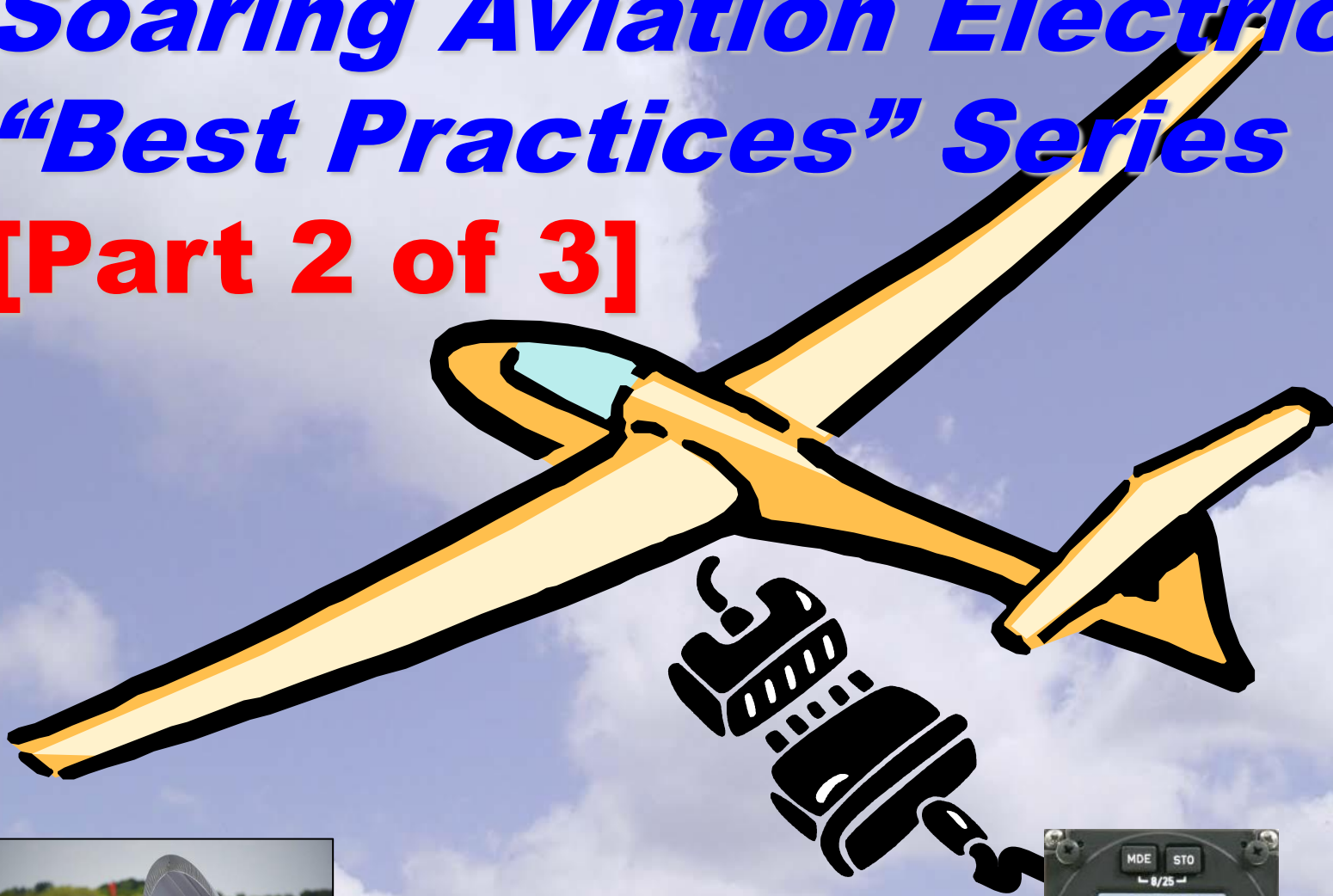


# ***Soaring Aviation Electrical “Best Practices” Series***

## **[Part 2 of 3]**



***John DeRosa OHM Ω***  
***Updated: December 30, 2023***



# PLEASE NOTE

This document may have been updated with new information, changes, and corrections.

