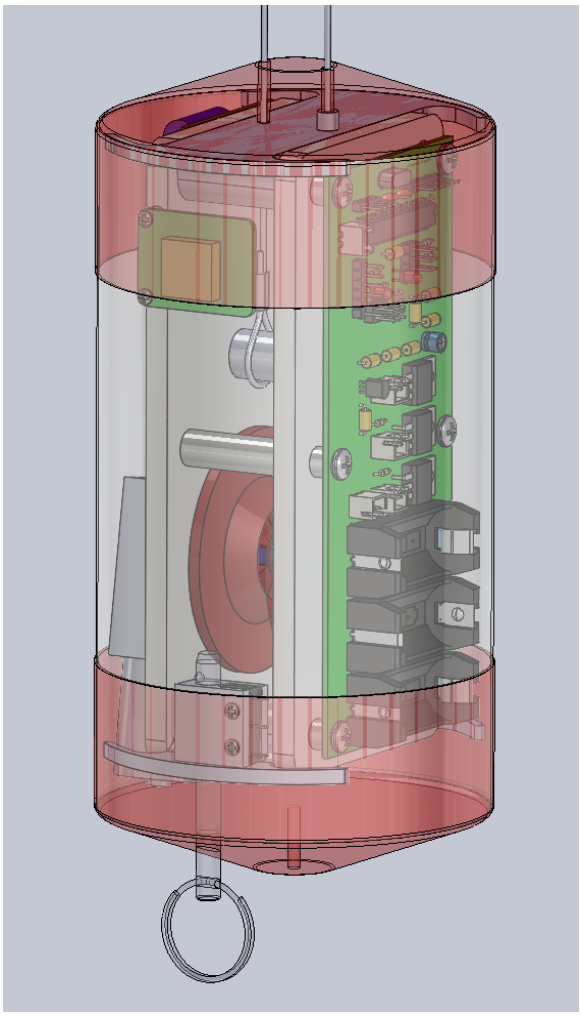
So BAD it’s good

Ballooning All-Purpose Device



Important Notes

Prerelease Version. This manual is currently incomplete, as the device is still under development and should be considered experimental.

Unforeseen Requirements. No set of procedures can cover all possibilities that can occur in an operational setting. The balloonist uses judgment in adhering as closely as possible to this manual, to handle situations not adequately covered by specific instructions. If procedures in this manual require changes or clarification, send them to doug.kennedy@noaa.gov for possible inclusion into future manual or handbook revisions.

Overview of capabilities

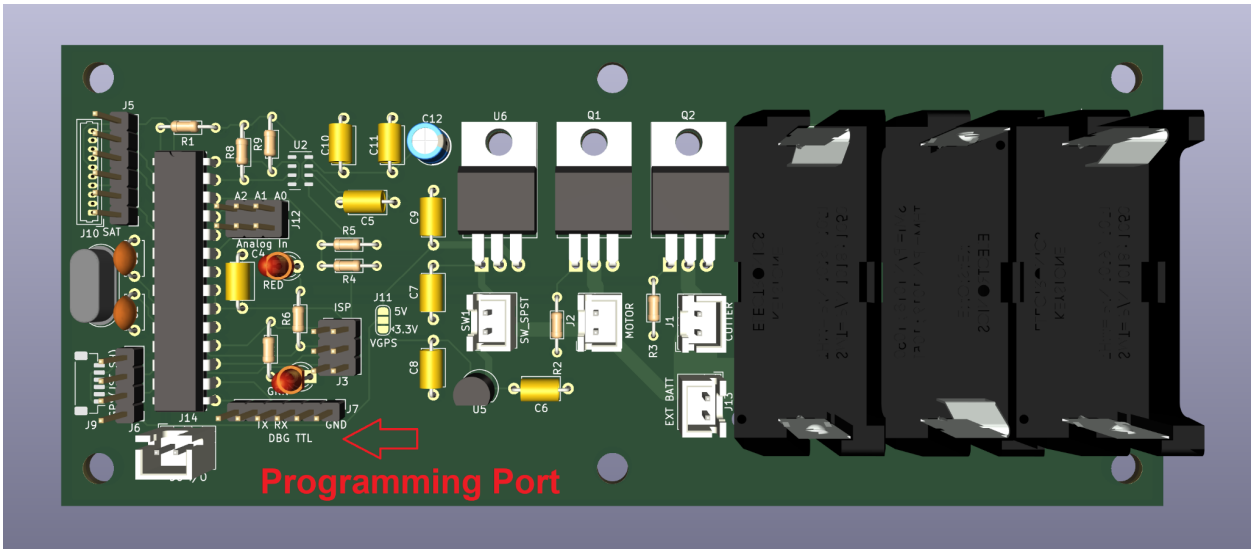
The Ballooning All-purpose Device (BAD) augments your balloon-borne experiments with several useful features. These include:

