Parrot V2.0-2.1 User's Manual

The Featherweight Parrot altimeter, first introduced as a single-deployment recording altimeter in October, 2007, has been significantly upgraded into a 3-output programmable flight controller, while still preserving the original Parrot's small size and high quality and quantity of data recording. This draft of the user's manual was last updated on August 3, 2008.

Description and Instructions:

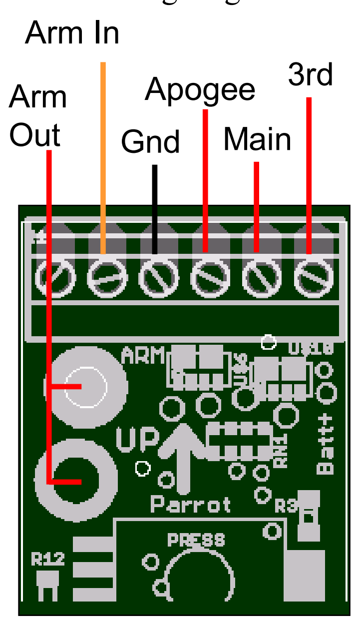
Mounting:

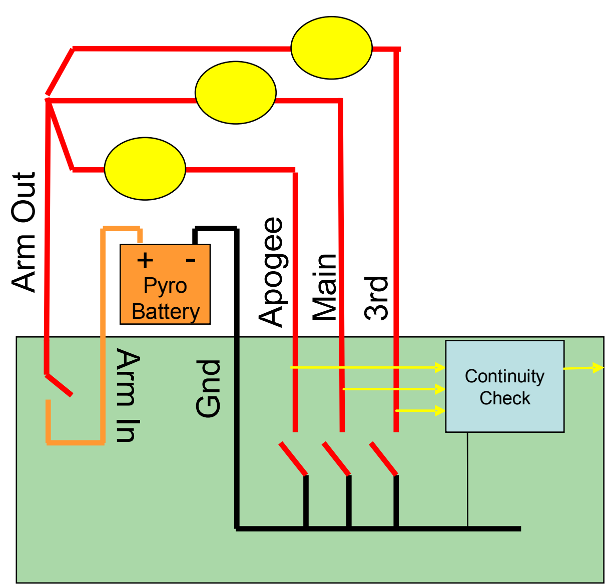
The Parrot V2 is mounted with its long axis parallel to the direction of flight. As an upgrade for version 2.0, either end can be up (the up arrow printed on some versions of the board can be ignored.) One of the mounting holes accommodates a #2 screw, and the other accommodates either a #2 or #4 screw. Two #2-56 screws, two spacers and two #2-56 nuts are provided with the Parrot V2.0. On some versions of the Parrot V2, the buzzer on the underside is square and can be used in place of one of the spacers. For these altimeters, a washer is recommended for use under the other mounting screw and spacer to ensure the Parrot is parallel to the direction of flight for best accelerometer performance.

The Parrot can also be mounted without the screws in weight-constrained applications, using zip ties or by simply gluing the altimeter onto an avionics sled. Like the original Parrot, the front edges of the Parrot 2.0 can be sanded down so that the Parrot V2.0 can be friction-fit into an 18mm nosecone, though the new version would also require removal of the deployment screw terminals to accomplish this.

Deployment Connections:

The following diagrams show how to connect the Parrot for deployments:





A description of the default program for the 3 outputs is given in the deployment programming section of this document.

Caution:

- The arm switch is isolated from the rest of the board and its use is optional. If it is not used, however, the use of an external mechanical arm switch is strongly recommended to eliminate the possibility of accidental charge ignition before the rocket is set up at the pad.
- No reverse polarity protection is provided. If you wire up a charge and battery backwards to the Parrot, the charge will fire as soon as the arm switch is closed.
- No deployment power source is provided. Please do not attempt to use the Parrot's built-in battery to fire a charge. I have verified that attempting to ignite an igniter from the altimeter's own battery will result in an altimeter reset every time. The Parrot's deployment feature is intended to be used with a separate external battery, up to 20 V. The FET used for the deployment output is rated for 4.1 Amps for pulses < 5 seconds, and has an Rds(on) of about 60 mOhms. A 9V battery is recommended.
- Do not use this altimeter for deployments until you have performed a ground test to verify the deployment charge sizing and you have verified that the Parrot will work correctly in your rocket and with your pre-launch procedures. Flying the Parrot in a rocket with motor ejection or another altimeter you are familiar with is strongly recommended for your first Parrot flights. Each Parrot has passed a basic functional test before shipment, but you alone are responsible for ensuring that your altimeter works for your application and that your rocket will fly safely.

Power:

The Parrot is powered by a single lithium polymer battery, with a normal range of voltage of 3.0 to 4.2 V. It is electrically connected to the board via the Phillips head screw switch on the front of the board. With the screw switch backed off about ½ turn, the battery is electrically disconnected from everything but the screw head and the nut on the back of the board. In this state, the battery should be o.k. for months.

The following is applicable to Parrot version 2.0, identifiable by an arrow near one end labeled "up":

> With the screw switch snugged down, the battery voltage will be applied to several circuits on the board, but the discharge rate should still be extremely low. This is standby mode. The board should be good for this state for days without recharging.
>
> Pushing the button on the side of the board will wake the Parrot up from standby mode, and into operational mode. The Parrot can be operational for several hours between recharges.