Be sure to visit my presentation web site and download the latest version of this document. It could make an important difference to your work!

**<http://aviation.derosaweb.net/presentations>**






Thank you, John

# Disclaimers

- I am **not** an FAA licensed A&P or IA
- I am **not** an approved avionics technician
- You should know the difference between Experimental & Standard airworthiness certification, and what you can and cannot do to your glider
- Work closely with an IA to get your work properly inspected and signed off in your glider's log book
- Proceed at your own risk.

# Chapters

## Part 1

1.  Reference Information
2.  Your Tool Box
3.  Wires and Wiring
4.  Making Connections
5.  Other Things of Note

## Part 2

### 6. Power Management

## Part 3

7.  Examples of Battery Circuitry
8.  Minimizing Lost Volts
9.  Providing USB Power



# Chapter 6

# Power Management & Distribution



# Selecting Correct Wire Gauge

## As per the FAA Advisory Circular AC 43-13-1b

AC 43-13-1B CHG 1

9/27/01

### FAA Advisory Circular AC 43-13-1b, Chapter 11, Section 5, "Electrical Wire Rating"

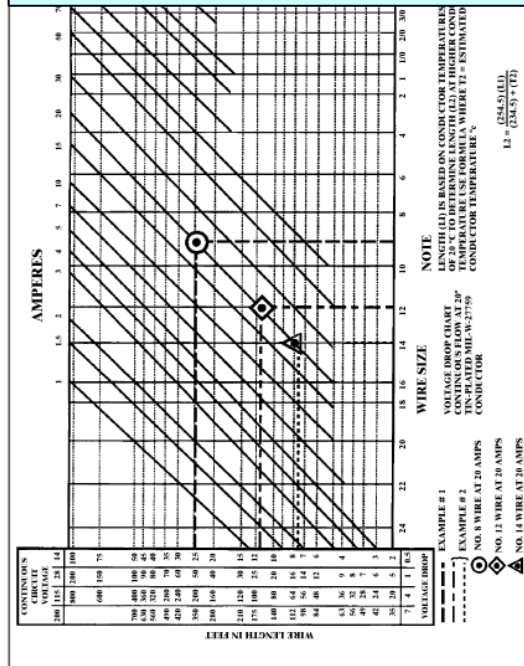


FIGURE 11-2. Conductor chart, continuous flow.

Page 11-30

To Learn More → Read **"Selecting Wire"**  
by Thomas Inman  
in *Avionics News*, July 2020 Issue



[http://aviation.derosaweb.net/presentations/documents/Avionics\\_News\\_Selecting\\_Wire\\_July\\_2020.pdf](http://aviation.derosaweb.net/presentations/documents/Avionics_News_Selecting_Wire_July_2020.pdf)

# “Suggested” Wire Gauges

**Must Comply with FAA Advisory Circular AC 43-13-1b**



- **12 to 14 gauge** - Main power lead from battery to the power bus
- **16 to 22 gauge** - Power leads to individual devices (depending on the current requirements of each individual device)
- **20 to 22 gauge** - Speaker wiring
- **22 to 26 gauge** - Control wires such as push-to-talk, air brake warning switches, flap switches, etc
- **Hint:** Leave extra length (slack) in the cables for future changes and modifications

## **Glider Power Wiring Quote for the Day**

***“It ain’t the current load that’s gonna’ get ya’ on that long flight. It’s the voltage drop!”***

**(More on this subject in Part 3)**



# Switches

- Always have a master switch on your panel
- Use good quality switches from reliable sources (Aircraft Spruce)
- Best Attributes
  - Brass Screw Terminals
    - Easier to replace, less prone to vibration issues
  - Sealed Switches – most are
  - Internal Gold Contacts are best
- Switch Name Brands
  - Switchcraft, C&K, NKK
- Sources: Aircraft Spruce, Wag Aero





# Circuit Protection - Types



- Fuses

- **Have one at the battery (+) terminal!**

- Glass Fuses

- Fragile

- ~~Slow-blow~~ ← **don't use!**

- Automotive Fuses

- More Rugged

- Allowed?

