



# User Manual and Instructions

## Model PET<sup>2</sup> - Programmable Event Timer

### Revision A

#### **System Overview**

The PET<sup>2</sup> provides a highly advanced and versatile dual-event timing control system targeted for rocketry applications. The design of the PET<sup>2</sup> utilizes a RISC microcontroller with a precise internal factory-calibrated 4MHz system clock for accurate and reliable event timing control. Each timer is fully independent, providing extremely flexible solutions for any timing application.

Just some of the applications that can be achieved with the PET<sup>2</sup> timer include:

- Precise booster separation and sustainer ignition of multi-stage composite powered rockets
- Ignition of secondary composite motors after primary motor ignition for airstarted boosts
- Fail safe backup and redundancy of primary rocket recovery control systems
- Triggering a camera shutter, audible/visual tracking device, or other electrical device at various stages of flight

#### **Specifications**

Arming Mode	G-switch	Test Current	80 $\mu$ a
Minimum G-load trigger	2.6 G's for 0.5 sec	Firing Current	1.25 A @ 0.5 sec.
Weight	33 grams / 1.6 oz.	Dimensions	1.38" W x 3.85" L
Battery	external 8-12 VDC	Nominal Battery load	15ma

#### **Handling Precautions**

*These units are sensitive to damage from ESD (electro-static discharge) and should always be handled in a properly grounded environment. ESD damage is not covered under your warranty.*

*Never directly handle the unit when it is armed and connected to live pyrotechnic charges as this may cause the premature detonation of the charges.*

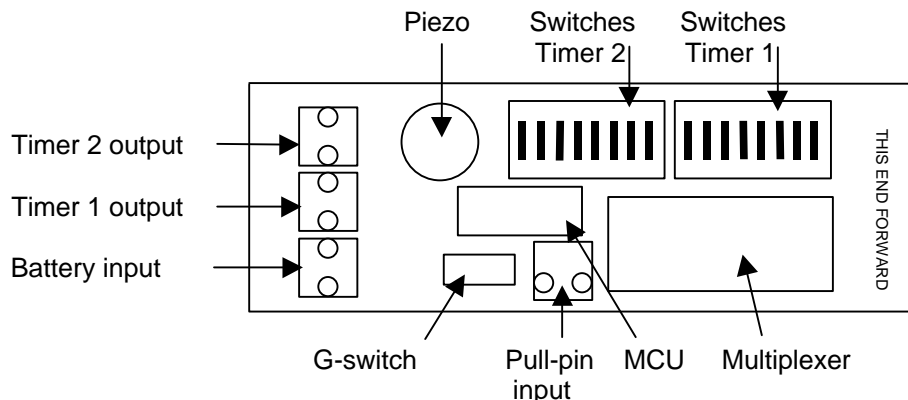
*Always allow the unit and the battery system to adjust to ambient temperature conditions prior to connecting, arming and flying.*

*Always prepare your rocket with the unit powered off. Never cycle the power switch off, then immediately back on. Always allow at least 10 seconds prior to restoring power.*

#### **Operational Overview**

Figure 1 depicts the general component layout of the PET<sup>2</sup> Programmable Event Timer. The unit is designed for several different modes of operation. Selection of these modes is made by the switches located on the circuit board.

**Figure 1 - General component layout of the PET<sup>2</sup>**



The switches are labeled 1 through 8 accordingly for each timer. The ON position for the switches is also labeled, indicated by a small arrow depicting the appropriate ON position. The following table describes the switch functions and the corresponding modes of operation. The timers are functionally identical, so the table applies to the setting for both timer events.

