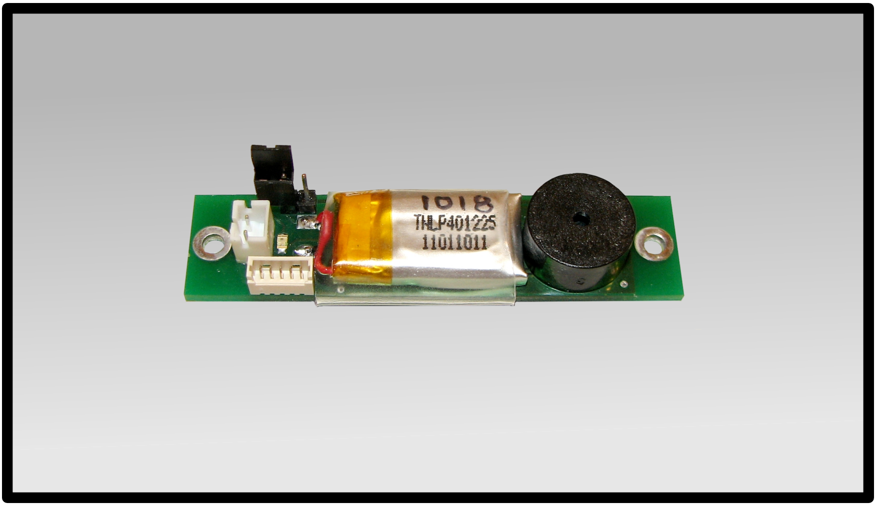
Pnut Users Manual



PerfectFlite

Pnut Users Manual

A miniature, high accuracy, data-logging altimeter
for advanced model rocketry research.

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Contents

Introduction

The *Pnut* is a high-quality, high-precision, full-featured rocket altimeter that acquires flight data continuously during your rocket's flight for later download and inspection. A large onboard memory stores altitude, temperature, and battery voltage data sampled 20 times per second for up to 9 minutes per flight, for the last 31 flights. It also provides immediate post-flight reporting of peak altitude and maximum velocity without the need for a computer. It is ideal for intermediate to advanced rocket education, advanced science fair projects, and contest use.

The *Pnut* is installed inside your rocket and activated prior to launch. When you retrieve your rocket, the *Pnut* will report the apogee altitude (how high your rocket went, up to 100,000 feet above ground) and the maximum velocity (how fast your rocket went, in miles per hour). It uses a convenient, easy to understand audio reporting method that is audible from outside your rocket, so removal or inspection of the altimeter is not necessary. The reported altitude and velocity are alternated with a 10 second siren sound that helps to locate your rocket even if it is hidden in tall grass or a tree.

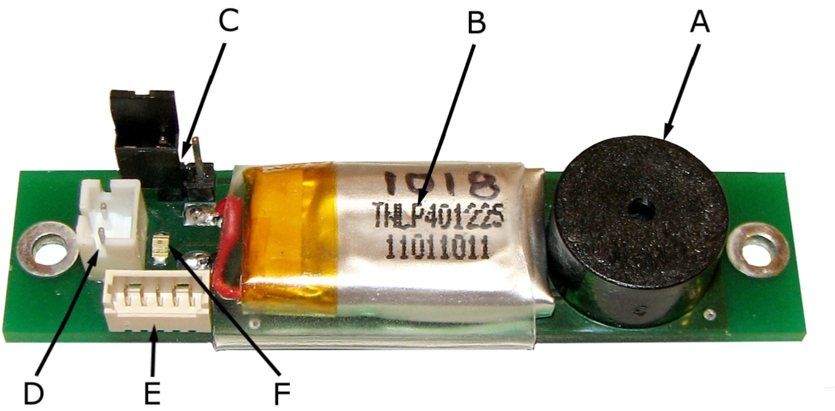
Using the optional USB Data Transfer kit, the full flight data (altitude, temperature, voltage) can be downloaded to a computer for storage, graphing, and additional manipulation. Because of the generous memory size, it is not necessary to bring the download equipment to the launch – 31 flights can be made before download of the data is necessary.

