Battery Connections
The RRC² is designed to be operated with a standard 9-volt alkaline battery. Always purchase and use premium alkaline batteries; 9-volt Nicad batteries may also be used -- however, the voltage of this battery type can range from 7.2 to 8.4 volts. A higher voltage Nicad is more desirable, as 7.2 volts is on the very edge of operational acceptance. When your battery voltage is too low, the continuity circuit will fail to operate and will not report (beep) the status of the ejection charges. This is a good indication that it's time to change your battery. It can reliably operate using battery systems up to 12 volts.

IMPORTANT: Always load test your battery prior to flight to ensure adequate power for reliable operation and ignition of the ejection charges. Inadequate sizing of an external battery system will damage or cause the unit to malfunction. Always pre-test your external battery system design prior to launch.

To load test a 9V battery, you will require a DC multimeter capable of DC amp measurement with a 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. Nominal load during operation is about

Mounting Considerations
The payload section or electronics bay used for the RRC² must be a sealed chamber with a static pressure equalization port. The sealing of the chamber is necessary for several reasons:

Isolation of the electronics from the ejection-charge heat, residue, and over-pressure
Isolation from the aerodynamic pressure and vacuum effects on the rocket airframe during flight
Provides uniform static pressure equalization to ambient flight conditions

IMPORTANT: Inadequate sealing of the payload section or electronics bay, or exposure of the electronics to ejection-charge heat, residue, or pressure will cause the RRC² to malfunction.

Static Pressure Ports
Equally as important as sealing the electronics bay or payload section is the proper location, sizing, quality, and quantity of static pressure ports. Always try to locate a static port on the airframe where it is not obstructed by any object that may cause turbulence upstream of the airflow over the port. Also try to locate the static port as far away as possible from the nose cone or body transition sections. The rule of thumb is a ¼" diameter hole for every 100 cubic inches of bay volume.

Bay Volume Calculations
The first step to sizing of the static port hole is to compute volume… use the following formula:

Volume (cubic inches) = Bay Radius (inches) x Bay Radius (inches) x Bay Length (inches) x 3.14

With the known volume of the electronics bay or payload section, calculate the required nominal diameter for a single static port with the appropriate formula:

If volume <= 100 cubic inches, you can use this simple approximation for a vent hole:

Single Port Diameter (inches) = Volume / 400

If volume > 100 cubic inches, use this formula to calculate vent hole diameter(s):

Single Vent Diameter = 2 * SQRT (Volume * 0.0004908 / 3.14)

Single Vent Area = (Single Vent Diameter / 2) * (Single Vent Diameter / 2) * 3.14

Multi Vent Diameter = 2 * SQRT ((Single Vent Area / # of holes) / 3.14)

Product Warranty
Missile Works Corporation has exercised reasonable care in the design and manufacture of this product and warrants the original purchaser that the RRC² Rocket Recovery Controller is free of defects and that 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 of 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.

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User Manual and Instructions
Model RRC² - Rocket Recovery Controller
Revision D

System Overview
The RRC² Rocket Recovery Controller provides two stage barometrically controlled deployment of rocket recovery systems and equipment. Two-stage (or dual) deployment is preferable to single parachute or streamer recovery systems for high-power rocketry. Recovery of large, heavy rockets with a small parachute or streamer alone does not supply enough drag to safely recover the rocket without damage. An adequately sized parachute deployed at a high altitude may cause the rocket to drift out of the launch area, making recovery difficult if not impossible.

Two stage (or dual) deployment recovery systems either separate the rocket airframe into two sections or eject a small drogue parachute or streamer at apogee, allowing the rocket to descend at a rapid yet controlled rate. When the rocket descends to a predetermined altitude above its initial launch elevation, it then deploys the main parachute, allowing the rocket to make a safe landing.

Specifications

Operational range	0-25K MSL	Dimensions	1.30" W x 5.9" L
Arming mode	barometric	Nominal Battery load	15ma
Minimum altitude for arming	300 ft. AGL	Main deployment ranges	Hi:1000'/500'
Battery	On-board 9 VDC		Lo:800'/300'
Weight	3.4 oz. w/battery	Ematch continuity current	80ua

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.

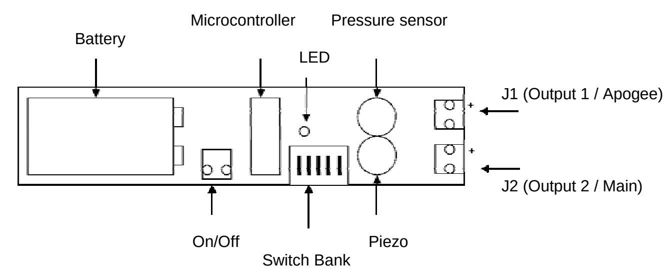
Always allow the unit and the battery system to adjust to ambient temperature conditions prior to connecting, arming and flying.