- A let-down reel to lower an instrument at a regulated rate after launch. The launch is automatically detected by the measurement of the rise rate derived from falling pressure.
- An automatic or manually triggered cut-down to terminate a balloon flight using a hot wire monofilament cutter. There are many termination options, including time, pressure, geofencing, distance from the launch point, or a command transmitted via satellite.
- A tracking system to transmit GPS position data over a RockBLOCK™ satellite modem
- A database and API to retrieve KML formatted paths of multiple balloons in flight. This can be used with Google Earth or another GIS system to visualize the balloon path.

The system has been carefully engineered for easy use in the field. After configuration, only one pin needs to be removed to activate the device. It will patiently wait for launch, let down the instrument after a configurable delay, and terminate the flight according to the selected parameters. A remote signal can terminate the flight at any time.

Configuration software

The device may be configured by transmitting a configuration string over the serial port using a 3.3V TTL serial cable, such as https://www.sparkfun.com/products/9717. Plug the cable into the port labeled J7, DBG TTL. **Be sure the black wire of the cable is aligned with the GND pin of J7.**



A python program is provided to ease the configuration. It is available at the project github repository, http://github.com/dwkennedy/ballooning/config_tools. The configuration options

available are also documented in this file. Edit the file to set the parameters required, then execute the program to transfer the configuration. For example, if the serial device is connected to COM20:

$ python configure.py COM20

unit_id: 1237
letdown_delay: 60 seconds after power on
letdown_duration: 1 seconds
max_flight_duration: 120 seconds
cut_pressure: no limit
cut_duration: 3000 milliseconds
rise_rate_threshold: 85
update_interval_satellite: 120
max_distance: ignore
min_latitude: ignore
max latitude: ignore
min longitude: ignore
max longitude: ignore

Hex string for RockBLOCK:
d504c4ff010078000000b80b55007800000000000000000000000000000000000000000000

Connect cable and turn on device now

. . .

You should see an "OK" response after the configuration string is sent. The hex string provided can be used to send a configuration to a device over the satellite connection. This could be useful to change the frequency of transmissions (or shut them off entirely) after the device has landed to save message charges, or modify the cut down triggers as conditions change after launch. After the device is configured the program will also re-read the configuration and dump it in text format for review.

Another program, *checkcfg.py*, will dump the configuration on device power up without changing the programmed configuration.

Configuration Options (set in configure.py)

unit_id (default: 0)

This is an integer from 1 to 65,535 that identifies the balloon flight. It should be unique from other concurrent flights. It is convenient to use a different number for each successive flight, as that will simplify the retrieval of flight information from the database. Do not use 65,536 as a unit_id, as that will reset the BAD to default settings. The default setting for unit_id is 0 (zero), which indicates that the unit hasn't been configured yet.

letdown_delay (default: 30)

How many seconds to wait to activate the let down reel after launch. Special trick: if this value is negative X, the let down reel will begin unwinding after waiting X seconds after device power up. The default value is 30 (initiate let down 30 seconds after launch)

letdown_duration (default: 30)

How many seconds to actuate the let down reel motor. The reel releases waxed nylon line at approximately X meters per second, so a 50 meter letdown will require about 50/X seconds. Set this to zero to disable the let down function.

max_flight_duration (default: 0)

Number of seconds after launch to activate the hot wire cutter. The default is 0 (zero) which disables the function.

cut_pressure (default: 0)

If the current pressure measurement, averaged over the last several readings is less than cut_pressure, the hot wire cutter is activated. The default is 0 (zero) which disables the function.

cut_duration (default: 5000)

How long, in milliseconds, to activate the nichrome cutter when any of the cutting conditions are achieved. The nichrome wire should be about 3 ohms. A 3 inch piece of 0.010” (30 AWG) nichrome wire will perform well.