If you want to step up to electronic parachute deployment, you may want to consider the PerfectFlite *StratoLogger,* which has the *Pnut's* flight data download features and adds two event electronic parachute deployment for advanced users. Electronic deployment provides the ultimate in control over when your parachute is ejected – no more guessing about which ejection delay length to use, the altimeter will always fire precisely at apogee.

The *Pnut* utilizes a precision pressure sensor and 24 bit delta sigma analog to digital converter to obtain an extremely accurate measurement of the air pressure surrounding your rocket. When turned on, the altimeter "tracks" the ambient pressure surrounding your rocket to get an up-to-the-second reading of the barometric pressure at ground level. As the rocket rises, the pressure decreases, and the altimeter converts the pressure differential to a precise measurement of altitude above launch point according to the US Standard Atmosphere model. All of the calculations are done inside the altimeter, with the results reported simply as "altitude above ground level". No conversion or adjustment is necessary.

Parts Identification

Refer to the top of the altimeter to locate the following items:



A) Beeper: Audibly reports altitude and velocity after flight.

B) Battery: Built-in rechargeable Lithium Polymer battery.

C) Power Pins and Jumper Shunt. *Shunt shown in storage ("off") position. Place shunt across both pins to turn altimeter "on".*

D) Charge Connector: Supplied charging cable connects here.

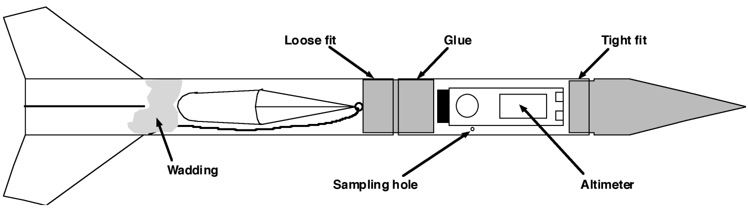
E) Data Connector: Connect to optional data transfer kit and computer for post-flight download of flight data. Can also be used for access to in-flight telemetry data.

F) Charge LED: Lights during charging, goes out when charge is complete.

Installation

For best results, your altimeter should be installed in a separate payload compartment, sealed from the pressure and heat of the ejection charge gasses. While other alternatives are possible, isolating the altimeter in a protected compartment will provide the most precise readings and will keep high temperature and pressure from affecting the long-term accuracy of the instrument.

A typical payload compartment consists of a section of body tube behind the nosecone with a sealed tube coupler connecting it to the main body tube (see illustration below). Some rockets (e.g. Estes "Nova Payloader", Quest "Zenith II") already have such a payload section, and one can be added easily if yours does not. Use pieces of foam rubber in front of and behind the altimeter to prevent it from shifting under acceleration and deceleration and to protect it in the event of a crash. The altimeter will slide into 18mm/BT20 size body tubes, and a "sleeve" made out of standard foam pipe insulation can be used for larger size tubes. Your payload section should close securely so that the altimeter is not "ejected" upon motor burnout deceleration or chute deployment shock.



You should perform initial testing on your rocket without the altimeter installed. Make sure that the parachute is ejected and opens properly so that you have a slow and safe landing. If you conduct your preliminary tests with the altimeter installed and the chute doesn't eject, the resulting high speed ballistic descent will likely damage the altimeter (and your rocket!).

When installing the *Pnut* in larger rockets it may be easier to add a short (~3" long) section of BT20 tube with padded end plugs for the altimeter to ride in. The short BT20 tube could be glued to the inside of the larger airframe or to a plywood mounting plate. A static pressure sampling hole can be drilled through the main airframe and into the inner tube to allow external air pressure to get to the altimeter.

As a last resort, if accuracy isn't of paramount importance, you can simply tie the altimeter to the rocket's shock cord and pack it in along with the chute. If you must do this, observe the following precautions:

1. Use plenty of wadding between the ejection charge and the parachute.
2. Position the parachute between the wadding and the altimeter to provide additional protection from the hot ejection charge gasses.
3. Make sure the altimeter is securely tied to the shock cord so that it doesn't separate and free-fall.
4. Add a wrap of tape around the jumper shunt so it doesn't get dislodged at ejection. *Note: Make sure the tape doesn't cover the pressure sensor (small white rectangle marked "U3") on the bottom of the altimeter.*

Static Pressure Sampling Holes

You must drill one or more clean-edged holes in the payload compartment to allow outside air pressure to be sampled by the altimeter (see table below for recommended sizes). These holes should be as far away from the nosecone shoulder and other body tube irregularities as possible (at least 3 times the body tube diameter or more) to minimize pressure disturbances being created by turbulent airflow over the body tube. Sand the area around the hole as necessary to eliminate flashing or raised edges.