The following is applicable to Parrot version 2.1, shipped after July 20, 2008 and does not have an "up" arrow printed on it:

With the screw switch snugged down, the Parrot will immediately boot up into prelaunch mode, and its beeps indicate it is ready for launch. The screw switch is the only means of turning the Parrot on and off. The Parrot is ready for launch for about 2 hours whe

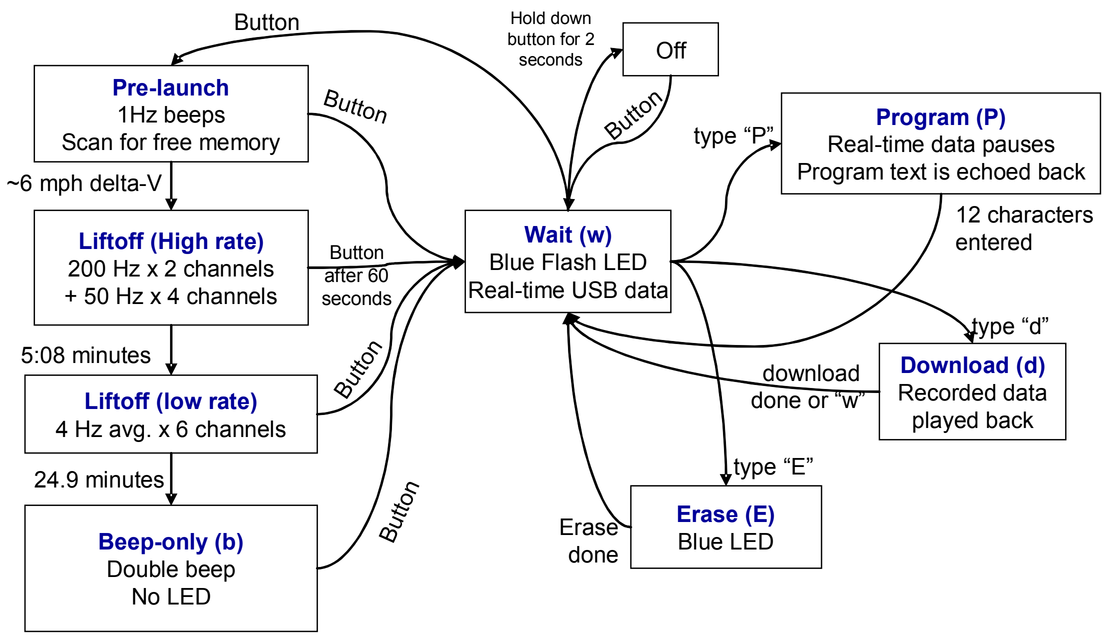
Plugging a USB connector into the Parrot while the screw switch is snugged down will begin charging the battery. The current is limited to 100 mA, or the current required to maintain 4.2 V, whichever is lower. It should take about 10-60 minutes to fully recharge the battery, depending on the state of charge of the battery at the end of a flight . Note that the battery will not charge unless the screw switch is turned on. When the battery is charging in constant-current mode, a red LED near the aft end of the altimeter will light up. If the Parrot is plugged in to a USB cable with the screw switch open (loose), the charging LED will light as if the battery is being charged, but no charging will occur. Also note that the head of the screw switch makes contact with the top surface of the board to complete the circuit, and installation of the screw upside down will not connect the battery.

There is separate cell protection circuitry built into the cell that shouldn't ever become active. If the battery is discharged down to 3.2 volts, the protection circuitry will prevent a battery overdischarge.

Don't attempt to charge the cell except via the provided USB connection. Don't abuse the cell, including puncturing it, exposing it to flame, etc. If the cell ever appears swollen, it's irreparably damaged. Disconnect it from the charging source and send me an e-mail.

Basic operation:

The operational states of the Parrot are shown in the state diagram below.



In a typical scenario, you will start with your Parrot connected to your computer. Close the screw switch [and for version 2.0, push the button] to turn the Parrot on. The Parrot will be in wait mode, with a short 1 Hz blue LED flash. Real-time data will be visible in the HyperTerminal window. (See HyperTerminal setup for details) Verify that there is space available to record a flight (See commands for details) and that the real-time data looks reasonable. Change the deployment program if necessary (see Deployment programming for details). Disconnect the Parrot and open the screw switch. Now you're ready to take the Parrot to the launch range.

At the range, turn on the Parrot again to make the Parrot start looking for liftoff in pre-launch mode. You can tell the Parrot is in pre-launch mode by its 1 Hz beep. In the pre-launch mode, data is being gathered at the full rate into a buffer (0.44 to 0.88 seconds long), but is not yet being written to flash memory.

If the Parrot is being used for deployments, arm the charges with the Parrot's built-in screw switch or with an external switch when the rocket is in a safe area. The single 1 Hz pre-launch beep will turn to a double beep while charge continuity is detected on one or more of the outputs. The charge continuity voltage reading is also recorded in flight.

When the Parrot detects a change in velocity of about 6 mph, it will go into Liftoff mode and start recording the data into flash memory. When you recover the rocket, push the button to end the flight recording. Note that the Parrot ignores the button for the first 60 seconds of the flight. For up to the first 5.5 minutes of the flight, it records the two accelerometer axes at 200 Hz, and the other 4 channels at 50 Hz. After that, it will record all channels at 2 Hz, which will last another 29 minutes. If you haven't pushed the button again by this time, the flash recording will stop and the Parrot will perform a double beep to help locate the rocket, until the battery power gets too low.

(Note: Whenever the Parrot is beeping, the beeping can be turned off by pushing the button to put the Parrot into wait mode.)

After the flight, the Parrot can be powered off without losing the recorded flight data. It can also record additional flights, without danger of over-writing recorded flights. Once the 5 flight memory banks are full, the Parrot needs to be erased via computer command before any more flight data is recorded.

When you get back to your computer and plug the Parrot back in, use the HyperTerminal text capture feature to save the flight data into a file. HyperTerminal has a text capture feature using the menu command: "Transfer/Capture Text...". Type "d" to start downloading the data. The download rate has been improved to be about 40% of real-time for the high-rate portion of the data, so a 1-minute flight will download in about 2.5 minutes. The download can be interrupted at any time by hitting the "w" key to put the Parrot in Wait mode.

When you see a lot of -1's start scrolling up, that means that you've gotten to the end of the recorded data.   (In case you're curious, erased flash memory is all 1's, which translates to -1 in two's complement notation). If you let the Liftoff mode get to the end of the flight, the Parrot will go back to wait mode on its own and you'll see the blue flash. If you want to download a different flight, just type the flight number you want (1-5), and check to see that the rightmost column has changed to the flight index you're interested in.