rise_rate_threshold (default: 85)

This controls the sensitivity of the launch detection filter. The National Weather Center elevators rise at approximately 100; a balloon launch of 5 m/s is about XXX (determine this value experimentally). The default is 85 to provide a reliable launch detection while doing elevator testing, and eliminating false launches.

update_interval_satellite (default: 120 seconds)

How often, in seconds, to attempt a satellite transmission of tracking data. The default is 120 (once every 2 minutes)

max_distance (default: 0)

The hot wire cutter is triggered if the **distance along the ground** from the launch point to the present position exceeds the parameter. The default is 0 (zero) which disables the function.

min_latitude (default: 0)

max_latitude (default: 0)

min_longitude (default: 0)

max_longitude (default: 0)

If the GPS reported latitude or longitude is less/more than one of these parameters, the hot wire cutter will activate. The default is 0 (zero) which disables the function. The latitude and longitudes are expressed in millionths of degrees: 35.220815 N, -97.446517 E would be 35220815 and -97446517, respectively. The function of each parameter is separable, i.e. you can set a maximum latitude and leave the others at zero if your only concern is keeping the device from falling into Canadian hands.

Visualizing the flight path

Use Google Earth Pro to track the progress of the instrument train. Add a network link and use this URL to view live tracking waypoints transmitted in the prior 24 hours: *http://kennedy.tw:8000/path/NSSL1313*. Set the refresh interval to 30 seconds or so for automatic updates.

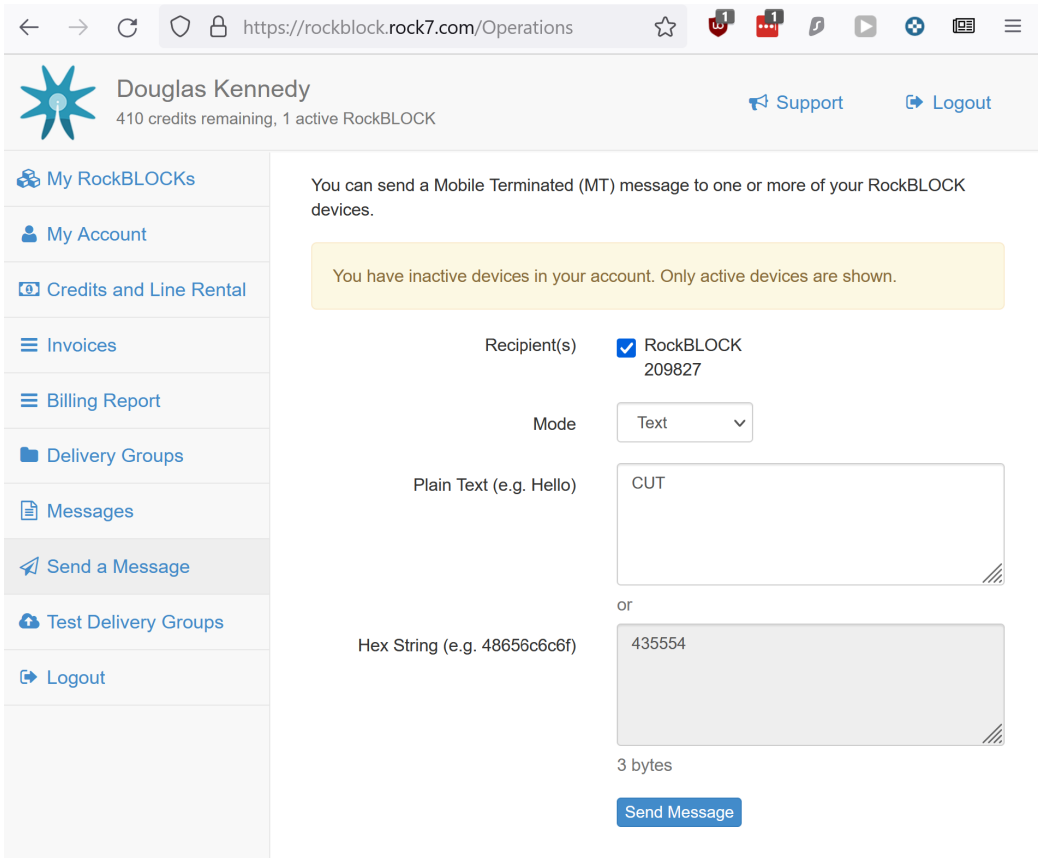
Yesterday's data is at *http://kennedy.tw:8000/path/NSSL1313/1*. There is no need to refresh the old data as it no longer updates.

