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APOGEE PEAK OF FLIGHT NEWSLETTER

Rocketry Electronics Primer

Part 1

INSIDE:

- High-Tech Gadgets for Your Rocket
- Tip on How to Protect Your Parachute
- Web Site of the Week
- Achievments in Rocketry
- Defining: Balsa Wood Grains

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Rocketry Electronics Primer - Part 1

by John Manfredo

How to make sense out of all the electronic gadgets and gizmos that are available

One of our readers suggested an article that does a comparison of the known altimeters and timers available today in the market. This is not an article of which one is better or worse. Rather, this is an article that compares the different features, capabilities, number of channels, programmability, etc. Hopefully this will be something that could provide numerous rocketeers with a reference guide of those devices available, and can help determine which meets your specific needs better. A lot of this article is taken (with permission) from John Walquist's "Rocketry Electronics 101". John is a member of Rocketry Organization of California and his full article is available through ROC's website at http://www.rocstock.org/wizards/rocket.electronics101.pdf. Part one of this two-part series will focus on what rocketry electronics are and part two will hone in on the different specifications and uses.

Rocketry Electronics Uses

The different uses for electronics in rocketry include:

- *Air-starting motors either for clusters or staging*
- *Parachute deployment - single/dual deployment*
- *Timed functions*
- *Tracking functions - audible or physical*
- *Telemetry - real time and delayed*
- *Data acquisition from onboard instrumentation*

Why Electronics?

Let's begin by looking at why we use electronics. Electronics provide more control over some aspect of our flight than we can get with a conventional delay element/ejection charge. They also can be used anytime we need to capture data not readily determined from the ground. The only control we have without electronics is by means of the motor's ejection charge. This is quite limiting, both from a timing aspect and from the range of functions that can be controlled. If we use a timer or an altimeter, we can more closely match the action of our rocket to an ideal behavior. That ideal 11.5 second delay can be set that we need for maximum coast time to apogee or start a timing motor to click the shutter on our camera. We can get data and information back from our flights: How high did it go, how fast, how hard did it hit? In addition, locating a rocket that drifts out of sight in the wind or following a rocket as it flies at night becomes much easier.

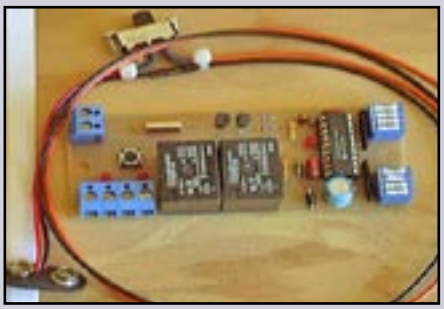
The downside of electronics is that while they free us up to do more things with our rockets, they also add weight, complexity and cost to our toys. On that basis, you can characterize the need to be familiar with and use electronics as such:

- *Model & Mid-powered - no real need to use them*
- *Certification I flyers - may use electronics*
- *Certification II flyers - should learn to use them*
- *Certification III flyers - must use electronics*

While there are many aspects of electronics that we could talk about, for the sake of space we will discuss the two most popular electronics, which are timers and altimeters.

Timers

Timers do exactly that. They time. Some timers have a single timer on the board, some have two, and a few have three, four, or more timing channels. A timer measures time from an event (usually, but not necessarily, liftoff) and then activates some function (usually, but not necessarily, an electric match or deployment charge). Did you note the "usually, but not necessarily . . .?" That's because you can use these timed events for any manner of actions - they are much more flexible than the delay/ejection



Typical Timer

continued on page 4

About this Newsletter
You can subscribe "FREE" to receive this e-zine at the Apogee Components web site (www.ApogeeRockets.com), or by sending an e-mail to: ezine@apogeerockets.com with "SUBSCRIBE" as the subject line of the message.