Best performance and greatest accuracy will be achieved by using four smaller holes distributed at 90 degree intervals around the body tube's circumference instead of a single larger hole. When using four holes, each hole should be ½ the size of a single hole as noted in the table. This will minimize the pressure variations due to wind currents perpendicular to the rocket's direction of travel.

Payload Diameter	*Payload Length*	*Single Hole Size*	*Four Hole Size*
<1.5"	6"	.024"	.012" (small pinholes)
1.6"	6"	.024"	.012" (small pinholes)
2.1"	6"	.042"	.021"
3.0"	8"	.113"	.057"
3.0"	12"	.170"	.085"
3.9"	8"	.202"	.101"
3.9"	12"	.302"	.151"

Other sizes:

Single hole size = Diameter * Diameter * Length * 0.0016
Four holes, each hole = Diameter * Diameter * Length * 0.0008

Operation

Battery

The altimeter is powered by a built-in Lithium Polymer rechargeable battery that should never need replacement. The battery is charged using the supplied charging cable and a standard 9V rectangular battery. When the cable is connected to the altimeter and a 9V battery, the "charge" LED on top of the altimeter will light. When the charge is complete the LED will go out. A full charge takes 2-3 hours if the onboard battery is fully depleted. As long as the altimeter is turned off between uses, a full charge can easily last for a year's worth of typical rocket launches. A single fresh 9V alkaline battery can provide up to 6 full charges to the Pnut's battery.

Tip: You can also use partially depleted batteries (e.g. old smoke detector batteries) and the Pnut's charger will extract any remaining life out of them.

Power Switch

The jumper shunt shown in the picture on page 3 is used to turn the altimeter on and off. Install the jumper shunt across the two pins on the altimeter's circuit board to turn the altimeter on, and remove the shunt to turn it off. When the altimeter is not in use, you can place the jumper shunt on just one of the pins for storage.

For added convenience, you can use the optional power switch cable to connect an externally-accessible on/off switch to the altimeter. The cable plugs onto the two pins on the circuit board in place of the jumper shunt, and your switch is connected to the loose ends of the cable.

Numerical Reporting

Numbers are reported as a long beep (separator), followed by a pattern of shorter beeps for the individual digits, with a pause before the next digit. You simply count the number of short beeps for each digit place and assemble them together to form a number. You will hear a series of beeps for the first digit (tens of thousands of feet), a short pause, another series of beeps for the next digit (thousands of feet), etc.

Leading zeroes are suppressed: 1,582 feet would be represented with four digits as in 1582, not five digits as in 01582.

Ten beeps are used to indicate the number zero (if zero beeps were used, you would not be able to differentiate between 2200 feet and 22 feet!).

As an example, 12,560' would be reported as:

long beep*-pause-****beep****-pause-****beep-beep****-pause-****beep-beep-beep-beep-beep****-pause-* ***beep-beep-beep-beep-beep-beep****-pause-****beep-beep-beep-beep-beep-beep- beep-beep-beep-beep****-long pause*

Digit	***Reported as:***
0	beep-beep-beep-beep-beep-beep-beep-beep-beep-beep
1	beep
2	beep-beep
3	beep-beep-beep
4	beep-beep-beep-beep
5	beep-beep-beep-beep-beep
6	beep-beep-beep-beep-beep-beep
7	beep-beep-beep-beep-beep-beep-beep
8	beep-beep-beep-beep-beep-beep-beep-beep
9	beep-beep-beep-beep-beep-beep-beep-beep-beep

Powerup

When the altimeter is turned on, it will report the peak altitude from the last flight and the current battery voltage before readying itself for flight. This is what you will hear:

- A three to six digit number (range of 160 feet to 103,500 feet) representing the apogee altitude of the last flight. ***Note: A warbling siren tone will sound instead of the last flight altitude if power was lost during the last flight. This error will clear after the next good flight.***
- A two second pause, and then a three digit number representing the battery voltage in hundredths of a volt (e.g. 3.97 volts would report as 397).
- A thirty second pause (giving you time to close up the rocket after turning the altimeter on), and then a periodic "chirp" approximately once per second when the altimeter is ready to launch.