Open the file in Excel, and paste into the template. When you're sure you've downloaded the data you meant to download, go back to HyperTerminal and type "E" to erase that flight's data to make room for another flight. As a protection against inadvertent data loss, the Parrot won't erase or over-write any flight's data on its own, so you have to clear each flight manually via USB command. If there aren't any clear flights when you try to go to Prelaunch mode, the Parrot will remain in wait mode. This is a common situation that is easily taken care as long as you're near a computer, but impossible otherwise. So make sure you have free space available before you go out to the range if you don't have a laptop with you!

***Commands*:**

The Parrot responds to the following commands, typed while in HyperTerminal. Note that the commands are case-sensitive:

[1 through 5]	Flight Index: Set the current flight index
d	Download data from the current flight index.
E	Erase the data from the current flight index.
w	Go to wait mode.
0	Flight index 0: Select read-only memory bank
P	Program the deployment logic, timers, and altitudes.

Flight Index 1 through 5: Sets the current flight index, which selects which memory bank to download or erase. Memory banks 1 through 5 are available for recording flight data.

Download: Downloads the data from the current flight index. When the end of a flight memory bank is reached, the Parrot will return to wait mode.

Erase: Permanently erases a flight memory bank. This command is the only way to clear a flight memory bank for future recording.

Wait: Interrupts a flight mode or a download to put the Parrot in wait mode. The blue LED flashes at 1 Hz while in wait mode and program mode.

Bank 0: Typing “0” selects memory bank zero for downloading. The erase command has no effect while bank 0 is selected. This memory bank is used only for storing the Parrot’s calibration coefficients, calibration data, and deployment program. It can be read back using the download command, and decoded using in the calibration coefficient tab of the post-processing template.

Program: See the following detailed description of programming the Parrot:

***Flight Event Register and Deployment Programming*:**

The Parrot uses on-board measurements and calculations to identify several flight events. These are recorded in the flight event register at 50 Hz, and are also used to trigger deployment events. The following table describes the flight events and the default deployment program for the 3 outputs:

Flight Program Deployment Logic

	User Inputs			
	Apo Output	Main Output	3rd Output	Flight Event Comments
Liftoff detected (required)	Check	Check	Check	No deployments will fire unless liftoff is detected.
Acceleration < 0 (burnout)				Only true while accel < 0
Time < user timer value				Useful for sustainer verticality check (only ignite if high enough before a certain time)
Time > user timer value	Check	Check	Check	Time from liftoff detection
Pressure change from liftoff < user Pressure Value 1		Check		Altitude above ground varies depending on launch altitude
Pressure change from liftoff > user Pressure Value 2				Useful for sustainer verticality check (only ignite if high enough before a certain time)
Pressure increasing		Check	Check	Based on filtered pressure
Pressure decreasing				Based on filtered pressure
Velocity < 200mph	Check	Check	Check	based logic to avoid Mach transition anomalies
Velocity < 0	Check			Integrated velocity based on axial accelerometer
Hold the switch closed continuously			TRUE	Select a continuous output

A deployment channel is triggered when all of the checked flight events are true. Note that some flight events, like acceleration < 0, can switch from true to false and back again throughout the flight. Other events, like time > user timer value, can have no more than one transition during the flight.

Each output will be activated for 1 second, unless the “continuous” option is selected for that output. The continuous output option is designed to turn on a non-deployment load, like a transmitter. This option is not recommended for use with deployment charges because charges can have residual shorts that could drain the pyro battery for future use and/or damage the FET switch.

Caution:

A fresh 9V battery powering a short circuit continuously can exceed the 2.2 Amp, rating of the FET for continuous current at 85C and permanently damage the altimeter. Ensure that any load connected to an output programmed with the continuous option draws less than 2.2 Amps through the FET. The FET is rated for 4.1 Amps for pulses of 5 seconds or less.

The flight program is modified by changing the values of the user inputs in the "Programming Calcs" tab of the Excel post-processing template to either "Check" or blank. The user-modifiable values for altitude and time can be programmed by changing the cells with green backgrounds in the lower part of the sheet that looks like:

Timer and Pressure User Values

	Inputs in Green		Comments
Pad altitude	Feet	2000	Launch pad altitude above sea level
Height #1 Above Pad	Feet	600	Deployment when below this altitude
Height #2 Above Pad	Feet	6000	Deployment when above this altitude
Time from liftoff detection	Seconds	1	Used for > and < checks. 0.16 sec resolution, up to 20 seconds
Pad Pressure	atm	0.9298	Fraction of atmophere above pad
Delta pressure 1	atm	0.0203	Fraction of the atmosphere between height#1 and the pad
Delta pressure 2	atm	0.1870	Fraction of the atmosphere between height#2 and the pad

The Excel worksheet then generates the text string to be entered into the Parrot to program the logic and time and pressure values, as shown below:

Text String for Parrot Programming (Case sensitive)

vhrJvZ@L@rNT

This text string programs all of the deployment logic, including the altitude and time settings, into the non-volatile memory of the Parrot. To enter this information, just type "P" to enter program mode, and the real-time data from the Parrot will pause. Type the 12 characters generated by Excel (case sensitive) and after the 12th character, the Parrot will store the program in flash memory and the real-time data will resume.