- Difficult to replace in flight

- Breakers (push/pull style)

- Easy to reset in flight

- Manual trip (pull) feature

- Available with integral master switch

- Rate the Fuse/Breaker for maximum load.

- Watch out for "**lost volts**". More on this topic in Part 3 of this presentation.

# Circuit Protection Requirements

Reference  
FAA Circular  
AC 42-13-1B  
Chapter 11  
Table 11-3

***Using small amperage breakers and fuses less than 5A will cause a loss of voltage at your avionics increasing the current draw. More on this topic on "Minimizing Lost Volts" in Part 3***

***FAA Suggests  
5 amps is the  
MINIMUM for  
Breaker & Fuse  
Sizing***

TABLE 11-3. DC wire and circuit protector chart.

Wire AN gauge copper	Circuit breaker amp.	Fuse amp.
22	5	5
20	7.5	5
18	10	10
16	15	10
	20	15
	30	20
	40	30
	50	50
	80	70
	100	70
	125	100
1		150
0		150

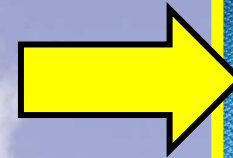
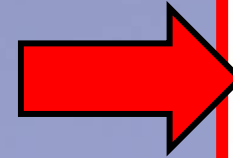
**Basis of chart:**

- (1) Wire bundles in 135 °F. ambient and altitudes up to 30,000 feet.
- (2) Wire bundles of 15 or more wires, with wires carrying no more than 20 percent of the total current carrying capacity of the bundle as given in Specification MIL-W-5088 (ASG).
- (3) Protectors in 75 to 85 °F. ambient.
- (4) Copper wire Specification MIL-W-5088.
- (5) Circuit breakers to Specification MIL-C-5809 or equivalent.
- (6) Fuses to Specification MIL-F-15160 or equivalent.

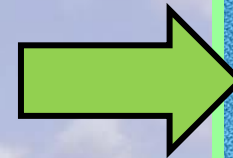


# Breaker Styles

- **Style: Push Only**
  - Older style - Push reset only
  - **NOTE:** While this type is legal it should not be used as it can only be tripped by an overcurrent event and cannot be tripped manually.
- **Style: Push/Pull**
  - Push & pull operation
  - Can be manually tripped
  - **NOTE:** FAA AC 42 11-51 says ***“Use of a circuit breaker as a switch is not recommended.”*** Klixon/Sensata breakers are specifically not rated for use as a switch per the manufacturer.
- **Style: Breaker/Switch**
  - Combination master switch and breaker
  - Can be manually tripped
  - Tyco model W31 - Best choice IMHO



TYCO W23



TYCO W31

# Connections: Power Bus\*



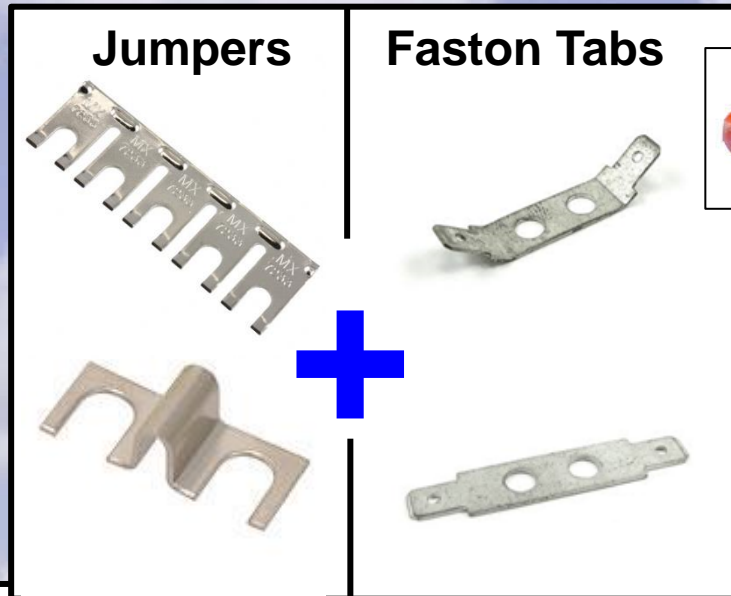
\* Bus has only one "S" in it. This is a common mistake due to our familiarity to Buss (Bussman) branded devices



