Maximum Recording Model Rocket Altimeter
For small rockets and aircraft

The following circuit was designed to provide an inexpensive, simple and easy to construct altitude recorder for small model and amateur rockets. Every effort was made to keep the design simple and within the capabilities of most amateur experimenters as well as to provide accurate and useful functionality. The circuit is small measuring 2 5/8 inches by 9/16 inches and weighs only about 0.3 ounces. It features PCB construction using standard size through-the-hole components. Also, it is cheap enough to be used in "risky" launches and durable enough to survive the occasional mishap.

Theory of operation:

The circuit is designed around a PIC 12F675 flash microcontroller (IC2). Pin 7 of IC2 performs an analog to digital conversion (A/D) of the voltage produced by T1 an absolute pressure transducer. The transducer used has a high level output (0.2 to 4.8 volt), which interfaces directly to the microcontroller. Pins 3 and 6 are used to output the altitude and operational data to LEDs. Switch S1 is used to trigger the output of the maximum-recorded altitude since "power-on". Power is provided by a 23A "lighter" battery and IC1, a linear voltage regulator.

The microcontroller program is written in Microchip assembler using their MPLAB-IDE development software and programmed on a microchip Flash Starter Kit. The program is composed of a series of subroutines, which should make the program easy to modify if the builder so desires. A free copy of the program can be downloaded from jbgizmo.com or a preprogrammed microcontroller can be purchased from the same source.

The output of the circuit is in A/D units (0-1024) and must be converted to an altitude measurement mathematically. This mathematical calculation is described in detail in the operational portion of this document. An Excel spreadsheet chart is available for download from jbgizmo.com, which makes computing the altitude easy and it is more suitable for field use.

The Pressure transducer output equation:

Vout=Vs(0.009P-0.095)+- error
P=pressure in kPa
Vs=5 volt
Temp= 0-85 C

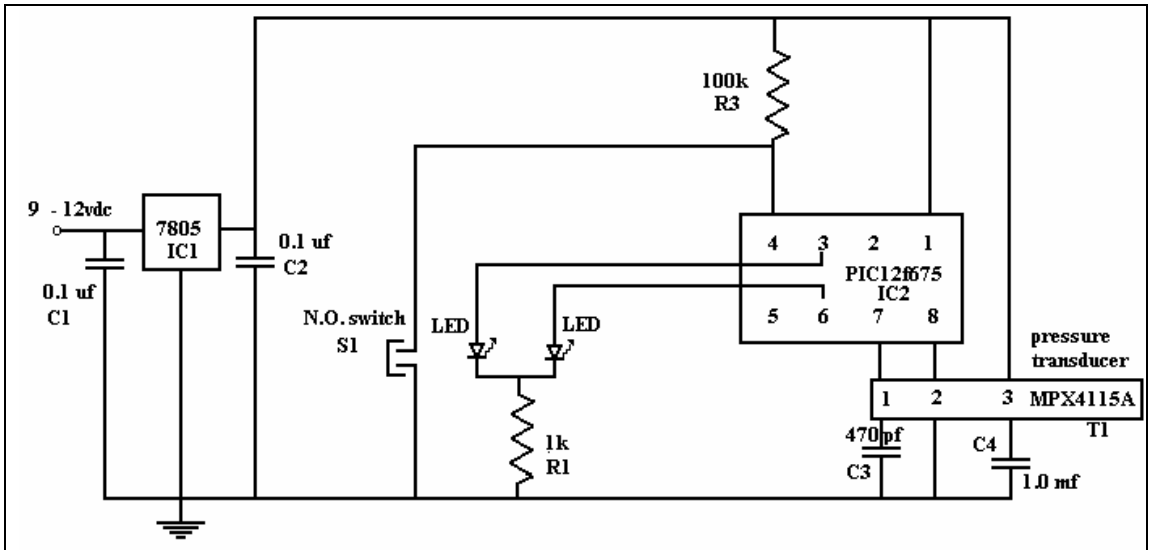
The altitude calculation:

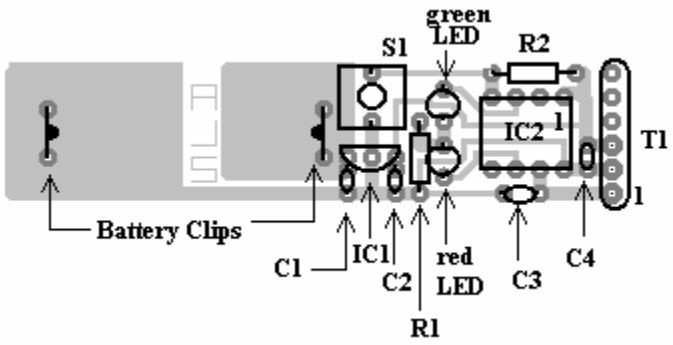
Altitude in feet=$\{[10^{\log(ph/p)}/5.2558797]-1\}/ (-6,875,585.6)$
p= sea level pressure (obtained from the local weather station or NOAA weather broadcast)
ph= station pressure measured and read from the circuit. These A/D units will need to be converted to inHg using this formula… station pressure inHg= [(A/D units * .032047)+3.11754]

Construction:
Construction is straightforward. Etch and drill a circuit board according to the pattern provided and solder the parts on the circuit board as indicated in the drawing. The only tricky procedure is the construction of the battery holder.

The battery holder is composed of the spring ends of two #1 safety pins. Cut and remove the clasp end of the safety pin, extend the ends through the PCB, fold ¼ inch over and solder flat against the foil. This

makes a nice small battery holder but may be a little awkward to construct. If the builder would like, any "N" size battery holder can be used instead.