Here are some examples of alternative programs for other uses of the Parrot:

Deployment Logic Examples

	Default Program						
	Accel-Based Apogee	Low-Altitude Deploy	Baro-Based Apogee	2nd Stage at Burnout	2nd Stage with Vertical Check	Pure Timer	Output Disabled
Liftoff detected (required)	Check	Check	Check	Check	Check	Check	Check
Acceleration < 0 (burnout)				Check			
Time < user timer value					Check		Check
Time > user timer value	Check	Check	Check			Check	Check
Pressure change from liftoff < user Pressure Value 1		Check					
Pressure change from liftoff > user Pressure Value 2					Check		
Pressure increasing		Check	Check				Check
Pressure decreasing					Check		Check
Velocity < 200mph	Check	Check	Check		Check		
Velocity < 0	Check						
Hold the switch closed continuously			TRUE				

To verify that the Parrot is programmed with the desired settings and values, the settings can be downloaded from flight 0 and decoded within the analysis template. First type 0 to select flight memory 0, and then start capturing text into a file as if downloading a flight. Type “d” and the programming and calibration area of nonvolatile memory will start scrolling. All of the useful information is contained in the first 2 seconds of flight 0 data. Open the captured text file, and copy and paste the data, starting with the row labeled with time=0, into the tab of the analysis template called “Program and Cal Coefficients.” The following table will be updated with the program from your Parrot:

Program Logic from Flash Memory

	Apo Output	Main Output	3rd Output	Flight Event Comments
Liftoff detected (required)	**Check**	**Check**	**Check**	No deployments will fire unless liftoff is detected.
Acceleration < 0 (burnout)				Only true while accel < 0
Time < user timer value				Useful for sustainer verticality check (only ignite if high enough before a certain time)
Time > user timer value	**Check**	**Check**	**Check**	Time from liftoff detection
Pressure change from liftoff < user Pressure Value 1		**Check**		Altitude above ground varies depending on launch altitude
Pressure change from liftoff > user Pressure Value 2				Useful for sustainer verticality check (only ignite if high enough before a certain time)
Pressure increasing		**Check**	**Check**	Based on filtered pressure
Pressure decreasing				Based on filtered pressure
Velocity < 200mph	**Check**	**Check**	**Check**	Should always be checked when using Baro-based logic to avoid Mach transition anomalies
Velocity < 0	**Check**			Integrated velocity based on axial accelerometer
Hold the switch closed continuously	**False**	**False**	**True**	Select a continuous output

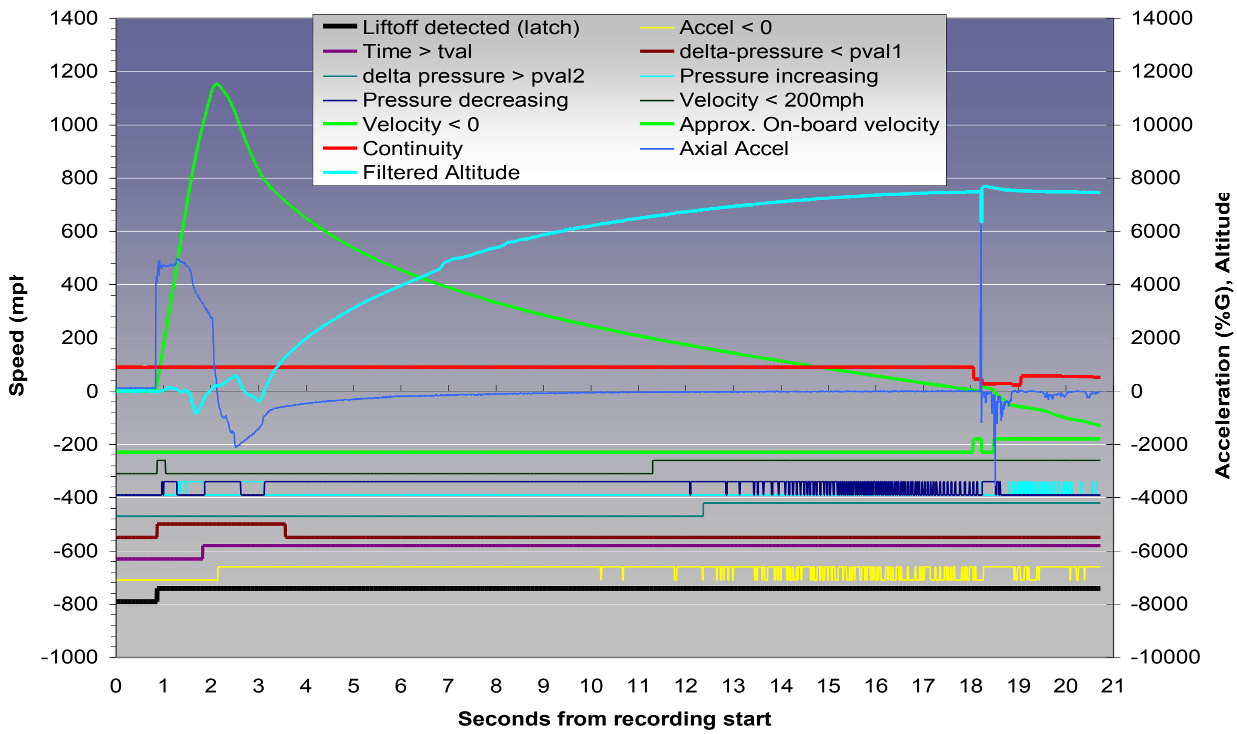
Timer and Pressure Values from Flash Memory

Timer value from Liftoff	0.96	sec	From flash program
Delta pressure 1	0.02	atm	Fraction of the atmosphere between height#1 and the pad, from flash
Delta pressure 2	0.1872	atm	Fraction of the atmosphere between height#2 and the pad, from flash
Pad Altitude	8593	feet	For converting deployment pressure to altitude
Pad Pressure	0.7261	atm	Fraction of atmophere above pad
Delta altitude #1	725	feet	Trigger height above pad #1
Delta altitude #2	7547	feet	Trigger height above pad #2

Note that this area of the analysis template is for reading back the programmed data. It is not used to change the program.

