

# PSC Handheld Launch Controller

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## Introduction

A few years ago, my Flying I-Beam teammates, Rod Schafer and Steve Foster, asked me if I could come up with a handheld launch controller that could be used for FAI contest events. It needed to be compact and rugged enough to withstand the rigors of international travel yet still deliver a knockout punch to the igniter when the Launch pushbutton is pressed. Now without a doubt there are various commercially available controllers that could do the job, but I thought this assignment might make for an interesting departure from my usual projects. So, I agreed to their request.

History shows that homebrew launch controllers are quite diverse, often reflecting the very personal tastes, preferences, and features that are considered “cool” by the operator. But other than cosmetic and economic considerations, there’s really no new science here - at the end of the day, most launch controllers provide for a minimum set of requirements: a power source that can rapidly heat an igniter, and a set of mechanisms to disable or safe the system, to indicate whether the firing circuit is electrically continuous, and to close the ignition circuit.

The handheld controller described in this article is no different. It is decidedly “uncool”, avoiding things like processors, software and any functional feature beyond the minimum requirements. Instead, its design focuses on ruggedness, portability, and the electrical ability to deliver sure heating power to an igniter. In this article, I’d like to share with you the details of this simple controller.

## Requirements, Revisited

Within the NAR’s Model Rocket Safety Code there are four requirements captured in two points that affect the design and operation of a model rocket launch controller:

- *"My launch system will have a safety interlock in series with the launch switch and will use a launch switch that returns to the "off" position when released."*
- *"Ensure that everyone is ... a safe distance of at least 15 feet away when I launch rockets with D motors or smaller, and 30 feet when I launch larger rockets."*

The NAR safety code doesn’t specify or restrict the type of ignition power source or its location, nor does it say anything about any pre-launch ignition circuit validation. Of note is the last requirement, the safe distance of operation - it uses the word “**everyone**”, so we must assume that “everyone” includes the launch operator as well. Thus, meeting this requirement means there must be an impulse-dependent distance of separation maintained between the launch operator and the model at launch. This would be air space in the case of a wireless control system, or a cable of the minimum prescribed length fully played out in the case of a hard-wired system.

## Design Synthesis

Our handheld launch control system must take these minimum requirements into its design. But practical operating experience shows there is value in having a mechanism that indicates firing circuit continuity, so we'll add this feature to our system even though it's not an NAR requirement.

To keep the controller simple and easy to operate, we'll incorporate just four control and indication appliances:

- **Power Indicator.** This indicator will illuminate **RED** when system power is active.
- **Continuity Indicator.** This indicator will illuminate **GREEN** when the internal continuity circuit detects a closed electrical path through to the igniter.
- **Power Switch.** This key switch embodies the NAR's "safety interlock" requirement and connects the internal power source when turned to the ON position. The safety key will be removable only in the "OFF" position.
- **Launch Pushbutton.** When pressed, this momentary ON pushbutton closes the ignition circuit, applying power to the model rocket's igniter(s).

To realize the NAR's safe distance of operation requirement we'll connect the control unit to a model rocket by way of a 30' 16AWG Igniter Extension Cable and a pair of copper micro clips. This will allow the unit to be safely used up to 'G' impulse. That just leaves the decision for the ignition power source.

## Sizing the Ignition Battery

The most obvious approach is "How big of a battery will fit in the controller case?" And that's not an unreasonable consideration, but perhaps we can precise this a bit, as the French would say. To be effective, the power source must be able to sustain a current level high enough, and long enough, to heat the igniter's bridge wire to a temperature that will ignite the initiator compound enclosing the bridge wire<sup>1</sup>. This is a heat generation and transfer problem, and we can take advantage of a pair of excellent papers that characterize the energy needed to fire a typical (Estes) model rocket igniter.

In 2000, Robert Briody<sup>2</sup> examined the energy requirements of several different igniter types. Using a fully charged 12V/7Ah Gel Cell (13.04V) and short 16AWG stranded copper wire connections to the Igniter Under Test, he showed in a relatively unconstrained current environment that a typical Estes igniter (Briody, Page 7, Figure 11) would fire with a relatively short duration, high current pulse. Specifically, Robert's test captured

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<sup>1</sup> Estes Paper "Igniters and Their Use" specifies that a temperature greater than 282°C is needed to ignite their black powder propellant. Note that the energy needed to produce this temperature can vary depending on initiator composition.