Avoid exposure of an armed unit to high intensity light (including direct sunlight), heat, cold, wind, or other extreme environmental conditions.

Always prepare your rocket and recovery system components 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 RRC² Rocket Recovery Controller. 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 RRC²



The switches are labeled 1 through 5 accordingly, switch 1 being the leftmost switch as illustrated in figure 1. The ON/OFF position is also labeled, with the ON position being UP, the OFF position being DOWN. The following table describes the switch functions and the corresponding modes of operation:

Table 1 - Switch functions and positions

	Switch 1	Switch 2	Switch 3	Switch 4	Switch 5
Func.	Main deployment altitude selection	Dual Deploy selection or Redundant Apogee	Mach delay timer selection	Mach delay timer selection	High or Low range Main deployment
On Pos.	Stage 2 (J2/Main) deploys at 1000 ft. (SW.5 OFF) or 800 ft. AGL (SW.5 ON)	Redundant apogee deployment operation (Stage 2/Main fires at apogee and overrides SW.1 & SW.5 setting)	4 seconds of delay time is added to the mach delay timer total	8 seconds of delay time is added to the mach delay timer total	Lo-range Stage 2 (J2) deployment altitudes are selected (800 or 300 ft) based on SW.1
Off Pos.	Stage 2 (J2/Main) deploys at 500 ft. (SW.5 OFF) or 300 ft. AGL (SW.5 ON)	Standard two stage deployment operation (Stage 2/Main altitude selected by SW.1 & SW.5 settings)	0 seconds of delay is added to the mach delay timer total	0 seconds of delay is added to the mach delay timer total	Hi-range Stage 2 (J2) deployment altitudes are selected (1000 or 500 ft) based on SW.1

IMPORTANT – The Mach Delay and High/Low range settings (SW. 3/4/5) 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.

Mach Delay timer

For high-performance rocket flights approaching or exceeding the speed of sound (mach), the unit can be configured to employ a time delay just after lift-off is detected. This time delay prevents the possibility of premature apogee detection caused by the high/low pressure effects present along the rocket airframe during transition into and out of mach. During the time delay, all barometric samples from the sensor are ignored so these pressure effects cannot falsely trigger the apogee charge. After the expiration of time delay, normal barometric sampling resumes. The unit can be programmed for 4 seconds (SW.3 ON / SW.4 OFF), 8 seconds (SW.3 OFF / SW.4 ON), or 12/seconds (SW.3 ON / SW.4 ON) of total delay. It is recommended to use the mach delay at velocities of 0.8 mach or above.

Deployment methods / Standard two-stage & Single-Stage (via Redundant Apogee mode)

Two-stage recovery of high power rockets is preferable as previously described in the "Overview" section of this document. Single-stage deployment has its own set of advantages when the launch site size or weather conditions permit main parachute deployment at apogee. They are much simpler in design and are simpler to operate and prepare. Redundant apogee mode fires both charges at apogee (1 sec apart).

Modes of Operation

The RRC² has several distinct modes throughout the course of its normal operation. These modes of operation are easily identified by the piezo beeper and the status LED.

Power-up switch position annunciation

After initially powering on the RRC² unit, it will annunciate (beep) the positions of all 5 switches in numerical order (1 through 5) with a series of '0's and '1's. A zero is a long beep, a 1 is a short beep A switch in the OFF position will beep as a '0', and a switch in the ON position will beep as a '1'. The LED flashes at a fast rate of 5 times per second. This annunciation allows you to double check the altimeter switch settings once inside the rocket.

Baro initialization mode

After the switch position annunciation, the unit goes through a 15-second initialization and start-up delay. The LED flashes at a fast rate of 5 times per second. There is no audible sound from the piezo beeper. This start-up delay allows stabilization of the electronics and establishes an initial barometric history.

Pre-launch mode

After the 15-second power up and initialization delay, the unit goes into the pre launch mode. The LED will flash at a slow 2 second rate, and the piezo beeper will indicate the continuity of the ejection charges as follows:

Long Beep	No continuity on either channel
1 Short Beep	Continuity on channel 1
2 Short Beeps	Continuity on channel 2
3 Short Beeps	Continuity on channel 1 & 2

The unit also monitors the barometric sensor for a change of 300 feet in elevation to determine the launch of the rocket. After this change, the unit transitions into mach delay mode (if selected) or apogee detection mode.