Interpreting the Flight Event Register:

The Parrot V2 records the flight event register and the deployment charge continuity during the flight. Although there are some (but not all) altimeters on the market that record the times of deployments, the Parrot goes a step beyond to record and display all of the flight events that are used to determine when a deployment happens, along with the continuity voltage that indicates exactly when the ematches and ignitors were turned on. This data is useful for verifying proper operation of the Parrot in a test flight, and for getting insight into what caused an unexpected event. The following is a graph of the flight event register events using example data found in the analysis template:



The lines at the bottom with rectangular bumps represent the different flight events that are recorded in the flight event register. Before liftoff, all the events are recorded as false. After liftoff is detected, when a line is in a high state, the condition it represents is true. When all the conditions that are programmed to be checked are true, then the deployment charge will fire. For example, liftoff was detected at about 1 second from the start of recording. The velocity was less than 200 mph until about ½ second after liftoff, and then it went back under 200 mph about 11 seconds from the start of recording. During that time, the velocity check inhibited the baro-based 3rd deployment, which was important because Mach effects were causing the pressure reading to rise and fall. When the accel-based estimated velocity went below 0 for the first time around 18.5 seconds (green line), the apogee deployment switch closed (visible in the red continuity reading) and 0.2 seconds later the charge fired (as seen by the pressure and accel spikes).

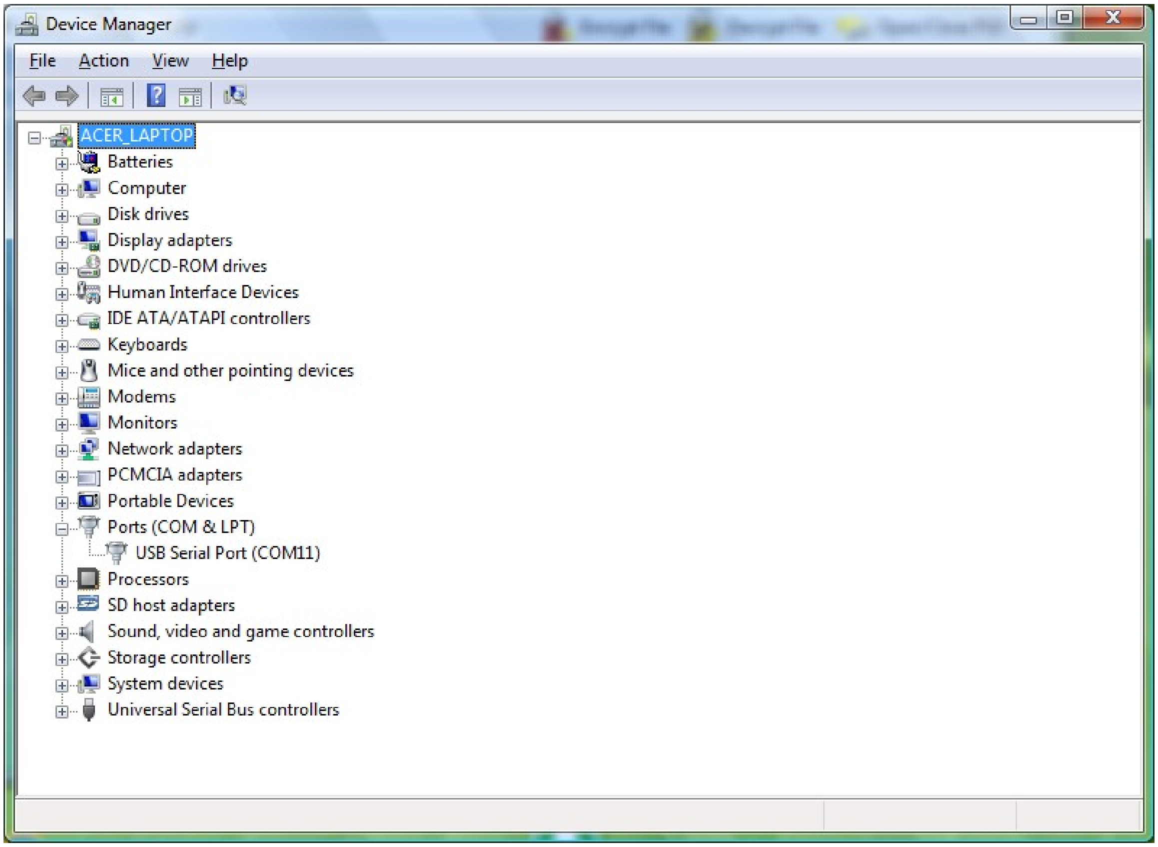
Notes on liftoff detection and velocity measurement:

The Parrot V2 has several new features to prevent accidental liftoff detection. In prelaunch mode, the Parrot uses a filtered value of the acceleration measurement to measure gravity at 1 Hz and compensate for any accelerometer sensor offset. If the Parrot senses that it is being dropped (sensed accel between -0.8 and +0.8 Gs), it suspends the offset updates. If it senses that it is upside down (< -.8 Gs), it reverses its sign convention so that down is now up, and it will function normally in that orientation (new feature unique to the Parrot V2). If it measures acceleration > 3 Gs, the Parrot integrates the difference between the measured value and the prelaunch filtered value to calculate the velocity. When the velocity reaches a threshold of about 6 mph, the Parrot detects liftoff and continues to integrate the sensed acceleration minus the measured offset for any value of the sensed acceleration, using the previous values for the sign convention and offset. This set of features provides near-immunity to drops or bumps, a very accurate velocity estimate, and the unique capability of operation with either end up.

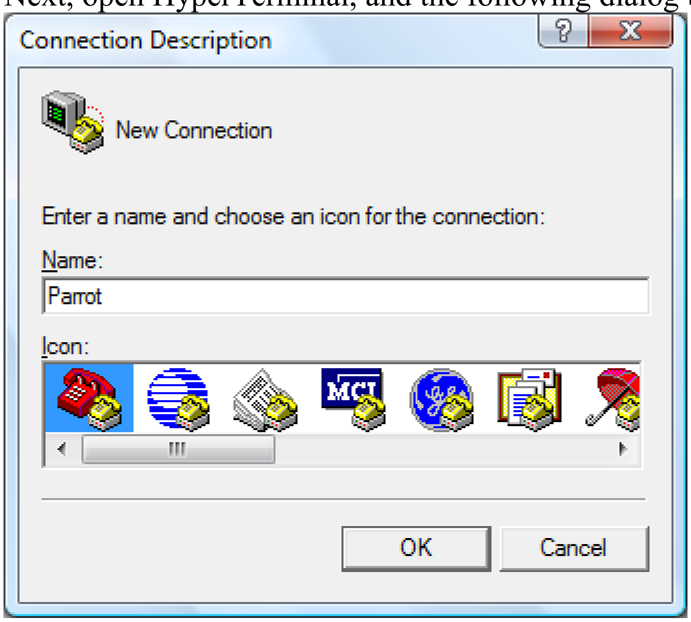
HyperTerminal Setup:

The Parrot communicates real-time data and recorded flight data using a modem interface program such as HyperTerminal. HyperTerminal is included with Microsoft Windows versions through Windows XP, and is also available as a free download for use with Microsoft Vista. Other modem interface software is available for the Macintosh. This section will focus on HyperTerminal.