[https://www.discountrocketry.com/media/model\\_rocket\\_educational\\_resources/pdf\\_files/Model%20Rocket%20Igniter%20Use.pdf](https://www.discountrocketry.com/media/model_rocket_educational_resources/pdf_files/Model%20Rocket%20Igniter%20Use.pdf)

<sup>2</sup> "Electrical Current Requirements of Model Rocket Igniters" by Robert Briody, 2000  
<https://www.privatedata.com/byb/rocketry/ignitor/igniters.pdf>

an almost rectangular current pulse of 30.4ms duration, with an initial peak of 12.39A, declining only slightly to approximately 11.56A immediately before the igniter bridge opened. Treating the decline as essentially a linear slope gives the pulse an average current level of approximately 11.98A. At first blush, using the battery's stated 13.04V open-circuit voltage, we can calculate an upper-bound estimate of the energy supplied by the battery during the firing event:  $13.04\text{V} \times 11.98\text{A} \times 0.0304\text{s} = \mathbf{4.75J}$ . However, some portion of that energy would have been dissipated elsewhere in the firing circuit (wires, relay contact), including approximately 0.65J in Robert's  $0.15\Omega$  current-sensing resistor, so the energy actually dissipated by the igniter itself would have been something less. Keep in mind that Robert didn't record the battery's loaded terminal voltage or the voltage directly across the igniter during the firing event. Thus, while his experiment gives us an excellent picture of the firing current pulse and its duration, it doesn't allow us to accurately determine the energy dissipated specifically in the igniter.

In a second paper, John Lyngdal<sup>3</sup> reports controlled current tests that provide a more direct measure of firing energy. His tests produced mean firing energies of approximately **4.6J at 6A, 3.1J at 12A, and 3.1J at 20A**<sup>4</sup>. Thus, for our battery capacity sizing purposes, we'll assume that a robust **5J** represents a reasonable nominal energy budget for firing a single Estes-type igniter, recognizing that actual requirements will vary with the igniter and firing circuit characteristics.

Let's now return to the question of battery size.

We know that the typical Estes igniter has a cold average resistance of about  $0.7\Omega$ <sup>5</sup>, and the controller's actual measured total loop resistance (minus the igniter) is  $0.311\Omega$ <sup>6</sup>. So, we can expect a total system resistance of about  $1\Omega$ . For calculation purposes we'll be a little conservative – clips get dirty, switch contacts pit over time, etc, so we'll take a total loop resistance assumption of about  $1.3\Omega$ . This means that a conservative estimate of initial firing current will be in the area of  $11.1\text{V}/1.3\Omega = 8.5\text{A}$ , assuming a 3S LiPo battery.

So - what does this all mean in terms of battery sizing? Well, perhaps the question to ask here is how many igniters do we plan to fire between battery charges? Let's say it's our practice to recharge our battery between successive contests. So really the question is how many igniters will we fire during the launch day? For the typical contest event, this might be just a handful of flights, not really something that would stress the system. However, since one of our key design goals is robustness, let's imagine we want to use the controller to support something like a club launch; then a busy day might be 200 igniters. Let's double that to include an operational capacity margin – 400 firings. We'll use 5J as our nominal single-igniter firing-energy estimate, then double that figure to 10J per firing to conservatively allow for circuit losses, igniter variation, dirty clips, and other real-world inefficiencies.

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<sup>3</sup> "Igniter Performance and its Dependence on Firing Current" by John Lyngdal, 2012  
[https://www.apogeerockets.com/education/downloads/Q2G2\\_Igniter\\_Report.pdf](https://www.apogeerockets.com/education/downloads/Q2G2_Igniter_Report.pdf)

<sup>4</sup> Lyngdal, Page 17

<sup>5</sup>  $\sim 0.655\Omega$ , Lyngdal, Page 16, and  $\sim 0.711\Omega$ , "Estes Igniter Specifications"  
[https://www.apogeerockets.com/Rocket\\_Motors/Estes\\_Accessories/Estes\\_Starter\\_6pk](https://www.apogeerockets.com/Rocket_Motors/Estes_Accessories/Estes_Starter_6pk).  
Note that Estes igniters are specified with a range of  $0.5\Omega - 2\Omega$ .