While sounding the launch ready "chirp", the altimeter will begin tracking ground level pressure, and will continuously update its internal ground reading to follow fluctuations in ground level pressure until time of launch.

The altimeter is ready to launch at this point.

Do not launch before the periodic "chirp" is heard or the altimeter will not function properly!

After flight the altimeter will report in this sequence:

- An extra-long tone to indicate the start of the reporting sequence.

- A three to six digit number representing the peak altitude in feet.
- A long separator tone followed by a two to five digit number representing the maximum velocity during the flight in miles per hour. This number, and its preceding separator, are reported in a higher pitch to differentiate it from the peak altitude number.
- A pause of 5 seconds, and then a 10 second warbling siren tone to aid in locating the rocket if it is hidden from sight in a tree, tall grass, etc.
- After a 10 second period of silence, the sequence repeats until power is disconnected. The flight's peak altitude is preserved when power is turned off, and will be reported every time power is turned on until a new flight is made.

Downloading Data to a Computer

If you have the optional USB Data Transfer Kit and a USB-equipped computer, you can download full flight data from the altimeter's last 31 flights to your computer. Instructions for installing the software and downloading the data are included with the data transfer kit. The download procedure is very simple and involves connecting a cable to the altimeter's "Data" port, turning the altimeter on, and selecting the flight you want to download. After a few seconds an altitude vs. time graph will appear with the data from your flight. You can also choose to display graphs of velocity, temperature, and battery voltage.

Changing Settings with a Computer

The Data Transfer Kit can also be used to modify several parameters that control how the altimeter functions.

The following descriptions assume that you have the software running and the altimeter connected to the computer and powered up. Select the "Settings" menu item from the "Altimeter" menu. A screen will appear with the current settings, altimeter model, altimeter serial number, firmware revision level, and total number of flights listed. *Note: You must make the initial connection to the altimeter while the last flight altitude and battery voltage are being reported; if you wait until the altimeter is making the "launch-ready chirp" it will not communicate with the computer. This prevents possible electrical noise from interrupting data recording during flight.*

Launch Detect

You can change the Launch Detect Altitude by selecting the text, entering a new number, and hitting "update". The Launch Detect Altitude controls the point that the altimeter recognizes liftoff and begins to acquire flight data. If a flight doesn't make it to this altitude no data will recorded and no altitude/velocity information will be reported when you recover your rocket.

The altimeter also stores 28 data points (1.4 seconds) of pre-liftoff data prior to the time that it reaches the launch detect altitude. This will include data back to the point that the rocket was stationary on the pad in most cases.

Valid settings range from 40 feet to 300 feet above ground level. Lower numbers allow data acquisition from low-altitude flights (e.g. smaller water rockets), while higher numbers provide more resistance to accidental triggering on the pad from wind gust-induced pressure fluctuations in the payload compartment. Factory default is 100 feet, which accommodates most flights and also provides considerable resistance to very strong winds (assuming that you have used properly sized Static Pressure ports as described earlier).

Powerup Delay

An additional delay can be inserted between the time that the altimeter finishes reporting battery voltage on powerup and when the "launch-ready chirps" start as the altimeter awaits launch. This is typically used when a power switch is not accessible from the outside of the rocket and additional time is needed after power is applied to provide time to close up the altimeter compartment and allow pressure to stabilize before the altimeter begins to look for a valid launch condition. If the altimeter is looking for pressure changes when you close up the payload compartment, pushing the rocket parts together can cause enough pressure fluctuation to trigger the altimeter, resulting in a false launch detection. If this happens, the altimeter will begin beeping out bogus altitude and velocity data instead of the normal "launch ready chirp" and it will not record the flight properly. In this case, remove the altimeter, turn it off and back on, and close the rocket back up *before* the chirp starts.

There is an unchangeable base delay time of 20 seconds built-in. The Powerup Delay adds additional time to this base delay. Acceptable settings are 0 (no additional delay) to 60 seconds. Factory default setting is 10 seconds additional for a total of 30 seconds.