Reversed foil side view

Parts:

Resistors	Description	part number	Supplier
R1	1000 ohm 1/4w	296-6314	Allied
R2	100k ohm 1/4w	296-6338	Allied
Capacitors			
C1, C2	0.1uf	881-3486	Allied
C3	470pf	881-3408	Allied
C4	1 uf	881-7172	Allied
Semiconductors			
IC1	78L05 (5volt regulator)	263-0136	Allied
LED1	LED red	263-1132	Allied
LED2	LED green	263-0828	Allied
Sensor			
T1	Absolute pressure sensor	858-4854	Allied
Other			
Switch	Tactile switch, SPST Momentary, NO	676-5050	Allied
IC socket	8 pin DIP socket	900-0004	Allied
B1	12 volt small “lighter” type	729-0023	Allied
Firmware			
Altimetry2.asm	PIC program listing		Download jbgizmo.com
Software			
Altitude conversion chart	Excel formatted chart		Download jbgizmo.com
Other parts			
IC2	PIC12F675 (micro controller) 8 pin DIP	579-PIC12F675-I/P	
Battery clips/holder	Spring ends of #1 safety pins		
PCB	See foil pattern above		
plastic shim	Used as on/off switch	Insert between battery and battery clip	

Operation:

1. Install the battery with the positive (+) end towards the middle of the PCB. Secure the battery to the PCB with 3 layers of electricians tape. Stretch the tape tight when applying. If the PIC12F675 is socket mounted then it will be necessary to secure it to the PCB in the same manner. It is important that the battery and microcontroller chip are secure. Force a small paper-thin piece of plastic between the negative battery terminal and the negative battery "clip" to turn the circuit "off". Remove the plastic to turn the circuit "on".
2. Remove the plastic shim to turn the altimeter "on". The red LED will light in approximately 3 seconds and stay lit for 2 seconds. The green LED will then blink the left most digit of a 3 digit number, followed by a red LED blink. This sequence will repeat for the other two digits. The red LED will then start to blink once approximately every second indicating that it is actively reading and recording pressures. Write down the 3-digit number. This number is the current station pressure (preflight) in analog to digital converter units (A/D units). Record this number. The altimeter is ready for launch.

   A reading of 821 would look like this;

   2 second red - 8 green blinks - 1 red blink - 1 green blink - 1 red blink - 2 green blink - 1 red blink
   = 8 1 2

   A zero is equal to two red blinks without a green blink in-between. For example
   a reading of 802 would look like this;

   2 second red - 8 green blinks - 1 red blink - - 1red blink - 2 green blink - 1 red blink
   = 8 0 2

3. Load the altimeter into the payload compartment of the rocket.
4. Launch and recover the rocket.
5. Push the momentary switch (S1) for one second and release. This places the altimeter in "read-out" mode.
6. The altimeter will blink the value of the lowest pressure that it recorded during the flight in A/D units. Record this number. The altimeter will continue to repeat this reading until reset.
7. If you know your launch site sea level pressure or altitude you can use the Altitude Conversion Chart to figure the maximum altitude obtained during flight.
8. If you want to do the math:
   p= sea level pressure obtained from your local weather station or NOAA broadcast in inches of Mercury
   p1h= ground level reading
   p2h= post flight reading
   p1h= [(A/D pre-reading *0 .032047) +3.11754] +-error … this converts the A/D reading to in.Hg
   p2h= [(A/D post-reading *0 .032047) +3.11754] +-error … this converts the A/D reading to in.Hg
   error ranges between 0 and 1
   preflight altitude at lunch site ={[$10^{\log(p1h/p)}$/5.2558797]-1}/ (-6,875,585.6)
   post flight maximum altitude ={[$10^{\log(p2h/p)}$/5.2558797]-1}/ (-6,875,585.6)
9. If you don't want to do the math and close is good enough then multiply the pre flight A/D reading minus the post flight A/D reading by 32. (P1-P2)*32
10. To reset the altimeter for another flight turn it "off" by inserting the plastic shim between the negative battery clip and the battery and then turn it "on" by removing the plastic shim.

Example Chart Reading
(download the complete chart from jbgizmo.com)

Example#1 if you know the launch site altitude: If your launch site was at 1,800 feet and your Altimeter read 803 when you first turned it "on" you would read down the left column to find the A to D reading of 803 then read across to find the altitude closes to you launch site altitude, which would be in column "3" (1,798). If after your rocket's flight the altimeter was reading 797 then you would read down the left column to 797 then across to column 3 and read "1,980". 1,980 feet above sea level is the highest altitude that your rocket reached. Subtract the launch site altitude (1,798) from the maximum altitude (1,980) and you have the vertical altitude flown by your rocket (182 feet).

Example#2 if you know the sea level pressure: If your sea level pressure is 30.91 inHg, find the column that has the pressure closes to 30.91 inHg. You will find the closes value to 30.91 inHg in column "2". Read down the left column to find the preflight A/D pressure reading, then read across to column "2" to find the preflight altitude. Repeat the process for the post flight reading in order to find the maximum altitude achieved.

Example section of chart

	1	Cal factor		1	2	3
altimeter reading			sea Level kPa	104.97	104.63	104.29
A to D	inHg	kPa	sea level inHg	31.00	30.90	30.80
803	28.851	97.69		2005	1886	1798
802	28.819	97.58		2035	1917	1828
801	28.787	97.47		2065	1947	1858
800	28.755	97.36		2096	1977	1889
799	28.723	97.26		2126	2008	1919
798	28.691	97.15		2157	2038	1950
797	28.659	97.04		2218	2069	1980
796	28.627	96.93		2248	2099	2011

Note: that a calibration factor is included at the top of the chart. This value can be used to fine-tune your altimeter readings. In most cases a “Cal factor” will be between 0 and 1.