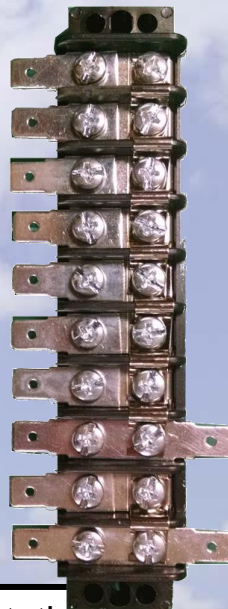
# Terminal (Barrier) Block + Faston Connections

- **Pros**
  - Robust
  - High Current Capability
  - Quick connection change flexibility (Faston type)
  - Adaptable to ring type crimp connections
- **Cons**
  - May not be certified for some aircraft
  - Somewhat expensive per terminal

## Terminal (Barrier) Block Bus Bar

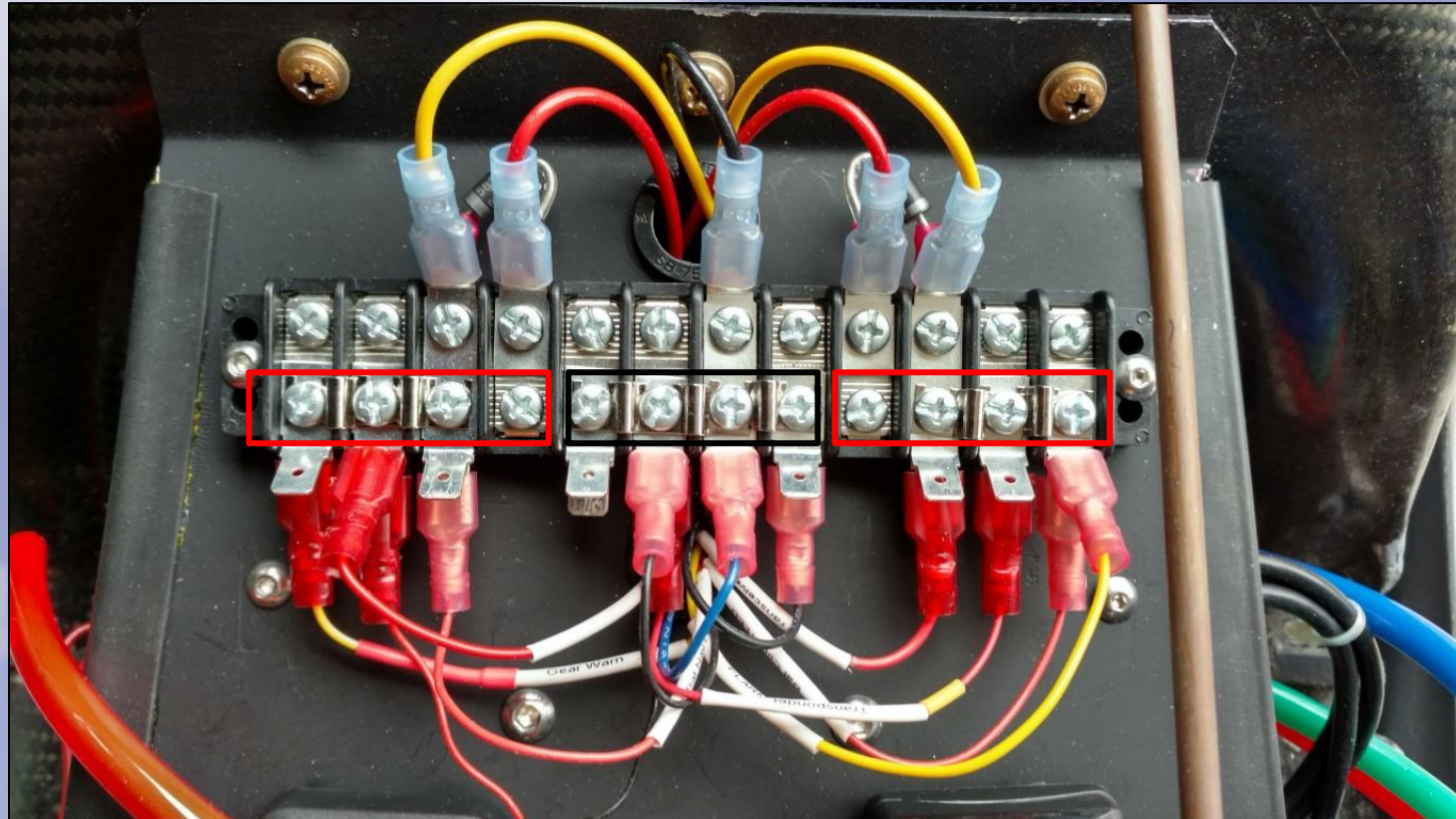


Faston Terminal



*Eaton Bussmann TB200 Series*  
Source: <http://www.waytekwire.com>

# Terminal (Barrier) Block Bus Examples



Positive Battery A  
Connections

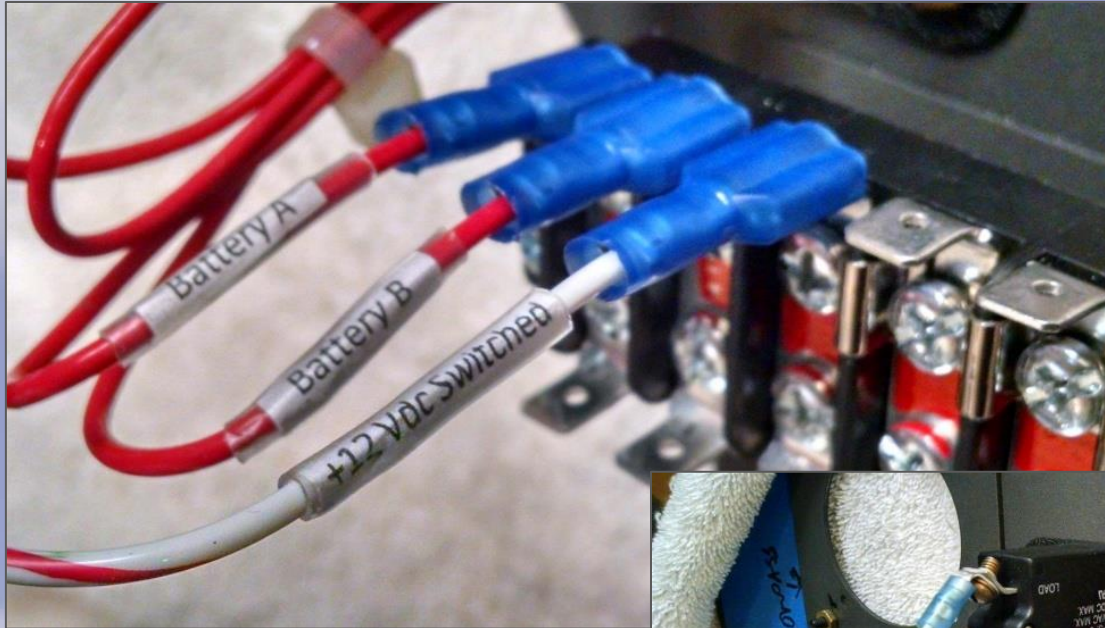
Negative Battery  
& Ground Connections

Positive Battery B  
Connections