Siren Delay

Shortly after landing, the altimeter begins its beeping sequence to report peak altitude and maximum velocity, with a pause of about 10 seconds before the sequence repeats. If the Siren Delay is set to a number other than 0 (disabled), the 10 second pause will be preceded by a delay as specified by the Siren Delay value, followed by a 10 second warbling siren from the beeper. This sound makes the rocket easier to locate, even if it is hidden from view by tall grass or other obstacles. The altimeter goes into a low power sleep mode while it is silent so that with the maximum siren delay of 120 seconds a full battery charge will continue to operate the altimeter for over two weeks. Even if you don't find your rocket the first day, you'll have many more opportunities before it goes silent!

Valid settings are 0 (siren disabled) to 120 seconds. Factory default setting is 5 seconds.

Telemetry

The telemetry option, when enabled, sends altitude information to the data port in real time during the flight. This information can be sent to a ground receiver via a user-supplied RF modem so you can see how high the rocket is at any point from the ground. It can also be used by other custom payload devices so that various functions can be controlled at different altitudes (air sampling, payload release, etc.).

The settings are controlled by a popup menu with three options:

Never: Telemetry is disabled, and no information is sent to the data port in real time.

OnPad: Telemetry is enabled. Altitude information is sent beginning at the same time as the start of the continuity check beeps and continues until the rocket has landed.

OnLaunch: Telemetry is enabled. Altitude information is sent beginning at the launch detect point and continues until the rocket has landed.

More information about the serial port settings and the telemetry data format is available on page 16.

Tips for Achieving Best Accuracy

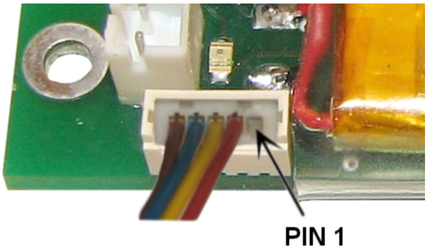
- Use four static sampling ports instead of just one. Make sure they are sized and positioned according to the instructions in the previous section. All barometric altimeters base their altitude measurements on the air pressure surrounding the rocket, so getting a clean, turbulence-free sample is essential. A single hole, especially if it is over-sized, will introduce pressure fluctuations whenever the rocket deviates from its normal trajectory. Four evenly-spaced holes will minimize this effect.
- With a properly designed rocket and motor combination, the parachute should eject at apogee (peak altitude), when the rocket is nearly stationary. This will guarantee a minimum of turbulent airflow around the rocket, and hence the cleanest, most accurate data. If you eject your parachute substantially before apogee, the rocket will still be traveling at a high rate of speed, which will degrade the accuracy of any possible measurements due to the massive fluctuations in pressure. In addition, deploying the chute while the rocket is traveling at high speed can potentially damage your rocket due to a zippered body tube, stripped chute, or broken shock cord.

  Ejecting at apogee is best, slightly after apogee is OK, but never before apogee if you can avoid it. Ejecting before apogee will always guarantee a loss in potential altitude. It will also introduce significant degradation in altitude repeatability since the final altitude will then be determined by the (in)consistency of the motor's ejection delay.

- Use a *long* shock cord. This will allow the ejected payload section and nose cone to slow gradually rather then being jerked to a stop when the cord comes to full extension. Again, minimizing abrupt changes in the rocket's trajectory will result in the smoothest, most accurate data.

Telemetry Information

The data connector pinout is shown below. All signals are 3.3V CMOS logic level, and the lines idle “high”. Please double-check your cables before connecting anything to the data port; make sure that the *input* to your device is connected to the altimeter’s *output*. Do not connect anything to the pins marked “NC”. Do not ground any pins other than pin 5, and never apply an external voltage to any of the pins.



Pin#	*Function*
1	N/C
2	+3.3V (do not use)
3	RX data input (unused)
4	TX data output
5	GND

Serial port settings should be configured for 9,600BPS, 8 data bits, no parity, and 1 stop bit. Output data format from the altimeter is ASCII text based, with a <CR> and <LF> character appended to the end of each line.