**Table 1 - Timer configuration switch settings**

Function	Switches/Positions				Mode of Operation	
Triggering mode selection	<u>SW. 1</u>		<u>SW. 2</u>		Trigger on G-switch Close event (initial G force detection) Trigger on G-switch Open event (deceleration) Trigger on Pull-pin event (break wire) Trigger on G-switch Close AND Pull-Pin event	
	Off	Off	Off	Off		
	On	Off	Off	Off		
	Off	On	Off	On		
Operating mode selection	<u>SW. 3</u>				Operates with a one-shot output (single output event) Operates with a repeated cycle (repeats at timing interval)	
	Off	Off	Off	Off		
Timing Range selection	<u>SW. 4</u>				Low timing range selected (0.5 - 8 sec. @ 0.5 sec. intervals) High timing range selected (2 - 32 sec @ 2 sec. intervals)	
	Off	Off	Off	Off		
Time Base Selection*	<u>SW. 5</u>	<u>SW. 6</u>	<u>SW. 7</u>	<u>SW. 8</u>	<u>Low (sec.) / High (sec.)</u>	
	Off	Off	Off	Off	0.5	2
	On	Off	Off	Off	1.0	4
	Off	On	Off	Off	1.5	6
	On	On	Off	Off	2.0	8
	Off	Off	On	Off	2.5	10
	On	Off	On	Off	3.0	12
	Off	On	On	Off	3.5	14
	On	On	On	Off	4.0	16
	Off	Off	Off	On	4.5	18
	On	Off	Off	On	5.0	20
	Off	On	Off	On	5.5	22
	On	On	Off	On	6.0	24
	Off	Off	On	On	6.5	26
	On	Off	On	On	7.0	28
	Off	On	On	On	7.5	30
On	On	On	On	8.0	32	

**\*Note: All timing values reflect the inclusion of the 0.5 second de-bounce timer (refer to G-switch close event).**

**IMPORTANT – All timer configuration switch settings MUST be made prior to powering up the unit. They are read at power up ONLY. Set ALL switch positions prior to turning the unit on.**

**Timer Functional Description**

Since the PET<sup>2</sup> provides a very flexible and versatile timing system, it's important that you fully understand how it functions. The following describes the functional timing operations of the PET<sup>2</sup>.

**Timer Triggering Modes**

There are (4) distinct modes of triggering available on the PET<sup>2</sup>. Each timer can independently select any of the triggering modes:

- **G-switch Close event** - The onboard G-switch will close when the rocket vehicle reaches at least 2.6 G's of acceleration. This acceleration level must be maintained continuously for 0.5 seconds in order to qualify as a valid close event and signify the launch of the rocket vehicle. This 0.5-second interval is referred to as a "de-bounce" time interval. The de-bounce is intended to filter out any inadvertent movement after arming that might accidentally trigger the unit. The primary use for G-switch Close event is to detect the initial launch of the rocket.

- **G-switch Open event** - The G-switch open-event will occur *after* the initial close event when the rocket vehicle drops below 2.6 G's of acceleration. The open event *must* be preceded by a valid G-switch close event (de-bounce time period of 0.5 seconds). Once the close event conditions have been met, the open event trigger occurs on the first open transition of the G-switch. The primary use of the G-switch open event is to detect rocket motor burnout.
- **Pull-pin event** - The Pull-pin trigger works physically on a breakwire circuit, so when the input transitions to an open circuit the timer will start. The PET<sup>2</sup> applies the same de-bounce time period of 0.5 seconds to the Pull-pin input as well. The inputs must maintain a continuous open circuit for 0.5 seconds. The primary use for the Pull-pin inputs are for low thrust flights where the minimum 2.6G's are not attained at launch, or possibly for triggering after airframe body components have separated from one another (for instance at parachute ejection). In addition, the Pull-pin functions as a convenient trigger for bench testing and verification.

**IMPORTANT: If Pull-pin triggering has been selected, the Pull-pin inputs MUST BE CLOSED prior to powering up the PET<sup>2</sup>. If the unit detects an open circuit at power up, the PET<sup>2</sup> will enter the Pull-pin Alarm Lockout Mode and WILL NOT FUNCTION. The Pull-Pin Alarm is indicated by a long, slow 0.5 second chirp rate. The unit must be powered off and the Pull-pin inputs must be corrected prior to flight of the unit.**

- **G-switch Close AND Pull-pin event** - This trigger event functions the same as the normal G-switch Close event, the exception being that it must happen in conjunction with the Pull-pin input trigger. Both conditions must be met simultaneously and satisfy the de-bounce timer period of 0.5 seconds. The same Pull-pin Alarm condition applies to this trigger mode as well. When using this mode, the Pull-pin input can act as a "safety" switch, as no trigger is possible despite the status of the G-switch. This mode could also be used to inhibit the G-switch Close event until proper conditions are met.