The geofence settings for {unit_id} can be overlaid by adding at network link for *http://kennedy.tw:8000/geofence/{unit_id}*. **This will look funny if any of the geofence latitude/longitude settings are zero.**

Remote commands via satellite

It is possible to activate the let down reel, the hot wire cutter, and even reconfigure the parameters of the BAD during flight or on the ground by using the satellite modem. In order to do so, navigate to the Rock7 control website at https://rockblock.rock7.com/Operations. After logging in, click "Send a Message" and ensure the correct RockBLOCK™ serial number is selected as recipient. Simple commands can be sent in Text mode, and reconfiguration requests will be sent in Hex mode.

A easier-to-use web-based interface will be made available shortly.



Simple commands (case is important!):

CUT

Activate hot wire cutter immediately for cut_duration milliseconds

LET

Activate let-down reel motor for letdown_duration seconds

CFG

Return the current configuration structure via satellite; CFG{configuration structure}

These commands also work via the serial interface immediately after device power on; use them to test the motor polarity and hot wire cutter when necessary.

Hex mode commands:

PRG{configuration}

Reconfigure the parameters; configuration is a 36 byte binary string. It can be generated by the configure.py program.

PNG{bytes}

"Ping" command: return {bytes} via satellite

UPD{XX}

Change the frequency of satellite updates. "5550440000" will set the update interval to zero, which will disable further updates. This is useful to save message credits after the device has landed and presumably won't be moving further. For another example, "5550447800" will set the update interval to 120 seconds. 0x0078 is 120 in hexadecimal (note that the LSB comes first!)

Preparing the BAD for launch

Insert fresh CR123A batteries, observing polarity markings

Wind appropriate length of adequately strong line on the let-down reel using the (forthcoming) reel winding device. Note the time required to wind the line, use this as a first guess for *letdown_duration*, minus 10-20 seconds. Test the let-down timing by using a similar weight, as the motor utilizes open-loop control and doesn't sense when the line is completely unwound.

Assign a unique *unit_id* to each device; this could be different for each flight of the same device. Flying two or more devices with the same unit_id will result in tragically messed up KML paths.

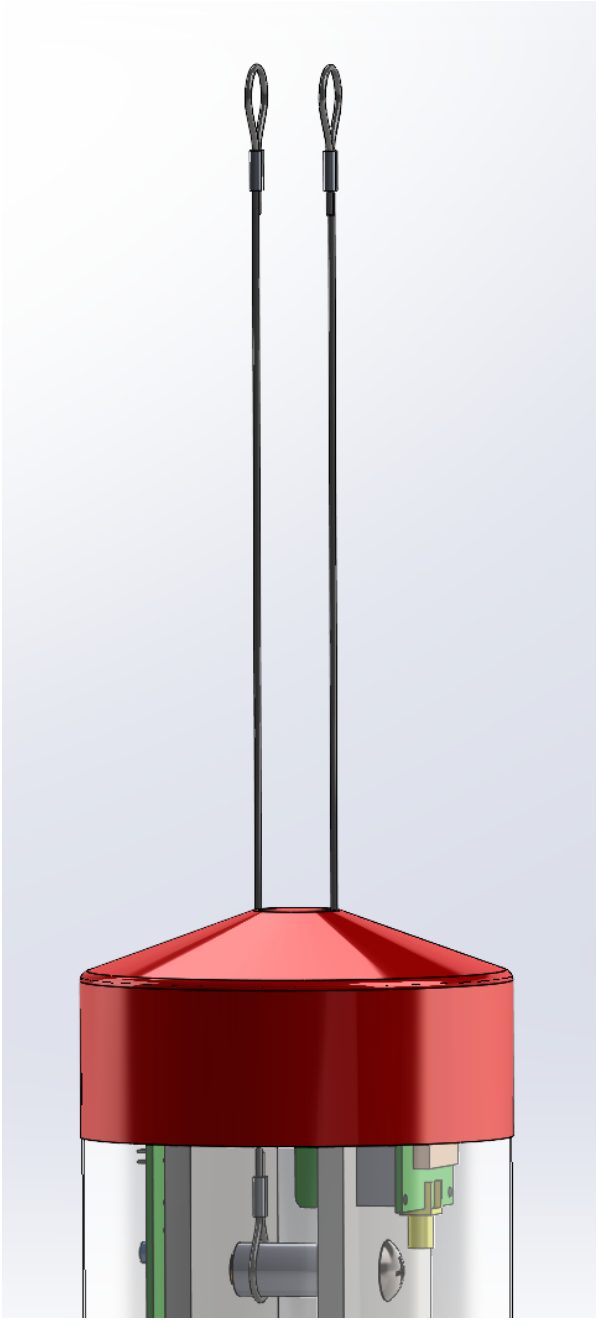
Configure the device with desired parameters, including the aforementioned unit_id. Use either the *configure.py* script and serial cable, or test the satellite communication by transmitting the configuration string. The configuration string can also be queried over satellite to verify the configuration.