Mach Delay mode

When either SW. 3 or SW. 4 is in the ON position, the unit will enter the mach delay mode. The LED flashes again at its fast rate of 5 times per second. There is no audible sound from the piezo beeper. After the expiration of the mach delay (if selected), the unit transitions into apogee detect mode.

Apogee Detection Mode

At this point, the RRC² has detected launch and is in flight. The LED continues to flash at its fast rate of 5 times per second. The piezo beeper will beep at a fast rate of ½ second. During this mode the unit is sampling for apogee (indicated by an increase in pressure). When this pressure increase is detected, the unit transitions into deployment mode.

Deployment mode

Now that the unit has detected apogee, it will fire the channel 1 (J1) output. The LED will continue to flash at its fast rate of 5 times per second. There is no output from the piezo beeper. If the unit was set to operate in standard dual deployment mode, it will continue to sample barometric pressure until it reaches the designated main deployment elevation above the initial launch elevation before firing the channel 2 (J2) output. Otherwise the unit is operating in redundant apogee mode, and it will then fire the channel 2 output immediately following the channel 1 output. After the unit has fired both output channels, it transitions into report mode.

Report mode

After deployment of the recovery system, the unit will report the peak altitude it measured during flight. The LED will continue to flash at its fast rate of 5 times per second. The piezo beeper will continuously annunciate the peak altitude by beeping out the individual digits of the measurement. Depending on the peak altitude, the unit will annunciate 3, 4, or 5 digits. For example, let's say the rocket flew to a peak altitude of 1230 feet. The unit would beep as follows:

Beep...pause…Beep, Beep…pause…Beep, Beep, Beep…pause…Beeeeeeeeeeep…long pause….(repeat)

Test Mode Operation and Diagnostics

The unit can also be placed into a test mode to verify the basic integrity of the unit, and also to ground test e-matches, igniters, ejection charges, or recovery system designs. To place the unit into a test mode, toggle either SW. #1 or SW. #2 during the power up and initialization period according to the test you'd like to run. Toggling SW. #1 will set the unit into input test mode. Toggling SW. #2 will set the unit into output test mode The unit will continue to operate in the test mode selected until it is powered off.

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

Input Test mode

After toggling SW. #1, the unit will enter the input test mode. This mode verifies the integrity of all the inputs to the microprocessor. Whenever an input is in the ON position, the unit will beep out a digit to indicate operational integrity of the input (see Table 2). The test mode scans and reports the inputs starting with the lowest value first (SW. 1). Lower value switch positions and inputs take priority over higher position switches and inputs. There are several factors to consider when it comes to the construction, mounting, wiring and arrangement of the RRC² in your rocket airframe. Careful planning during the construction and preparation of your rocket will improve your chances for a successful recovery.

Table 2 - Input Test mode beep indications

1 Beep	SW. #1 in the ON position	5 Beeps	SW. #5 in the ON position
2 Beeps	SW. #2 in the ON position	6 Beeps	J1 continuity
3 Beeps	SW. #3 in the ON position	7 Beeps	J2 continuity
4 Beeps	SW. #4 in the ON position		

Output Test Mode

After toggling SW. 2, the unit will enter the output test mode. This mode can be used to test the integrity of both outputs (J1 and J2) and to also ground-test your pyrotechnic e-match, igniter, flashbulb, ejection charge, or ground test deployment of your entire recovery system. The test mode begins by beeping the piezo beeper at a fast rate of 5 beeps per second. After 10 seconds of countdown, the unit will fire the J1 output. This is followed immediately by firing the J2 output (this functions identical to the deployment firing sequence used in the redundant apogee mode).

IMPORTANT: Always exercise caution when using live pyrotechnic charges in the output test mode.

Another useful accessory for testing the outputs are 12 volt DC panel lamps. The lamps will allow you to observe the proper operation of the outputs without the use of pyrotechnic devices.

Barometric Limits Alarm

The unit also features a barometric limit alarm. This alarm mode is easily identified by the continuous actuation of the piezo beeper. While the unit is in the pre-launch mode it tests the barometric sensor reading for basic integrity. If the reading is below 0' MSL or above 14000' MSL the alarm will sound. This extreme reading indicates a failed sensor (unless of course your attempting to launch from those base elevations, in which case you cannot do so).

IMPORTANT: Do not fly the unit if it activates the baro sensor alarm.