#### ***Timer Operating Modes***

There are (2) distinct timer operating modes available on the PET<sup>2</sup>. Each timer can independently select and operate in either of these two modes:

- **One Shot Operation** - This mode functions as the name implies. There is a single one time firing event of the timer output after the expiration of the selected time delay. The duration of the timer output event is 0.5 seconds. Use this mode for staging or airstarting motors, ejection charges, or other single output event needs
- **Repeat Interval Operation** - This mode operates identical to One Shot Operation, the exception being that after firing the timer output, the unit restarts the time delay and repeats the timing/firing process continuously as long as power is applied to the unit. The 0.5 second duration output event period is the same time as the initial de-bounce timer period, thus the unit can maintain repeat timing intervals identical to the initial timing interval that was compensated with the de-bounce timer. A typical use for Repeat Interval mode could be driving a camera shutter, a flasher device, or beeper device.

The shortest repeat period that can be selected is 1 second (0.5 second output period + 0.5 second delay). When the timer is set for a 0.5 second duration in Repeat Interval mode, it is automatically overridden with a 1 second period setting.

#### ***Timer Range Selection***

There are (2) timing ranges available on the PET<sup>2</sup>. Again, each timer can independently select and operate in either of these two ranges:

- **Low Timing Range** - The low timing range enables you to program the time base for short duration periods between 0.5 and 8 seconds. The timing increments in low range mode are 0.5 seconds each. Typical applications of shorter duration timing events would be staging or clustering events.
- **High Timing Range** - The high timing range enables you to program the time base for long duration periods between 2 and 32 seconds. The timing increments in high range mode are 2 seconds each. Typical applications of long durations timing events would be recovery system backup deployment of drogue or main parachutes.

#### ***Time Base Selection***

Depending on the setting of the Timer Range switch (low or high), the Time Base Selection switches can specify delays from 0.5 - 8 seconds or 2 - 32 seconds. The delay times specified Table 1 *include* the de-bounce time of 0.5 seconds. Refer to Table 1 for the proper time base settings.

## **Modes of Operation**

The PET<sup>2</sup> has several distinct modes throughout the course of its normal operation. These modes of operation are easily identified by the piezo beeper.

### ***Power-up annunciation***

After initially powering on the PET<sup>2</sup> unit, it will annunciate (beep) a continuous tone for 3 seconds. During this annunciation period, you can transition switch position 1 on either of the timer DIP switches to enter the input testing mode (refer to the Input Test Diagnostics description).

### ***Pre-launch state***

After the power-up annunciation, the unit enters the pre-launch mode. While in this mode, the unit will continuously chirp out the continuity status of the timer outputs (at a rapid rate) once per second as follows:

- Beep                                      Powered on / No continuity on Timer 1 or Timer 2 outputs
- Beep Beep                                Powered on / Continuity on Timer 1 output / No Continuity on Timer 2 output
- Beep Pause Beep                        Powered on / No Continuity on Timer 1 output / Continuity on Timer 2 output
- Beep Beep Beep                         Powered on / Continuity on Timer 1 and Timer 2 outputs

The unit also monitors the selected triggering source(s) as selected. After any triggering condition has been met, the timer transitions into Countdown state.

### ***Countdown state***

Once triggered, the timer enters countdown state. The piezo chirps at a very fast rate (10 chirps per second). The countdown state remains active until both timing events have completed their initial timing cycle. After this the unit transitions to Post Event state.

### ***Post Event state***

At this point, the PET<sup>2</sup> has completed the initial countdown of both timer events. The piezo will chirp out the continuity status of the timer outputs (at a slower rate) once per second in the same fashion as pre-launch state.

## **Input Test Diagnostics**

The unit can also be placed into a test mode to verify the basic operation of the DIP switch inputs and Multiplexer. To place the unit into input test mode, toggle SW. 1 of either timer's DIP switches during the power up annunciation period. The unit will continue to operate in the test mode until it is powered off.