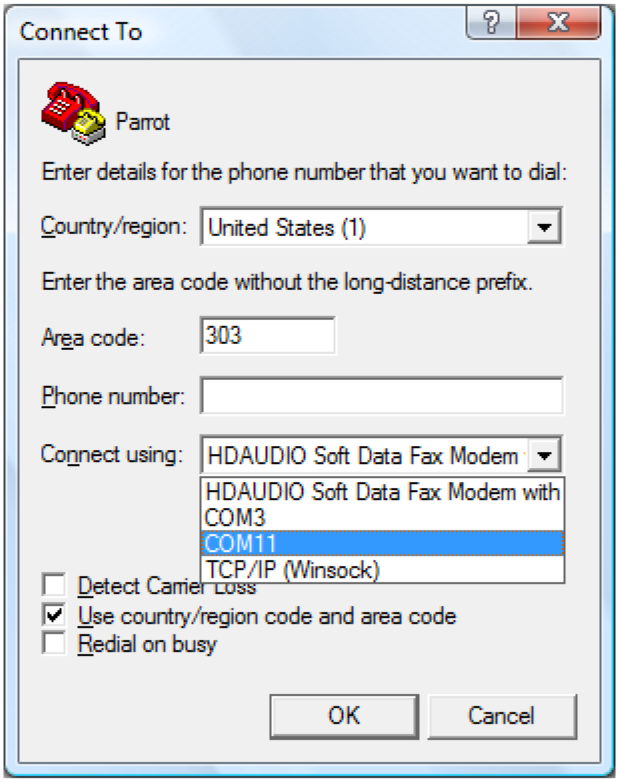
The Parrot uses a USB interface chip from FTDI that allows the Parrot's microcontroller to output data via USB. The FTDI chip has drivers available for PC and Macintosh computers for passing serial data back and forth over a USB connection. Download these drivers from FTDI, using the link at www.featherweightaltimeters.com. Install the drivers on your computer before plugging in the Parrot for the first time. When you plug in the Parrot, Windows will complete the driver installation, and the Parrot should show up as one of your computer's COM ports. You can verify this using the Windows Device Manager, which is available from the control panel via the System icon. The following is a screen shot of the device manager with the hardware and drivers correctly installed:



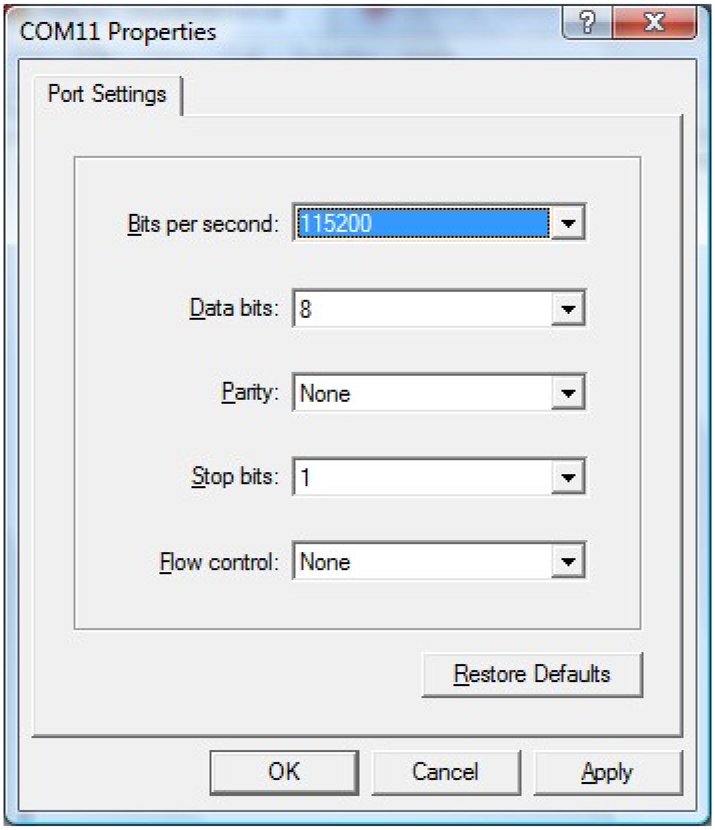
Next, open HyperTerminal, and the following dialog box comes up:



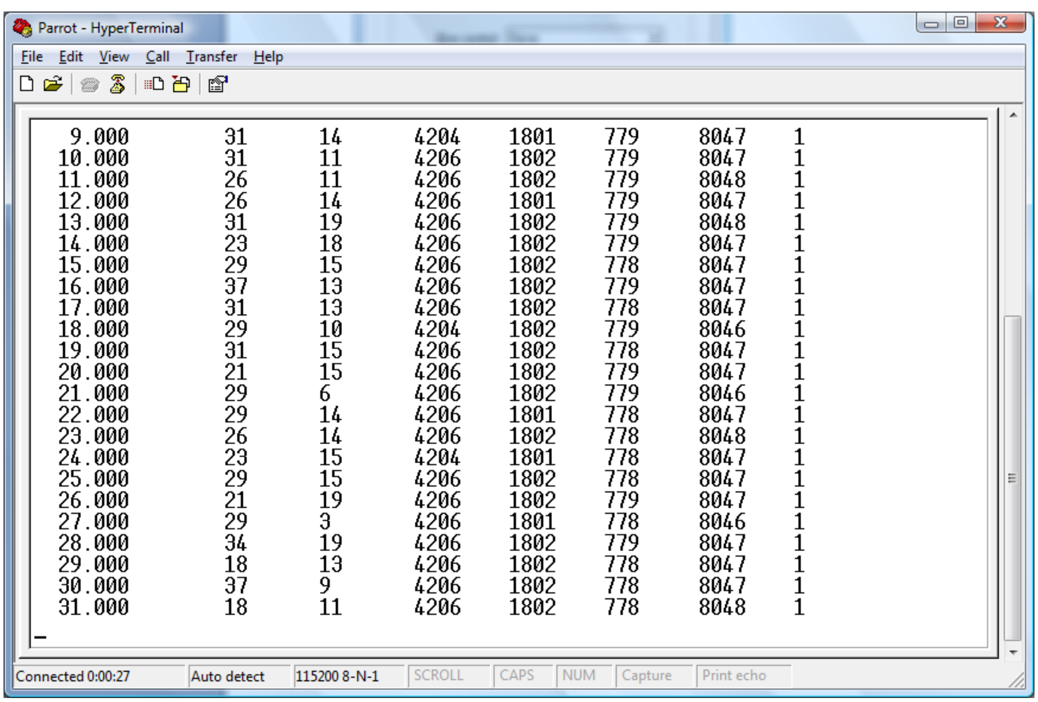
Choose a name that you will use to re-load the interface settings, for example, "Parrot." Hit "OK". In the next dialog box, ignore the dial-up information and select the highest available COM port. Note that in your system, the COM port associated with the Parrot is unlikely to be COM11.



In the next dialog box, select the data rate of 115200 bits/second and hit OK. Be sure the flow control is set to "None" and that the other settings are as shown below.



Next, the communication window will appear. Click the disconnect icon, (phone hanging up) followed by the connect icon (phone). Push the button on the Parrot to put it in wait mode, if it's not there already, and real-time data should start flowing:



The data columns and units are the following:

Time	Axial Accel	Lateral Accel	Continuity Voltage	Flight Event Register	Temperature	Pressure	Flight Index
Seconds	% Gee	%Gee	millivolts	Flight event bits	degF x10	Atm, x 10,000	0-5

So in the figure above, the Parrot has been on for 31 seconds, and is measuring 0.18 g's axially and 0.11 g's laterally. The continuity measurement is 4.206 V, the flight event register is 1802, the temperature is 77.8 degrees F, the pressure is 0.8048 standard atmospheres, and the flight index is 1.

Calibration and Accuracy:

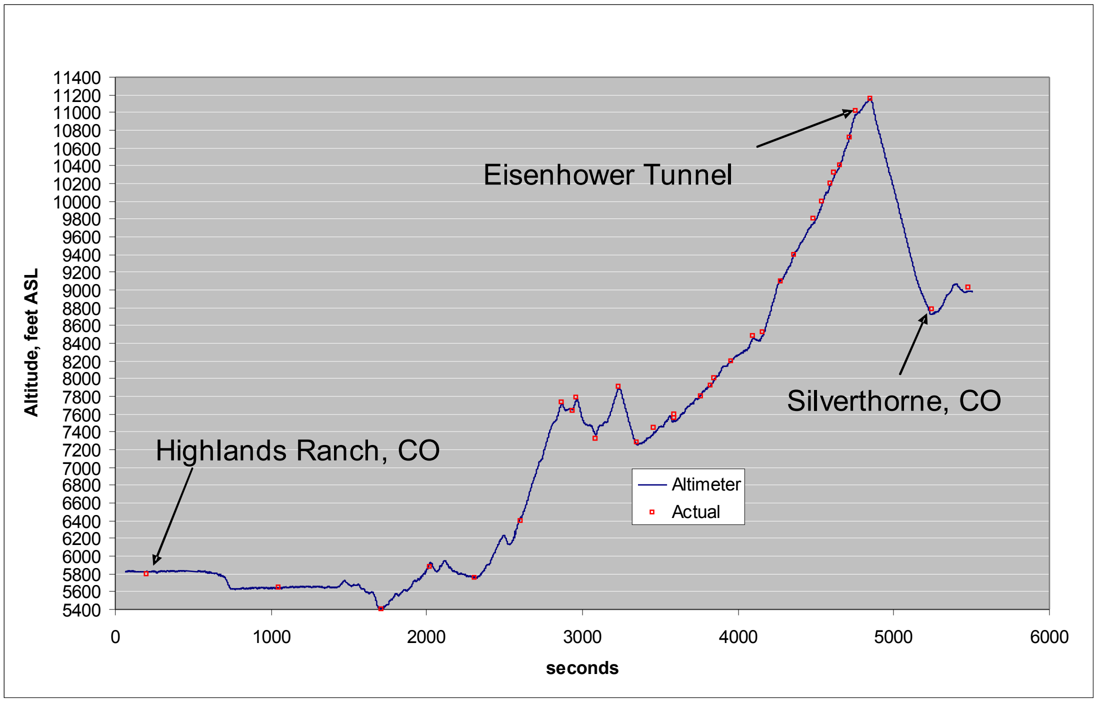
The accelerometer and the pressure transducer are both significantly affected by temperature. Typical variations in the scale factor for the accelerometer over a 40 F range are 1.6% for the accelerometer, and 3% for the pressure transducer. Without temperature compensation, the measured altitude on a 5,000 foot flight could be off by hundreds of feet on a particularly hot or cold day.

For this reason --and unique to the Parrot, as far as I know-- full calibrations of the 2 axes of the accelerometer and the pressure transducer were conducted under two different temperatures (approx. 40 F and 100 F). The Parrot's on-board temperature sensor measured the temperature during these calibrations, which was used to derive calibration adjustment coefficients for both the slope and offset of each measurement. These temperature adjustments, as well as the calibration coefficients themselves, are unique for each altimeter, and were measured in the fully-assembled configuration. The Parrot flight code adjusts the slope and offset used in each sensor 50 times per second during the flight, based on the measured temperature.

