can find more information, such as answers to frequently asked questions and updates to documentation for the CPO Science Timer at the CPO Science Support website:

http://support.cpo.com/

You can also sign up at the website to receive email when updates become available.

Warranty Information

CPO Science warranties this instrument against defects in materials and workmanship for a period of one year. Repair and/or replacement parts can be obtained from CPO Science by sending the damaged or defective parts to:

CPO Science

26 Howley Street, 3rd Floor

Peabody, MA 01960

1-866-588-6951

support.cpo.com