**IMPORTANT: After selecting input test mode, you must power off the unit prior to flight or additional testing.**

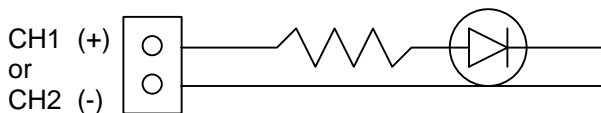
Once the input test mode is selected, the unit will read each switch in numerical order (1 through 8) and chirp out a "zero" chirp (long beep) for a switch in the OFF position, or a "one" chirp (short beep) for the ON position. After it has read all eight switches, it will pause for 2 seconds and restart the test. You can change the switches during this test to ensure that all the configuration switches are being read correctly by the MCU.

### **Timer Bench Testing**

It is recommended you become familiar with the operational characteristics of the PET<sup>2</sup> by doing some bench test operations. The timer can be easily triggered by use of the pull-pin trigger (breakwire). You can then verify the selected timing intervals and/or timing operation.

In addition it's a good idea to periodically test the timer output channels to ensure they are functional. A useful accessory for testing the outputs are 12 volt DC panel lamps. The lamps will allow you to verify the proper operation of the outputs without the use of pyrotechnic devices. An LED with a current limiting resistor can be used in place of a lamp; however, you have to observe the diode polarity when connecting to the output terminals. A 470 ohm resistor is suggested when using an LED. Connect the LED for output testing as depicted in Figure 2.

**Figure 2 - Output Test connections with LED**



**Wiring / Mounting Considerations**

There are several factors to consider when it comes to the construction, mounting, wiring and arrangement of the PET<sup>2</sup> in your rocket airframe. Careful planning during the construction and preparation of your rocket will improve your chances for successful operation.

**IMPORTANT: Always load test your battery system prior to flight to ensure adequate power for reliable operation and ignition of the output events.**

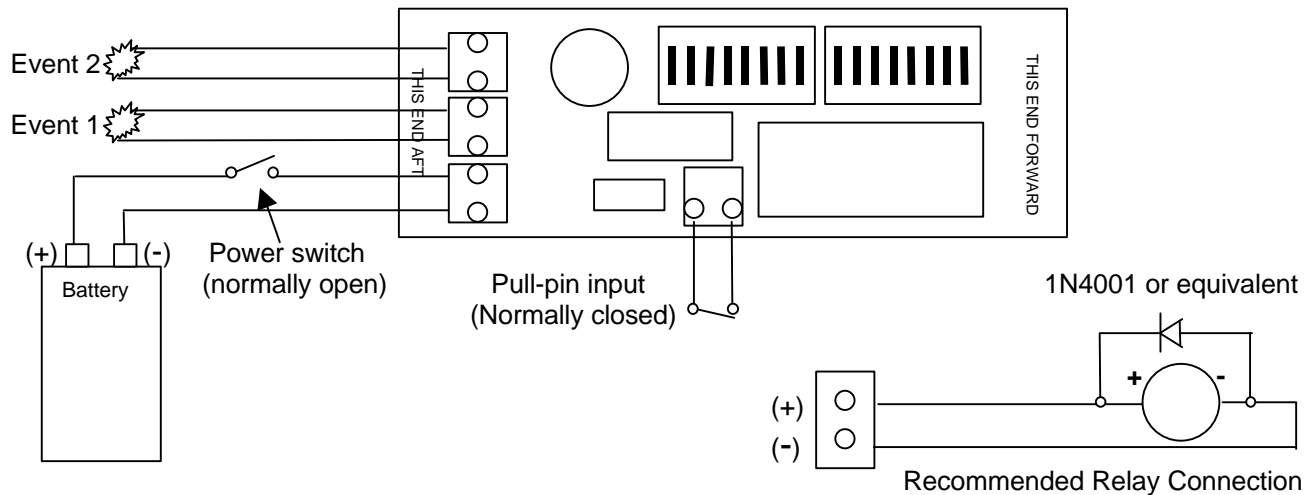
To load test a battery, you will require a DC multimeter capable of DC Amp measurement with 10 Amp capability. A 9-volt battery can easily source in excess of 5 Amps. Briefly connect the meter leads across the battery terminals to measure the DC current capacity. If the measurement is close to or drops below 2 Amps, do not use the battery. Some batteries have built in testers; however, it is still recommended that a meter be used for testing.