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Questions and Answers

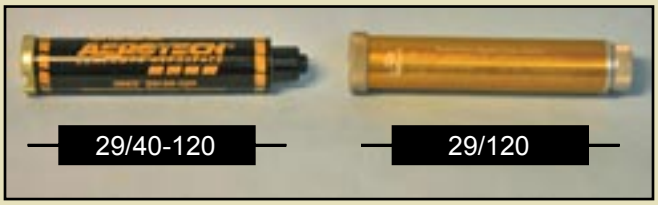
A question that we have been receiveing from customers quite often since we started carrying reloads is, "Why aren't the 29/40-120 reload propellant-kits interchangeable with the three cases that Apogee Components carries: 29/60, 29/100, and 29/120?" For the answer we turn to the expert on this, Gary Rosenfield, who is the President of AeroTech Consumer Aerospace.

Gary tells us, "The 29/60 and 29/100 “high power" cases were originally designed as shorter versions of the 180 and 240 motors, that would fit in AeroTech kits. They are the same lengths as the AeroTech ‘F’ and ‘G’ single-use motors respectively. However, if you look at the motor specs the propellant weight of the 29/100 is limited to about 46 grams. They use special length propellant grains that are not used anywhere else in the line."

"On the other hand, the 29/40-120 was designed from the ground up as a motor that would maximize the propellant capacity of a reloadable casing that fits the AeroTech kit motor mount. That’s the reason for the shorter thread forms, reduced diameter delay closure, etc."

"Finally, the 29/120 is not intended to fit any particular length motor mount but was designed to simply use two of the same grains included in the 29/180 and larger reloads, and could be sold as a model rocket motor and be shipped via USPS."

We thank Gary for shedding some light on an often confusing area. If you would like to purchase the 29/120 reload motors and cases , please visit our website at http://www.apogeerockets.com/Aerotech_Reload_Motors.asp for the propellant kits and http://www.apogeerockets.com/Rouse-Tech_Motors.asp for the Rouse-Tech motor cases.



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continued from page 2

wire or plug completing an electrical circuit. When this circuit is broken by the wire breaking or the plug being pulled from the socket, the timer starts counting. The timer counts until the pre-set time is reached and then switches power to an output channel. A G-switch is built into the timer and senses when the movement of the rocket starts at liftoff. This is usually activated at a certain speed so that a slight movement will not trigger the timer.

A typical mission for a timer would be to monitor the liftoff of a rocket and, once liftoff is detected, start timing a period of time equal to the burn time of the motor and the amount of coasting time desired. At the conclusion of this time interval (which must be predetermined and set on the ground before flight), the timer would allow current to flow into a pair of igniters inside the airstarted motors, lighting them and sending the rocket onward and upward.

Now that we have some understanding of what a timer is and what it can do for us, let's discuss about some typical uses for these units. Timers are most typically used to control the starting of onboard motors separate from the ground control equipment (launch system) or to eject a parachute at a certain time after launch

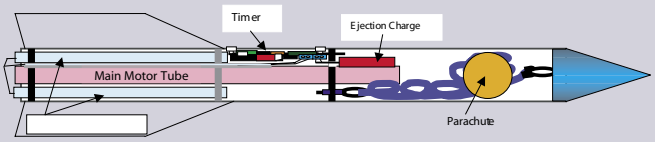

Figure 1

is detected. Figures 1 and 2 show typical placements within the airframe of the rocket when used in this manner. Note that in Figure 1 the timer is placed in back of the forward centering ring and that in figure 2 it is placed

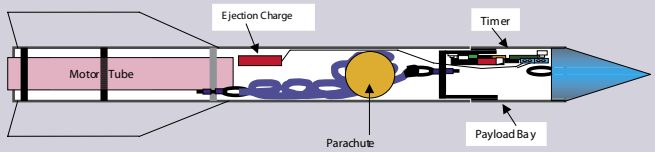

Figure 2

in a separate compartment forward of the motors. The forward placement makes it more difficult to control airstarts but makes it possible to do a two-stage deployment, if desired. Finally, a word on mounting – watch the orientation of any timer that uses a G-Switch to activate it. These timers must always be mounted so that the G-Switch is lined up with the direction the rocket will accelerate. As seen to the right, such a unit will usually have some kind of warning printed on the circuit board saying "This End Up" or something equivalent to aid in properly orienting the board. A G-Switch will only operate properly if it can be closed by the rocket's acceleration and therefore it must be oriented in the same plane as the rocket's acceleration in order to function. Don't mount the board upside down or sideways – if you do, your timer won't activate and you will have a less than optimal flight.