<sup>6</sup> Measurements performed with a 4-wire digital milliohm meter in the Author's shop.

Thus –

$$10\text{J} \times 400 \text{ firings} = 4000\text{J}$$

$$4000\text{J}/(3600\text{s/h}) = 1.11\text{Wh}$$

At a nominal 3S voltage of 11.1V, we get  $1.11\text{Wh}/11.1\text{V} = 0.1\text{Ahr}$ , or 100mAh

Since we don't wish to fully discharge the battery by the end of a launch session, we'll double this theoretical capacity to 200mAh. That really doesn't sound like much, although with a conservative firing current of 8.5A, the battery would need a discharge rating of at least 42.5C.

Unfortunately, we'll find that the market doesn't offer very many 3S batteries in this range, or with the connectorization needed to handle such a discharge rate. Plus, there are follow-on considerations, like voltage sag in such a small battery, and heat buildup if the duty cycle is too rapid. So, while our energy calculation might suggest that a 3S 200mAh battery could theoretically satisfy the launch-day requirement, energy capacity alone won't determine a suitable battery; peak-current capability, voltage sag, connector capacity and practical availability are equally important considerations. We should more properly consider a battery with an XT30 or XT60 connector, or a Deans Ultra Plug, something that can handle large burst-like discharge currents. That requirement points us toward the larger 3S packs commonly supplied with higher-current connectors. Accordingly, for our project, we'll use a 3S 2200mAh/75C LiPo battery, which is far more capacity than our energy calculation suggests and will easily provide the current capability we need. And, as it turns out, it's also the largest battery that will fit inside the handheld case we've selected.

So - with our key design requirements and decisions set, let's get the design and fabrication of our handheld launch controller underway.

## Circuit Design

Figure 1 illustrates the schematic for our Single Pad Launch Controller. A 10A auto-resetting thermal circuit breaker provides a measure of short circuit protection. The Safety Key Switch is a DPST switch with the Safety key removable only in the "OFF" position. The Power ON indicator is a high-brightness **RED** LED, and the circuit provides an option to shunt the current limiting resistor in the event the LED is replaced by an indicator that includes its own integral current limiting resistor.

The Continuity Check circuit uses a bipolar PNP transistor to control the continuity-check current. The resistor values have been selected to limit the continuity-check current to a nominal 2.36mA when a complete path through the igniter is present; this check current level is safe for most commonly used model rocket igniters. The check current will flow as soon as the micro-clips are connected and there is a continuous electrical path for the circuit. The completed check circuit causes the high-brightness **GREEN** Continuity indicator to illuminate. **The handheld control unit does not need to be turned on to check for continuity.**

Finally, at the other end of the circuit is the Igniter Extension Cable. This 30', 16AWG two-conductor cable provides the connection to the model rocket igniter(s) at the pad and does so at the maximum NAR safe distance of operation.



## Fabrication

Some internet searching brought us to Amazon, where we happily found the handheld enclosure needed for the project. Measuring 6.2"L x 3.5"W x 2.375"H, the two-part IP65 ABS plastic enclosure is the perfect size. The enclosure's bottom includes molded standoffs for mounting a false floor; this feature ensures that all internal component mounting hardware remains inside the box, precluding any exposed protrusions or sharp edges on the enclosure's external underside.