Make careful note of the RockBLOCK serial number, as this is what is used to transmit commands to specific devices during flight using the Rock 7 operational web interface. Every RockBLOCK modem has a unique serial number and IMEI.

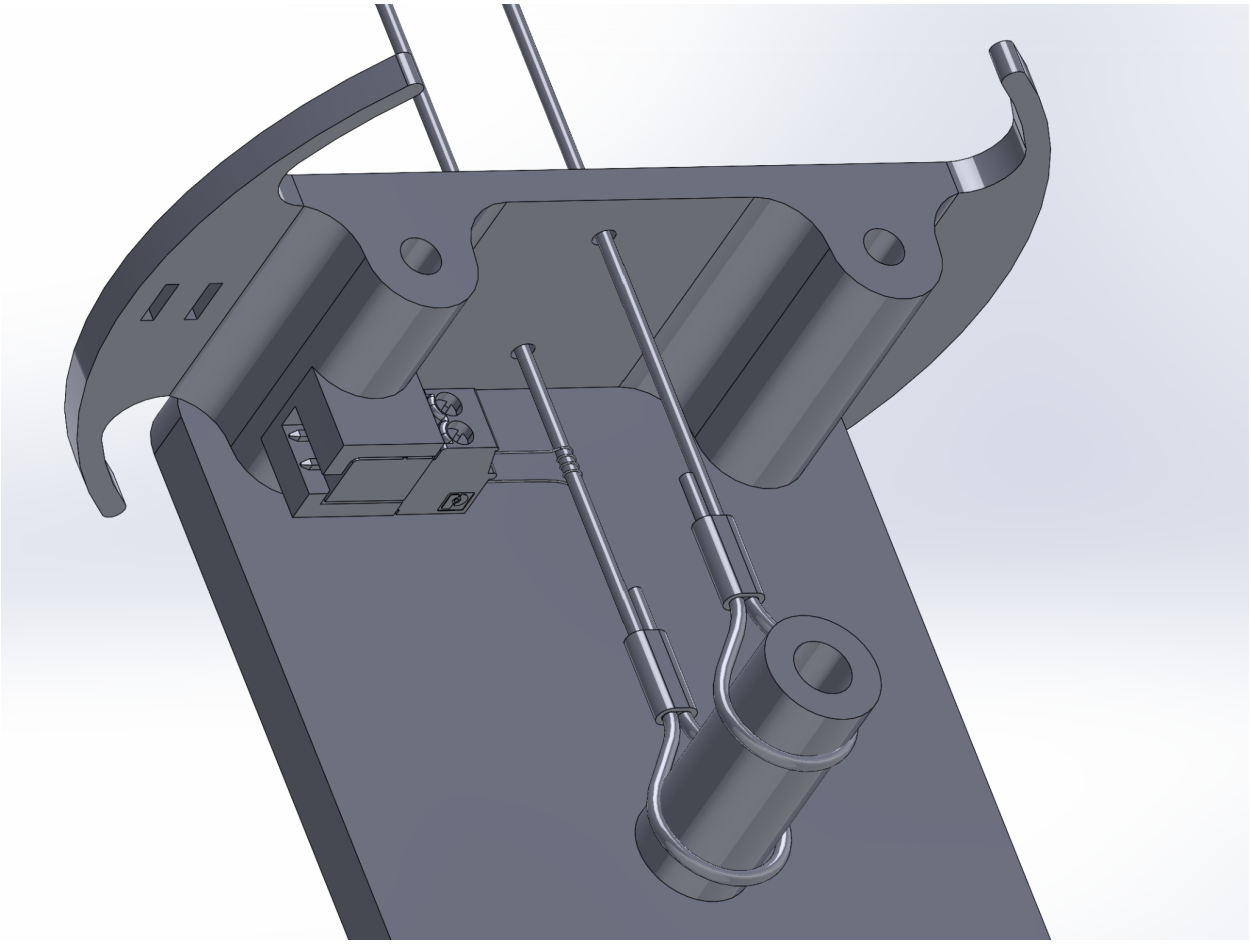
Insert pin to power off device.