Figure 3

Altimeters

Altimeters generally come in two flavors, barometric - or accelerometer - based. Barometric altimeters work by measuring changes in atmospheric pressure using a barometric cell. As you go up in altitude the pressure exerted by the atmosphere drops. The amount that the atmospheric pressure drops with increased altitude is well characterized. The designers of altimeters can use this not only to measure when an altimeter starts rising and stops rising above the ground, but to also note the exact (or very close to exact) altitude (pressure) at apogee. Most barometric altimeters are activated by a quick change in pressure equivalent to anywhere from 100' - 300' of altitude change. Typical ranges for barometric altimeters are from sea level up to 15,000' - 25,000' of altitude. Some special models claim to be readable up to 50,000'.

How Does a Barometric Sensor Work?

A modercn barometric sensor is made with two chambers separated by a diaphragm. The diaphragm has an electronic strain gauge on its surface to detect any stretching due to differences in pressure on the diaphragm. There is generally a vacuum on one side of the diaphragm (reference pressure). The other side is exposed to the atmosphere whose pressure is being measured. As we go up in altitude, the 'measured' atmospheric pressure decreases and the amount of pressure (strain) on the diaphragm changes. This change is measured by the strain gauge and a signal proportional to the current pressure is sent to the electronics for

continued on page 5

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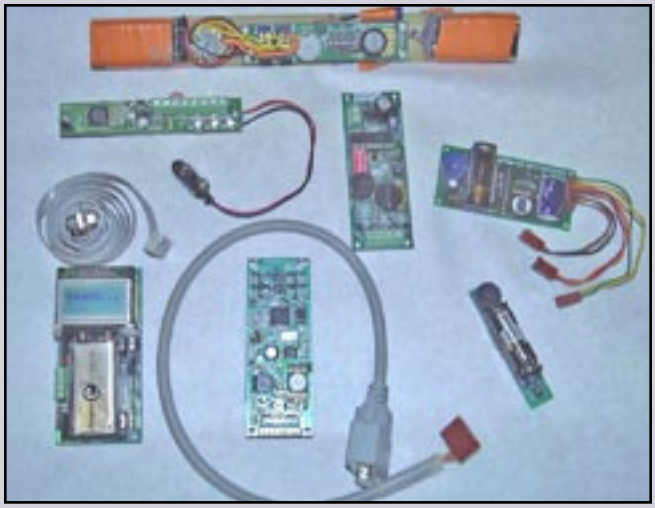

(Clockwise from top) Perfectflite MiniAlt 25 (mounted for minimum I.D. installation), Missileworks RRC2X, Adept ALTS25, Adept A-1, Defy Gravity 'Control', Olsen FCP-M2, G-Wiz LC Deluxe 400

Drawbacks

Barometric altimeters are quite versatile, but they have two drawbacks. The first is that they need to be in a chamber that is sealed off from any ejection charge gases (which are corrosive and can foul the altimeter), but is vented to the outside so that changes in atmospheric pressure can be detected. The second is that as a rocket passes through the sound barrier, (Mach) a shock wave forms at the tip of the nosecone and travels down the airframe. When the shock wave passes over the vent ports for the altimeter chamber, the pressure fluctuation it causes can fool the altimeter into believing the rocket has reached apogee and is started back down to the ground.

This can result in a premature parachute deployment while the rocket is traveling at a high rate of speed (as we are talking Mach+ speeds, this usually results in the destruction of the rocket). Both these problems have been addressed by the various altimeter manufacturers, either in their designs or in their instructions on how to make reliable use of the altimeter.