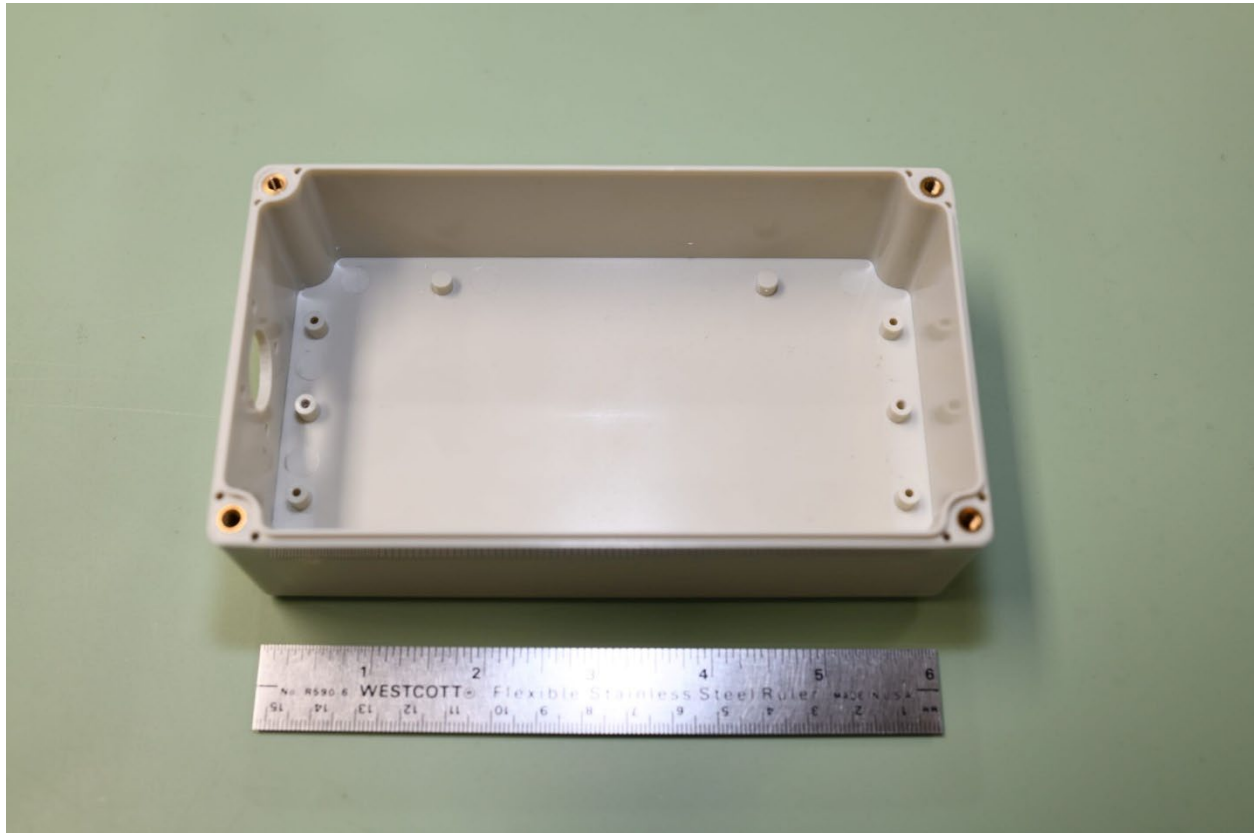


**Photo 1: Enclosure Bottom**

To mount the internal components, a false floor was created from a piece of 0.060" sheet Styrene. A length of 1/2" x 1/2" Aluminum angle was cut and secured in place with a pair of pop rivets; the angle piece provides a fence to hold the ignition battery in place.