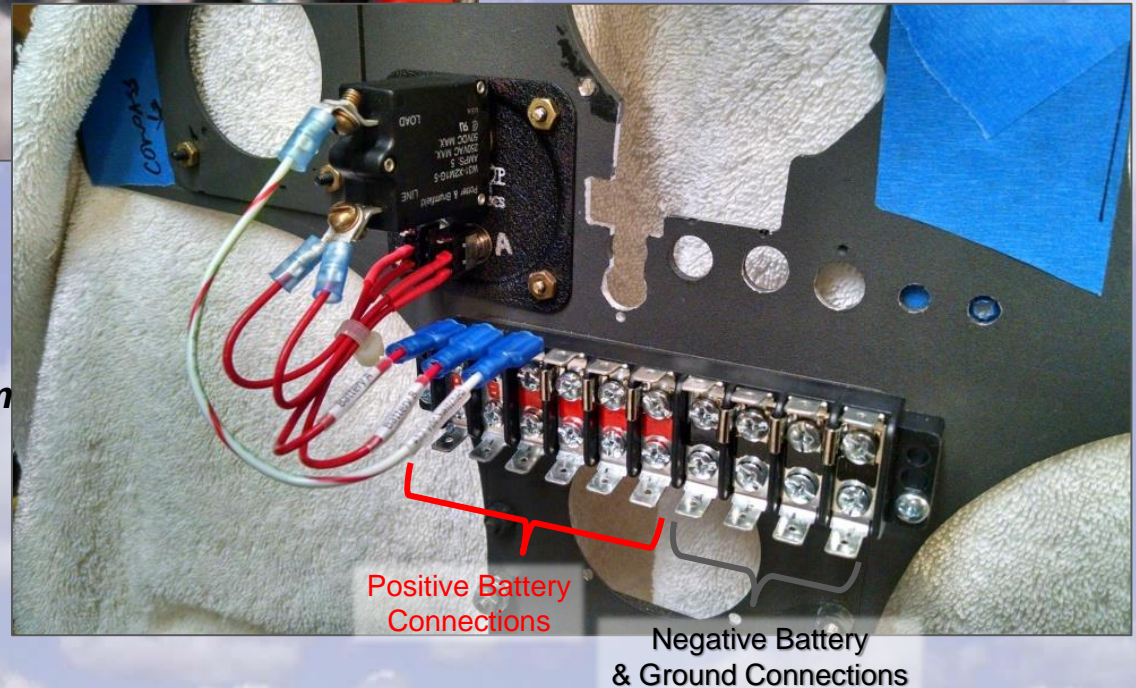
**Eaton Bussmann TB200 Series**  
**Source: <http://www.waytekwire.com>**



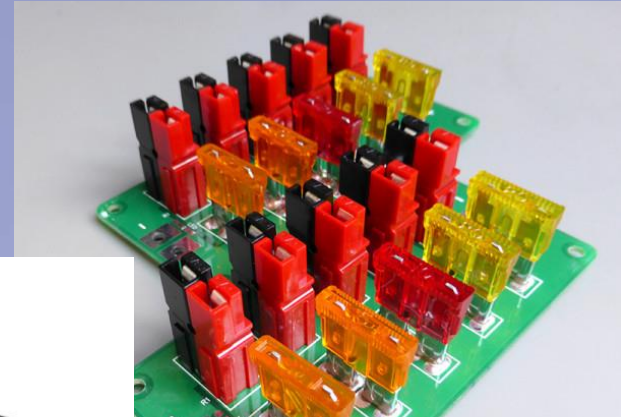
# Terminal (Barrier) Block Bus Examples



**Eaton Bussmann TB200 Series**  
Source: <http://www.waytekwire.com>



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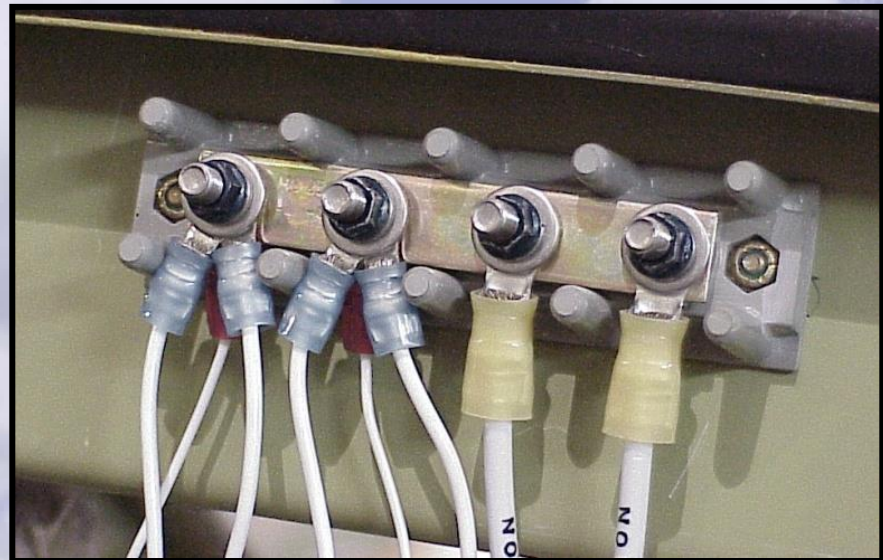