Accelerometers

Accelerometer - based altimeters use a small solid state accelerometer rated to measure anywhere from +/- 25 G's of acceleration to +/- 100 G's (a G is one gravity or 9.8 meters/second/second of acceleration). As the acceleration sensor in the altimeter must be in the proper position to measure the acceleration, orientation of these accelerometers is critical to the proper operation of the altimeter. Because of this, all accelerometer based altimeters (and those altimeters that use a G-Switch to arm) have wording or markings on the altimeter to indicate "this end up", ensuring that if installed in that orientation, that the sensor is properly oriented with respect to the (intended) direction of flight.

How Does an Accelerometer Work?

Today's accelerometers are typically based on a small plate on an arm supported in a cavity in an integrated circuit (IC). This arm/plate assembly moves closer to one side of the chamber and farther from the other when acceleration (G forces) occurs along the axis of the chamber. Think of it as a weight on a spring. The ends of the chamber and the sprung mass are electrically isolated from each other forming a capacitor. By applying a charge to the sprung mass and an opposite charge to each end of the chamber, the capacitor is charged. As the sprung mass is moved closer to one end of the chamber or the other by the force of acceleration, the amount of capacitance in the system changes.

By monitoring the capacitance of the cell, it can be determined what the force of acceleration on the sprung mass is and, thereby, the acceleration of the rocket as well. Determination of apogee is made by monitoring the accelerometer and integrating the signal to determine the point at which the rocket stops rising. Is this a true apogee? Not always, but it's usually close enough. Altitude measurements derived in this manner are seldom accurate as the accelerometer integrates acceleration versus time (which yields velocity) and then integrates velocity vs. time to obtain distance traveled. The main problem with this approach is that the distance traveled is only equal to altitude if the rocket flies a perfectly vertical trajectory - no weather-cocking, no arcing over, no deviation from a vertical flight, period. If the rocket's flight path is anything other than vertical the actual altitude attained will be less than the distance traveled by the rocket to reach apogee.

In spite of this measurement problem with altitude, an accelerometer-based altimeter does have two significant advantages over the barometric altimeter when used in high performance rockets. These advantages are that the accelerometer requires no venting of the electronics bay in order to work, and that the acceler-

continued on page 6

continued on page 5

eter is not sensitive to pressure differentials caused by supersonic flight. One significant negative for accelerometers is that a single axis accelerometer of the type most often used in rocket electronics cannot measure how high the rocket is following apogee and, therefore, is not a suitable sensor for dual deployment situations.

This limitation could be bypassed by employing a full three axis accelerometer suite and a more powerful microprocessor, but that would raise costs beyond what most of us would be willing to pay. Most altimeters are designed to indicate the peak altitude attained - that's why they are called "altimeters" (short for altitude meter). This need not be the only thing they can do. Most of the better altimeters will also activate an event at apogee that can be used to deploy a parachute - just like with the timers, but here you don't have to guess or calculate the desired flight time before parachute deployment. Apogee is determined by the altimeter and acted upon when detected, whenever it occurs.

Many altimeters equipped with barometric cells also monitor the altitude on the way down (after a parachute has been deployed) and control deployment of a second parachute based on reaching a set altitude above the launch site. This feature, which allows the deployment of a small drogue parachute at apogee - allowing the rocket to fall rapidly back towards the ground - and then releases a larger chute in time to slow the rocket for a soft landing, is often called "two stage deployment", "dual deployment" or "close proximity recovery". Two-stage recovery can dramatically reduce wind drift on a windy day or for rockets that are flying to extreme altitudes.

Mounting and Placement of Electronics

Now that we've covered the basic equipment (and the not so basic as well), the question of how to use these items comes up. The mounting and use of altimeters are subject to a few more constraints than timers. Again, we want to keep our wiring runs, where needed, short. But now we are faced with the possibility of wiring running in two directions and also some positional restrictions imposed by the use of barometric cells as sensors. Figure 4 shows one way to do this for a rocket doing 2-stage deployment (Drogue and Main). We also need to protect our electronics by making certain they are located in an area that ejection gases or rocket motor gases can't get to (a sealed chamber of some sort).