Remove the power pin at least a minute or two before launch. This will give the GPS time to obtain a valid fix and record the launch location. The fix LED on the GPS board will blink about once a second when it is acquiring a fix, and will blink every 10 seconds or so when a valid fix is achieved. After the boot up sequence, the red LED will blink about once a second indicating the power is on. The green LED will illuminate when the GPS has obtained a valid fix.

Balloon and parachute rigging **(outdated)**

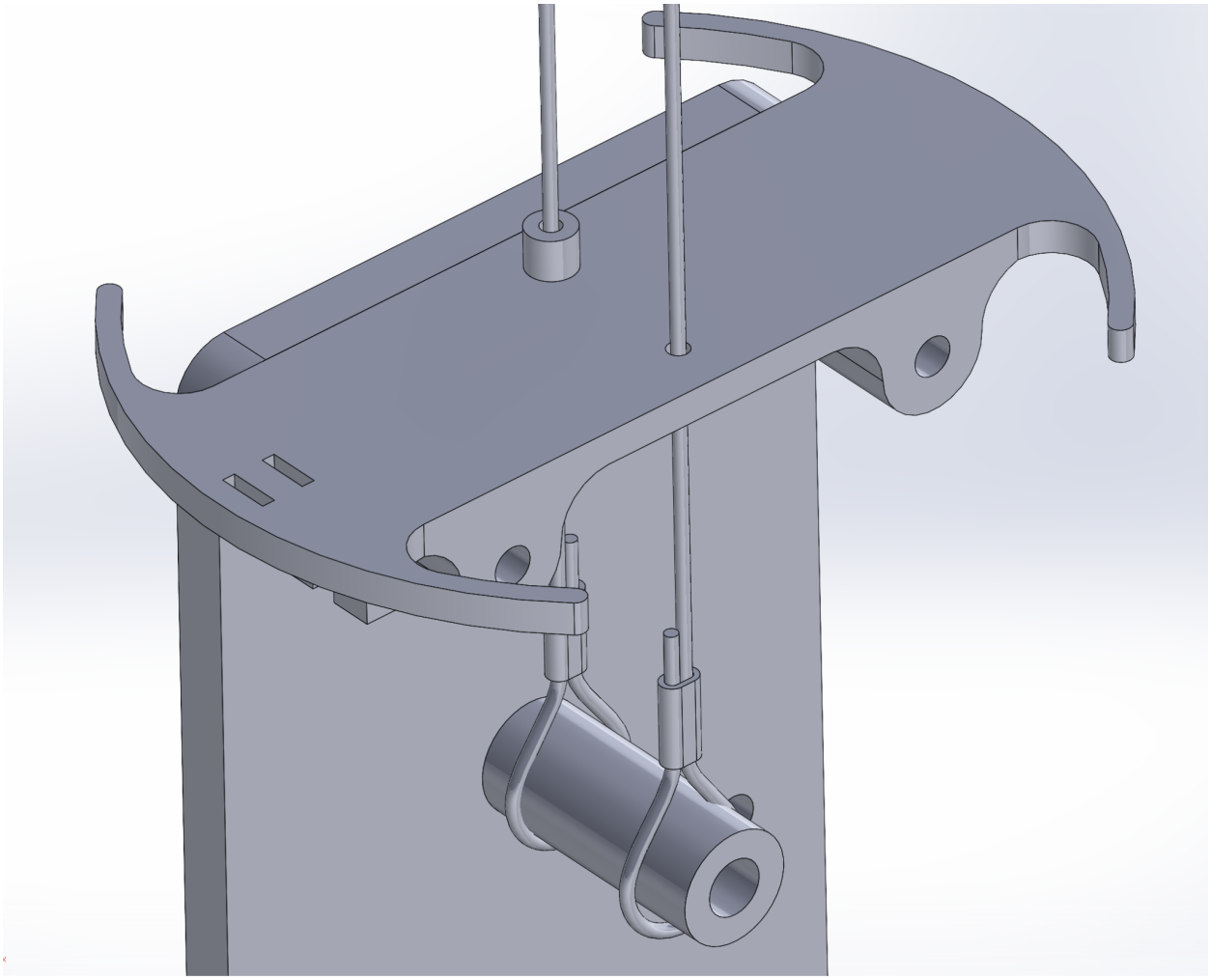


Use about 129.5” of 160lb test (0.060) monofilament for the balloon line. Place loops as illustrated. Modify length as required for different parachutes. The balloon monofilament will be much longer than illustrated. The parachute will be rigged in parallel with the balloon monofilament. Cut 12” monofilament for pigtail and make loops at each end. Attach swivels and carabiners as appropriate.



1. Disassemble the fixing post (remove ¼” screw) and the upper enclosure brace (remove 2 #8 screws). The hot-wire cutting assembly can be removed from the upper enclosure brace by pulling it out of the hot-wire cutting assembly holder.
2. Form a loop of monofilament around the fixing post and apply a compression sleeve (McMaster-Carr 3633T2). Ensure that the loop fits lightly around the post but is still movable.
3. Take the free end of the monofilament and form a coil from **4” of AWG 32** nichrome wire as shown around the monofilament. The free ends of the coil should extend about ½” and each turn of the coil should not be touching. Insert the free ends into the screw terminals of the hot-wire cutter assembly and tighten securely. **Ensure that the hot-wire cutter assembly is oriented as shown in the illustration** so that it can be later inserted into the hot-wire cutter assembly holder. The screw terminals will be facing away from the side plate. Measure the coil resistance to verify that the wire is properly affixed to the screw terminals, is of proper length, and unbroken.