**Battery Considerations**

Though the unit is intended to operate with a standard 9-volt alkaline battery, the user may elect to power the PET<sup>2</sup> with a different battery source. The voltage requirements for the PET<sup>2</sup> battery source is 8 to 12 Volts. **DO NOT EXCEED 12 VOLTS OR DROP BELOW 8 VOLTS.** Nominal load during operation is about 15 ma; and during output firing, the unit requires upwards of 2 Amps. **ALWAYS PAY CLOSE ATTENTION TO THE BATTERY POLARITY (+ AND -) WHILE CONNECTING YOUR WIRING TO THE PET<sup>2</sup>.** If you're driving an external relay with the PET<sup>2</sup>, an external diode across the relay coil is recommended as shown in Figure 3 to protect against inductive load transients.

**IMPORTANT: Inadequate sizing of an external battery system can damage the unit or cause the unit to malfunction. Always pre-test your battery system design prior to launch.**

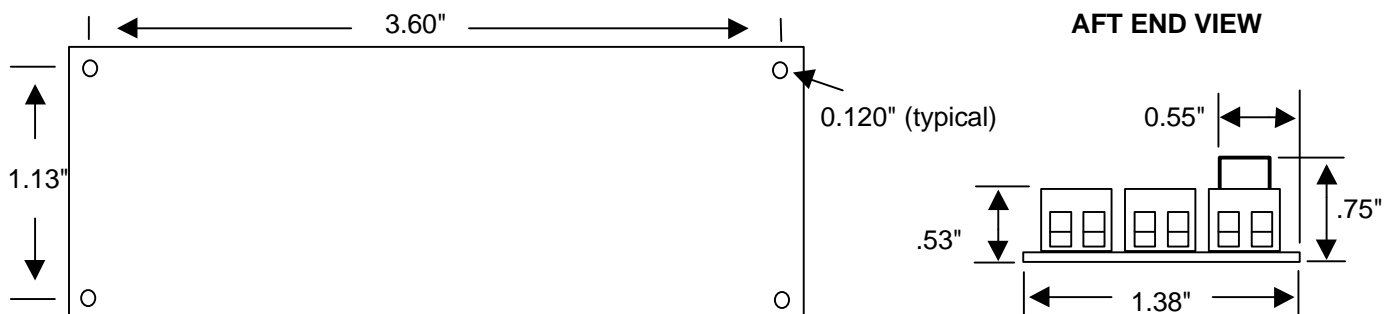
**Figure 3 - Standard Wiring and Relay Drive Connections**



**Mounting Considerations**

The PET<sup>2</sup> can be mounted with standard #4 screw hardware. Ensure that it is mounted securely to a rigid component of the rocket airframe. The mounting hole pattern is shown in Figure 4:

**Figure 4 - Mounting hole pattern and clearance requirements**



**IMPORTANT:** Please note the orientation of the PET<sup>2</sup> in the rocket airframe. The PET<sup>2</sup> has a Forward End and Aft End marked clearly on the top side of the circuit board. You must orient the Forward End of the PET<sup>2</sup> TOWARD THE NOSE of the rocket. Also ensure that the PET<sup>2</sup> is mounted parallel to the center axis of the rocket. Failure to mount the unit as described will prevent the onboard G-switch from operating properly.

**E-matches and Igniters**

The topic of e-matches and igniters is often overlooked and not given a proper evaluation. Improper selection or improper application of e-matches and igniters can result in failure of the timing events and potentially result in damage or loss to your rocket

**IMPORTANT:** Always ground test the type of e-match or igniter you'll be using under actual flight conditions prior to committing to flight.

Improper selection of an e-match or igniter will result in a malfunction. Always use an e-match that is suited for the test and firing conditions of the RRC<sup>2</sup> unit (e.g., do not use a high current device).

Always check your e-match, igniter, or flash bulb devices for continuity and proper resistance prior to using them under testing or actual flight conditions.

***Selecting an adequate E-match***

The PET<sup>2</sup> has been tested and flown with several commercially available e-matches. The PET<sup>2</sup> was also tested with a cluster of (4) Oxral Ematches in parallel. When selecting an e-match supplier, refer to the "Specifications" section for the typical test current and firing current of the PET<sup>2</sup> to ensure the device you'll be using can be used reliably. Refer to Table 3 for adequate commercial e-match suppliers for the PET<sup>2</sup>.