The primary restriction is positional. In order to have a smooth flow of air over the vent ports (remember - barometric cell based altimeters have to be able to measure the air pressure outside of the rocket and that means pressure equalization vents) into the chamber you have mounted the altimeter in, the vents should be at least four calibers (1 caliber = 1 body diameter) back from the point at which the body diameter becomes constant (this is usually four diameters back from the shoulder of the nosecone) with no protrusions, fins or other items that could cause turbulent airflow ahead of the vents.

For example, a rocket that is 54mm (~2.125") in diameter should have the vent port(s) located at least 8.5" back from the shoulder of the nosecone. As to vent port sizing, the common body of knowledge says that

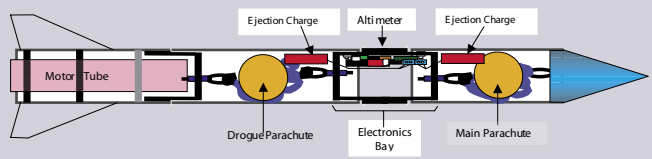

Figure 4
Typical Dual Deployment Configuration

for every 100 cubic inches of altimeter bay volume you should have a vent port equivalent in size to a 1⁄4" hole. Vent sizing much below this causes delays in pressure equilibration and could result in late deployments and inaccurate altitude reporting. Is a single vent port best? Not necessarily. A single port can be affected by wind blowing across it (much like a flute). A better way to go is to use 3 or 4 vent ports (never use only two vent ports) symmetrically (evenly) spaced around the altimeter bay. Vent ports should be cleanly drilled with sharp, clean edges both inside and out so no additional turbulence is introduced. A good source for port hole size that has been a featured website is Vern's Rocketry at http://www.vernk.com/AltimeterPortSizing.htm. Another source that is fantastic is Mark Canepa's book, *Modern High Power Rocketry 2.* This resource has chapters that go into great detail on both altimeters and creating electronics bays for rockets. It is available through Apogee at http://www.apogeerockets.com/Modern_hpr.asp

Coming Attractions

The next issue will look into the differences between units and the pros and cons of them. Hopefully, this will provide you with enough information to make an informed decision about the unit best suited for you.

Achievments in Rocketry

At Apogee Components, we like to give special recognition to our customers that have worked extra hard to make astounding achievements. Recently, these individuals made significant rocketry accomplishments, and we would like to recognize them:

Moshen Chan	Level 1	CA
William Kissee, Jr.	Level 1	CA
Mike Furlotti	Level 1	CA
Erik Gilling	Level 1	CA
Robert Tashjian	Level 2	CA
Andy Zollar 7/15/2006	Level 1	CO
(WOW!) 7/22/2006	Level 2	CO
10/28/2006	Level 3	CO
John Smolley	Level 3	CO
Richard Hitchner	Level 2	CO
Paul Harrison	Level 1	CO
Brian Coyle	Level 2	FL
Don Lorenzo	Level 3	FL
Steve Hoffman	Level 2	IL
Nick Cassavaugh	Level 1	IL
Warren Evans	Level 2	IL
Jim Watts	Level 2	MI
Chris Watts	Level 2	MI
James (Jimmy) Harris	Level 1	MO
Nathan Warner	Level 2	NE
Robert Krausert	Level 2	OR
Casey Smith	Level 1	TX
Scott Cook	Level 2	TX
Kurt Crowhurst	Level 1	WI

Also, Leonard Johnson from the St. Andrews two time TARC National Finalists team wrote to let me know that these rocketeers earned a contract from NASA to design and build a rocket and experimental payload that will have a flight profile of 5,280 feet AGL.
Check them out at: www.orionrocketprojectsli.com

Congratulations go out to all of these individuals! Great work to all of you. We know it took a lot of effort, grit, and determination. For those reasons we celebrate your accomplishments! If you see a name in the above list that you know, why not send them a note of congratulations?

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Web Sites Worth Visiting

The website I would like to turn your attention to is that of the MarsDrive Consortium. It can be surfed at http://www.marsdrive.com.