The reference source for the accelerometer calibration is Earth's gravity. Automated placement of the accelerometer part, as well as careful leveling during the calibration, ensures that averaged measurement of the Earth's gravity is repeatable within 1 count (.037 G axial, .018 G lateral). You will notice some noise in the acceleration signal. This is due to an intentional lack of filtering between the sensor and A/D converter, to capture the full bandwidth of the accelerometer part, which has its own built-in filter with a 400 Hz roll-off frequency.

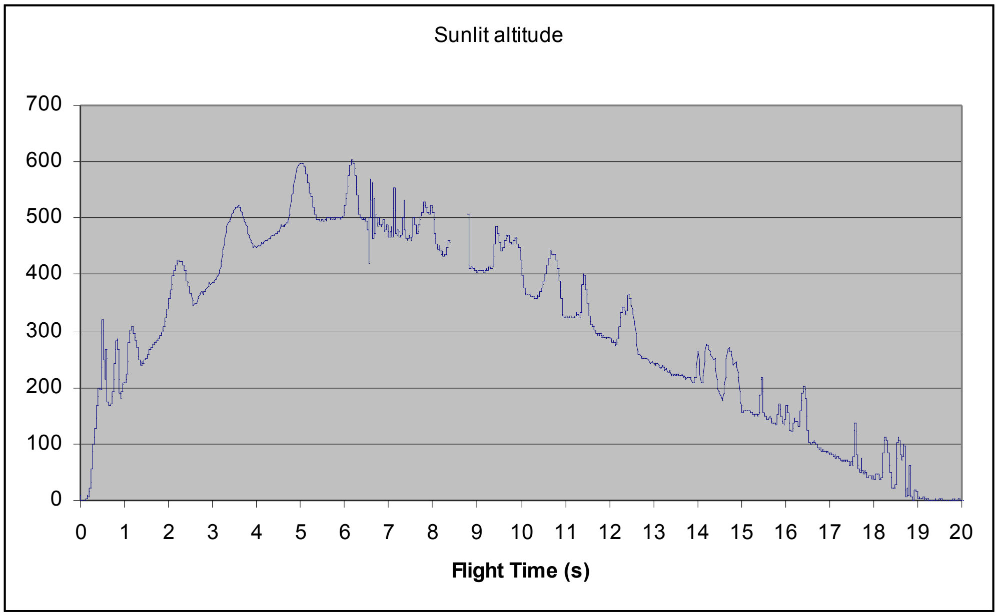
The pressure transducer was calibrated with a vacuum gauge that was calibrated against a 0.025% accuracy reference that is traceable to NIST standards. The pressure in the altitude chamber used in the calibrations was adjusted to within 0.1% (~28 feet at sea level) of the target pressure.

The first batch of Parrots were also subjected to a simultaneous simulated flight to determine the calibration repeatability. The standard deviation of the altitude for a batch of 18 altimeters was 9.5 feet during a 3600 foot simulated flight. One of the altimeters from the first calibration batch was also taken on a drive, while its real-time data was recorded, to validate the calibration process. The plot below shows the measured altitude (blue line) along with the altitude of landmarks taken from USGS-measured topographic maps (red dots).



This data was used to determine that the selected altimeter had an altitude scale factor that was low by 0.68%.

The pressure sensor is strongly affected by sunlight. For maximum accuracy, the Parrot should be kept in the dark, as would be typical with most avionics bay setups. The Parrot is designed, however, to also be used inside an 18mm nose cone. Note that in this application, an unpainted polystyrene nose cone reduces, but does not eliminate, this effect. If the Parrot is to be used with this type of installation, use it in a painted nose cone or cover the pressure transducer with tape and aluminum foil to eliminate this issue. Below is a plot of a Parrot flight in an unpainted polystyrene nosecone:



The rounded spikes in the data occurred when the pressure sensor was facing the sun. From this data it can be inferred that this rocket rolled 6 revolutions on the way to apogee.

Specifications:

	Featherweight
	Parrot
Axial Accelerometer Frequency	200 Hz
Lateral Accelerometer Frequency	200 Hz
Axial Accel Resolution (G's)	0.023735894
Lateral Accel Resolution (G's)	0.011867947
Axial Accel Range	+/-70 G
Lateral Accel Range	+/-35 G
Accel Temperature Offset Compensation	Yes
Accel Temperature Scale Compensation	Yes
Altitude Range (ASL, feet)	100k + ft*
Barometric Altimeter Frequency	50 Hz
Baro Altitude Resolution @ sea level	2.5 ft
Pressure Scale Temp. Compensation	Yes
Battery Voltage Measurement	50 Hz
Chip temperature	50 Hz
Spare Analog Hardware Ports	N/A
Altitude report without data download	N/A
Duration at high rate (minutes)	5:08
Duration with low rate (minutes)	24.9
Separate flights recorded	5
Data Download Rate	115 kbps*
User-modifiable Firmware?	Open-source
PC Transfer software	Hyperterminal (Free Download)
PC Graphing software	Excel template
Width	0.6"
Length	1.7"
Height	0
Mass, with battery	8.5 g
Deployment Outputs	1*
Flights before battery replacement	> 100
Audible mode indication	Yes
Price, including data transfer hardware	110
	0
	0
	*Transfer rate could increase to 345 kbps if custom transfter interface software is developed
	*The Parrot apogee deployment output is very bare-bones. No continuity checking; apogee deployment only; no reverse battery protection; separate battery and arm switch required.
	*100,000 ft altitude range option makes the altitude resolution 5 ft/count

To be updated for V2

Contact Information:

Email: Adrian@featherweightaltimeters.com
Or post a message at the forum at www.featherweightaltimeters.com
Or send a private message to "Adrian A" via www.rocketryforum.com or "Adrian_A" via www.ncrocketry.org