**Table 3 - Recommended E-match suppliers**

Daveyfire Inc.	OXRAL Inc. (Luna-Tech)
7311 Greenhaven Dr, Suite 100 Sacramento, CA 95831-3572 Tel: 916.391.2674 Fax: 916.391.2783	PO Box 160 Owens Cross Roads, AL 35763 Tel: 205.725.4226 Fax: 205.725.4811

Model	Resistance	Test Current	Firing Current	Wire Color
Daveyfire 28B	1.6 ± 0.3 ohms	20 ma (0.020 Amp) max	370 ma (0.37 Amps) min	White
Daveyfire 28BR	1.6 ± 0.3 ohms	20 ma (0.020 Amp) max	370 ma (0.37 Amps) min	Orange
Daveyfire 28F	1.6 ± 0.3 ohms	20 ma (0.020 Amp) max	1.00 Amp min	Black
Oxral	2 ohms (nominal)	25 ma (0.025 Amp) max	500 ma (0.5 Amp) min	Red/Blue

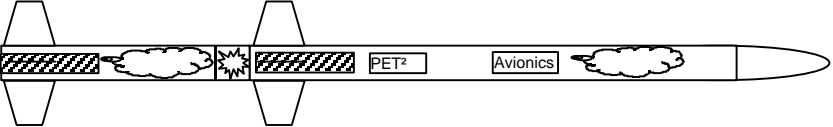
**Example Applications with the PET<sup>2</sup>**



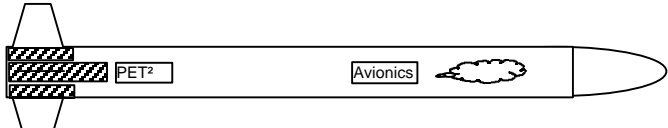
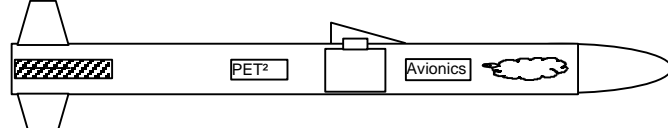
The following examples are just some of the possibilities that can be achieved through application of the PET<sup>2</sup>.

<b>Symbol Legend</b>	
 Motor	 PET <sup>2</sup>
 Separation charge	 Parachute
	 Avionics
	Altimeter/Accelerometer

*\*NOTE: Refer to the Timer Functional Description on pages 2 & 3 for a detailed explanation of the PET<sup>2</sup> operations and switch settings.*

<b>Basic 2-stage rocket</b>	<b>Suggested Timer Setup*</b>
(1) PET <sup>2</sup> in sustainer	<u>Timer1:</u> G-switch OPEN trigger / One shot / Low Range / 0.5 sec. Use for booster separation charge
Booster ignition via launch system	
Booster recovery via motor ejection	
Sustainer separation/ignition via PET <sup>2</sup>	<u>Timer2:</u> G-switch OPEN trigger* / One shot / Low Range / 0.5 sec. Use for sustainer motor ignition
Sustainer recovery via motor/avionics	