The executive staff are located all over the world. Hal Fulton, Public Outreach Director from the U.S.A. says, “MarsDrive is all about outreach. That sums us up in a single word. We’re not the engine or even the gasoline. We’re the oil. We want to be facilitators, communicators, and educators. We want to be part of the glue that holds it all together. We are building a network of contacts in the space advocacy community, in industry, and among entrepreneurs. But we’re also building contacts in other areas. We’re not going to be just scientists and engineers. We’re going for broad-based public support.

We have three major projects in mind for the near future. We hope to get these underway in early 2007 and issue press releases once they are near completion. Our aim is to become a significant and useful part of the space community within the next year.” Basically, this site is "everything Mars" and then some!

In a nutshell, this is "The MarsDrive Mission":

- To raise public support and awareness for human exploration and settlement of Mars.
- To bring together groups, individuals, and resources for the purpose of enabling a human mission to Mars in the near term (within 20 years).
- To be a bridge between many of the current space organizations having compatible goals.
- To provide active support for the new private space sector in all of its aims, and especially to help lower costs for access to space.
- To educate people of all ages on the importance and value of humans in space and to inspire the next generation into the sciences.

Hal's parting words are, "I am determined to do my part to see humans land on Mars within my lifetime."

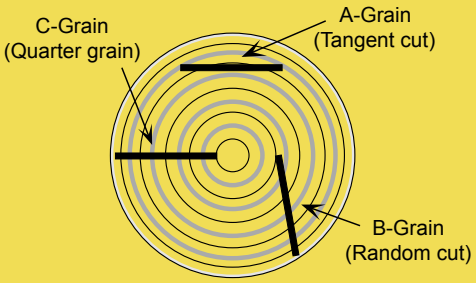
DEFINING MOMENTS

Balsa Grain

A-GRAIN sheet balsa has long fibers that show up as long grain lines. It is very flexible across the sheet and bends around curves easily. It also warps easily and is sometimes called “tangent cut”. Use this for covering rounded fuselages and wing leading edges. Planking fuselages, forming tubes, strong flexible spars, and hand-launched glider fuselages. Also, fins for small, ultra-light competition model rockets.

B-GRAIN sheet has some of the qualities of both type A and C. Grain lines are shorter than type A, and it feels stiffer across the sheet. It is general purpose sheet and can be used for many jobs. It is sometimes called “random cut”. Use this for the flat sheet fins on most rockets, for flat fuselage sides, trailing edges, wing ribs, formers, planing gradual curves, wind leading edge sheeting.

C-GRAIN sheet balsa has a beautiful mottled appearance. Some people say it looks like fish scales. it is very stiff across the sheet and if bent it splits easily. When used properly it helps build the lightest, strongest models. This is the most warp-resistant type, but it is difficult to sand. It is sometimes called “quarter grain". Use this for sheet balsa fins on larger model rockets. Can also be used for sheet balsa wings on larger gliders, tail surfaces, flat fuselage sides, wing ribs, formers, and trailing edges. Best type for wings on larger boost gliders and hand-launched gliders.



Cross section of a tree log to illustrate how balsa is categorized

Balsa Grain Graphic from Model Rocket Design and Construction www.apogeerockets.com

TIP OF THE FIN

The tip for this issue is in regards to how to give yourself a little extra insurance on keeping your parachutes burn-free.

To begin with, follow the manufacturer's recommendations for the amount of wadding to insert into the body tube prior to inserting the parachute.

Next, when you pack your parachute, place a sheet of wadding around the end of the 'chute and slide the it into the body tube with the recovery wadding sheet on the side that faces the motor.

Revovery wadding on aft end of 'chute

This will perform like a chute sack and acts as a last point of protection during ejection charge activation. This technique it is great chute saver against burns and pinholes!

Quest Recovery Wadding is available through Apogee. Please see http://www.apogeerockets.com/wadding.asp .

Customer Comment:

Yes, the 1/70th scale Apollo capsules arrived just as quickly as ever. I can't say your service was any better this time; you guys already set the standard for Customer Service and fast shipping, so I'd say you're rather challenged to improve on this. It's your commitment to Customer Service (and the great products of course!) that makes me a frequently returning Apogee customer. --***John Brohm***

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