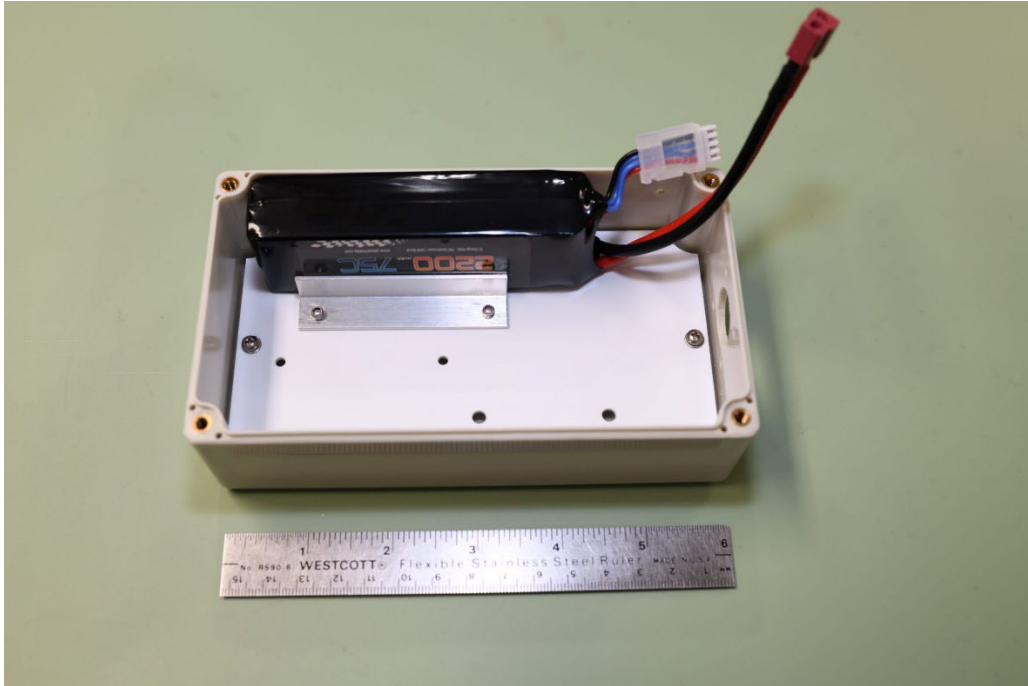


**Photo 2: False Floor, with Battery Retention**

A printed circuit board was created to capture the components comprising the Continuity Check circuit.

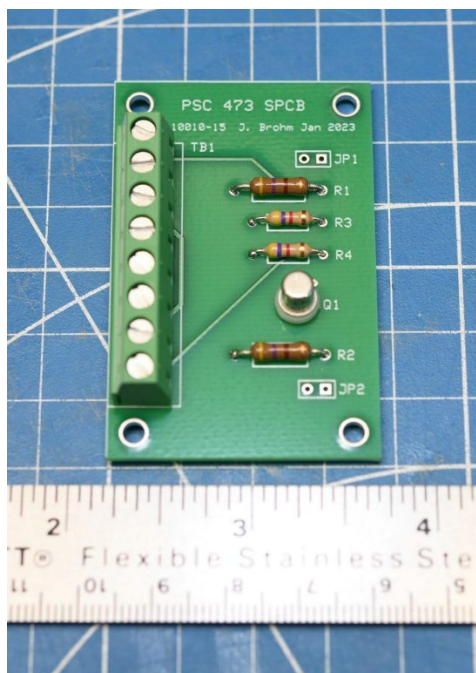


**Photo 3: Continuity Check PBA**

Connections are made to the board by way of an eight-position terminal block. This termination approach facilitates future maintenance should any of the connecting appliances need to be replaced.

With the Circuit Breaker and the Continuity PBA mounted, the false floor is then ready for installation.



**Photo 4: False Floor Assembly, Ready for Installation**

Before wiring can begin, the top side of the enclosure must be prepared to accept the control and indication appliances. I had hoped to engrave the nomenclature on the top shell, but my tests with this technique returned unacceptable results. Instead, I prepared a set of permanent vinyl labels, which, once burnished in place, were then secured with two coats of Testors #1261 Glosscote.



**Photo 5: Enclosure Top Shell**

Control and indication appliances were then installed.



**Photo 6: Appliances Installed**

With this, wiring got underway.

The power/launch loop was wired with 16AWG stranded copper wiring. Low current connections were made with 22AWG stranded copper wire. All wiring connections were made such that each individual appliance can be removed, if necessary, for maintenance without having to cut any wire.