When telemetry data is selected to start “OnPad”, the first value sent will be the approximate ground elevation, and all subsequent data will be AGL (Above Ground Level) altitudes:

880<CR><LF>	{first data point is launch elevation MSL}
0<CR><LF>	{all subsequent data points are AGL altitude}
0<CR><LF>	
0<CR><LF>	
5<CR><LF>	
25<CR><LF>	
56<CR><LF>	
99<CR><LF>	
149<CR><LF>	
198<CR><LF>	
248<CR><LF>	
300<CR><LF>	
349<CR><LF>	
398<CR><LF>	
447<CR><LF>	
497<CR><LF>	

When telemetry data is selected to start “OnLaunch”, all data will be AGL altitudes:

198<CR><LF>	{all data points are AGL altitude}
248<CR><LF>	
300<CR><LF>	
349<CR><LF>	
398<CR><LF>	
447<CR><LF>	
497<CR><LF>	

Testing

A simple apparatus for testing the altimeter can be made with a small jar and a length of plastic hose. Drill a hole in the center of the jar's lid and insert one end of the plastic hose. Glue hose in place to achieve a tight seal (hot melt glue works well).

Turn on the altimeter and place it in the jar. Tighten the lid and wait until you can hear the periodic beep from the altimeter indicating launch readiness. Suck on the free end of the plastic hose to create a vacuum within the jar. The altimeter will sense this as a launch condition and the beeping will stop. When you stop sucking on the hose, the altimeter will sense apogee as the pressure stabilizes. Open the hose and allow air to bleed back into the jar and the altimeter will sense descent. The altimeter will then beep out the "altitude" that your vacuum was able to create within the jar.

Cautions

- Do not touch circuit board traces or components or allow metallic objects to touch them when the altimeter is powered on. This could cause damage to your altimeter.
- Charge the battery using the supplied charging cable; never exceed 15 volts charging voltage.
- Do not charge the battery when the altimeter is colder than 32F or hotter than 115F.
- Do not charge the battery or use the altimeter if the battery has been punctured or shows signs of damage; contact PerfectFlite for details on obtaining a replacement battery.
- Provide adequate padding fore and aft of the altimeter for protection in the event of a crash or excessively hard landing.
- Do not allow the altimeter to get wet. Only operate the altimeter within the environmental limits listed in the specifications section.
- Do not rupture pressure sensor diaphragm with excessive pressure or sharp object.

Specifications:

Power:	3.5V to 4.2V, built-in 3.7V LiPo battery
Current consumption:	1.5 ma
Battery life:	100 hours (40% pre-flight, 60% post-flight)
Launch detect:	40’ to 300’ AGL, default is 100’
Maximum altitude:	100,000’ MSL
Altitude resolution:	1’ up to 38,000’MSL
	< 2’ to 52,000’MSL
	< 5’ to 72,000’MSL
Analog to Digital Converter:	24 bit Delta Sigma
Calibration accuracy:	+/- 0.05% typical
Measurement precision:	+/- (0.1% reading + 1 foot) typical
Sample rate:	20 samples per second
Operational temperature:	-10C to +60C (14F to +140F)
Charging temperature:	0C to +45C (32F to +113F)
Dimensions:	2.50”L x 0.59”W x 0.45”H
Weight:	0.26 oz. including battery

Warranty

All PerfectFlite products include a full three year/36 month warranty against defects in parts and workmanship. Should your PerfectFlite product fail during this period, call or email our Customer Service department for information about returning your product. The warranty applies to the altimeter only, and does not cover the rocket, motor, or other equipment. This warranty does not cover damage due to misuse, abuse, alteration, or operation outside of the recommended operating conditions included with your product. Broken pressure sensor diaphragms due to puncture or exposure to ejection charge pressure/hot gasses are NOT covered under this warranty.

Liability

Due care has been employed in the design and construction of this product so as to minimize the dangers inherent in its use. As the installation, setup, preparation, maintenance, and use of this equipment is beyond the control of the manufacturer, the purchaser and user accept sole responsibility for the safe and proper use of this product. The principals, employees, and vendors of the manufacturer shall not be held liable for any damage or claims resulting from any application of this product. If the purchaser and user are not confident in their ability to use the product in a safe manner it should be returned to the point of purchase immediately. Any use of this product signifies acceptance of the above terms by the purchaser and user.