4. Pass the free end of the monofilament through the monofilament hole, through a rope stop (McMaster-Carr 3914T11) or bootlace ferrule and through the red upper enclosure cap. This is the balloon monofilament that may be cut to terminate the flight. **Do not compress the rope stop or ferrule until the device is reassembled, or proper tension will not be achieved.**

5. Take a second length of monofilament and form a loop around the fixing post, then pass through the other monofilament hole and through the red upper enclosure cap. This is the parachute monofilament. It is not cut and should be a permanent part of the rigging.
6. The entire assembly (upper enclosure cap, upper enclosure brace, hot-wire cutter assembly, and fixing post) can then be affixed to the body of the device with screws.
7. Slide the hot wire cutter assembly along the balloon monofilament and press it into the hot-wire cutter assembly holder molded into the upper enclosure brace.
8. Move the upper enclosure cap out of the way and apply a slight crimp to the rope stop or ferrule while applying tension to the balloon monofilament. This will protect the nichrome line-cutting coil from bending, experiencing metal fatigue, and possibly breaking during flight.



9. Form loops in the free ends of the monofilament, making sure to include a swivel if desired. Use colored heat shrink or strain reliefs to identify the balloon and parachute monofilaments.

Warning: Thread monofilament through the upper enclosure brace, rope stop, and cap before crimping the top loops!

Specifications

Power supply: Three (3) CR-123A batteries, nominal supply voltage of 9.0V.
Nichrome wire: 32 AWG, 0.008” diameter, such as McMaster-Carr number 8880K82. Fabricate a coil of 3 ohms or about 4 inches of wire. Shorter or thicker nichrome wires can cause the device to reboot due to excessive current and supply voltage drop!
Nichrome wire holder: TERM BLOCK PLUG 2POS STR 3.5MM, DigiKey number 609-4727-ND
Weight limitation: Tested with 6 lb weight. Do not exceed without further testing and evaluation
Pressure sensor: NXP 3115A2 MEMS sensor, 300 to 1500 mbar range
GPS receiver: MTK3333, 99 channel. Maximum reported altitude: xxxx meters. 3V CR1220 battery for GPS hot start capability.

CAD drawings, STL files, firmware, schematics, configuration software, and PCB designs can be found at:

https://github.com/dwkennedy/ballooning