<p><b>Advanced 2-stage rocket</b></p> <p>(1) PET<sup>2</sup> in booster (1) PET<sup>2</sup> in sustainer</p> <p>Booster ignition via launch system Booster recovery via PET<sup>2</sup> Sustainer separation via PET<sup>2</sup> Sustainer ignition via PET<sup>2</sup> Sustainer recovery via avionics Recovery Backup via PET<sup>2</sup></p>	<p><b>Suggested Timer Setup*</b></p> <p><u>Booster Timer 1:</u> G-switch OPEN trigger / One shot / Low Range / 0.5 sec. Use for booster separation charge</p> <p><u>Booster Timer 2:</u> G-switch OPEN trigger / One shot / Low Range / 2 sec. Eject booster recovery system 2 seconds after booster shutdown</p> <p><u>Sustainer Timer 1:</u> G-switch OPEN trigger / One shot / Low Range / 0.5 sec. Use for sustainer motor ignition</p> <p><u>Sustainer Timer 2:</u> G-switch OPEN trigger / One shot / High Range / 20 sec. Use for sustainer recovery system backup</p> 
<p><b>2 stage rocket with Airstart Boosters</b></p> <p>(1) PET<sup>2</sup> in booster (1) PET<sup>2</sup> in sustainer</p> <p>Main booster ignition via launch system Outboard booster ignition via PET<sup>2</sup> Booster recovery via PET<sup>2</sup> Sustainer separation/ignition via PET<sup>2</sup> Sustainer recovery via motor/avionics</p>	<p><b>Suggested Timer Setup*</b></p> <p><u>Booster Timer 1:</u> G-switch CLOSE trigger / One shot / Low Range / 1 sec. Ignites outboard booster motors 1 sec. into main motor burn</p> <p><u>Booster Timer 2:</u> G-switch OPEN trigger / One shot / Low Range / 2 sec. Eject booster recovery system 2 seconds after booster shutdown</p> <p><u>Sustainer Timer 1:</u> G-switch OPEN trigger / One shot / Low Range / 0.5 sec. Use for booster separation charge</p> <p><u>Sustainer Timer 2:</u> G-switch OPEN trigger / One shot / Low Range / 0.5 sec. Use for sustainer motor ignition</p> 
<p><b>Advanced 2 cluster Airstart rocket</b></p> <p>(1) PET<sup>2</sup> in rocket</p> <p>Main motor ignition via launch system 1<sup>st</sup> cluster ignition via PET<sup>2</sup> 2<sup>nd</sup> cluster ignition via PET<sup>2</sup> Recovery via avionics</p>	<p><b>Suggested Timer Setup*</b></p> <p><u>Timer 1:</u> G-switch CLOSE trigger / One shot / Low Range / 1 sec. Ignites 1<sup>st</sup> cluster booster motors 1 sec. into main motor burn</p> <p><u>Timer 2:</u> G-switch OPEN trigger / One shot / Low Range / 0.5 sec. Ignites 2<sup>nd</sup> cluster booster motors after booster/1<sup>st</sup> cluster shutdown</p> 
<p><b>Camera rocket with sonic locator</b></p> <p>(1) PET<sup>2</sup> in rocket</p> <p>Main motor ignition via launch system Timer 1 drives camera shutter Timer 2 drives sonic locator Recovery via avionics</p>	<p><b>Suggested Timer Setup*</b></p> <p><u>Timer 1:</u> G-switch CLOSE trigger / Repeat / Low Range / 1 sec. Drives camera shutter at 1 sec intervals</p> <p><u>Timer 2:</u> Pull-pin trigger / Repeat / Low Range / 2 sec. Drives high decibel piezo horn / trigger at recovery separation event</p> 

### **Product Warranty**

Missile Works Corporation has exercised reasonable care in the design and manufacture of this product and warrants the original purchaser that the PET<sup>2</sup> Programmable Event Timer is free of defects and will operate at a satisfactory level of performance for a period of one year from the original date of purchase. If the system fails to operate as specified, then return the unit (or units) within the warranty period for repair or replacement (at our discretion). The system must be returned by the original purchaser and be free of modification or any other physical damage which renders the system inoperable. Upon repair or replacement of the unit, Missile Works Corporation will return the unit postage paid, to the original purchaser.

### **Product Disclaimer and Limit of Liability**

Because the use and application of this equipment are beyond our control, the purchaser or user agrees to hold harmless Missile Works Corporation and their agents from any and all claims, demands, actions, debts, liabilities, judgements, costs, and attorney fees arising out of, claimed on account of, or in any manner predicated upon loss or damage to property of, or injuries to or the death of, any and all persons arising out of the use this equipment. Due to the nature of electronic devices, the application and environments for those devices, the possibility of failure can never be totally ruled out. It is the responsibility of the purchaser or user of this equipment to properly test and simulate the actual conditions under which the device is intended to be used to ensure the highest degree of reliability and success.

### **Rules to live and fly by**

1. Before you use the PET<sup>2</sup> Programmable Event Timer, make sure you have read and understand all the instructions, operations, and warnings contained herein.
2. Do not alter the system in any way, as this voids the warranty and could render the system inoperable or unreliable.
3. Always fly within the guidelines established by either the National Association of Rocketry or the Tripoli Rocketry Association whenever you participate in hobby rocketry activities.

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