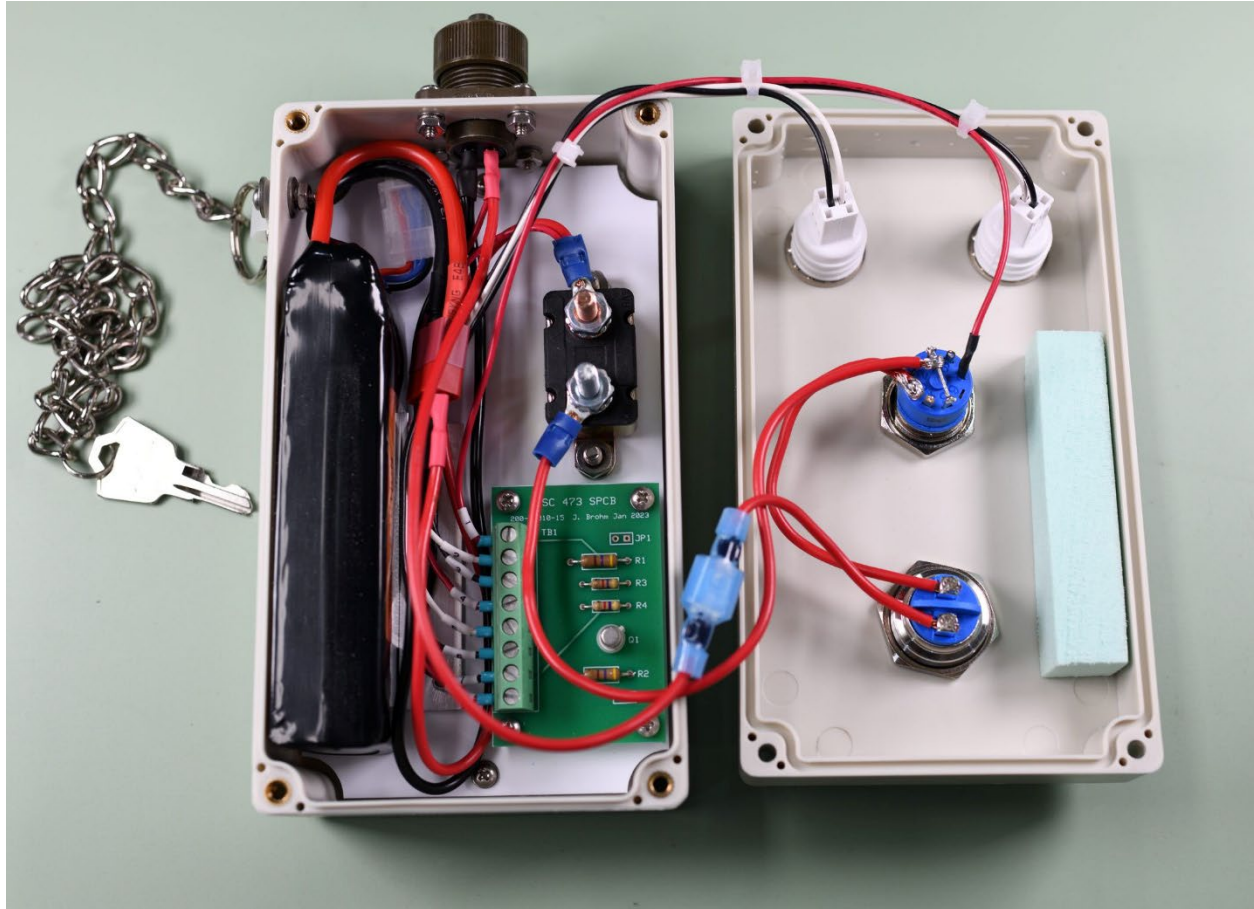


**Photo 7: Internal Wiring**

One will note the high current Deans Ultra Plug battery connection. Also visible in Photo 7 is a foam strip located on the underside of the top shell. This foam strip, held in place with a length of 3M double sided tape, retains the battery vertically. Once the top is set in place, the battery is firmly held in all axes.

One will note the absence of an external battery charging jack. That's because the Designer was uncomfortable having the LiPo charged in a potentially unattended situation. The design requires the battery to be removed for charging.

Photo 7 also shows the Amphenol Series 97-3102A two-pin box connector located on the front end of the enclosure. This connector mates with the corresponding plug connector on the Igniter Extension Cable, providing a robust physical and electrical connection to the controller.



**Photo 8: Amphenol Two-Pin Plug Connector**

With all connections completed, we can now close the device. We'll secure the safety key to the unit with a short chain.



**Photo 9: Handheld Launch Controller Complete**

A quick turn up test shows the unit ready for operation.



**Photo 10: Ready for Launch**

And there you have it; a high capacity, high current handheld launch controller, ready for international competition. We've since built several more of these units, two of which are now with the Canadian FAI Team. So far, the performance of the unit has been very reliable, and operators seem happy.

I hope this article has been of interest, and as always, I wish you every success with your rocketry projects.