17



# Connections: Grounding Bus

- Connect all ground/negative wires together at a central point with ring lugs
- This can be to a single ground “stud” (bolt) or to a ground bus.
- This helps prevent “ground loops” which can cause electrical interference and noise.

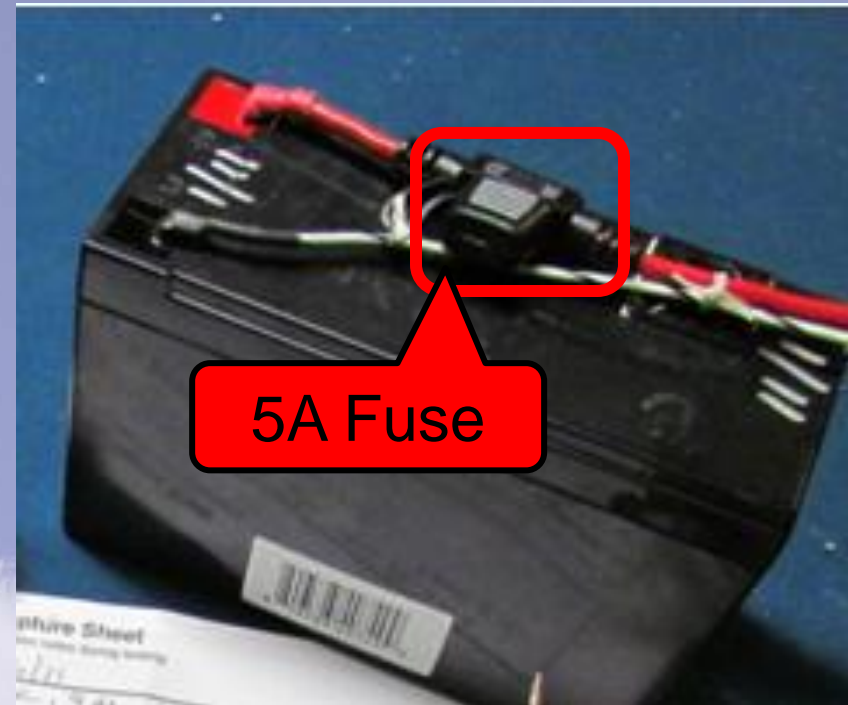


# Power and Batteries

- Topics
  - Protection from over current
  - Types of Battery Chemistries (SLA and Li-Ion)
  - Charging Properly
  - Measuring Current (Amps) Usage
  - Estimating Battery Life
  - Distribution (bus bar)
- Voltages Needed
  - Most avionics we use operate at 12Vdc and above
  - Some avionics will operate properly below 12Vdc
  - OLD avionics may require 13-14Vdc to operate properly
- Watch out for “**lost volts**”. More details in Part 3.

# Batteries

- **Fuse at Positive Terminal!**  
**Fuse at Positive Terminal!**  
**Fuse at Positive Terminal!**
- Types Typically Used in Gliders
  - Sealed Lead Acid (SLA) Gel Cells
    - Pros: Inexpensive (~\$25)
    - Cons: Heavy, Voltage decay
  - Lithium (LiFe-PO4)
    - Pros: Light weight, Flat voltage profile
    - Cons: Fire risk if shorted, Expensive (~\$100)
- Amp Hour Rating
  - 9AH = 9 continuous amps of current draw for one hour ... maybe ... better to measure/test
- Chargers
  - Charger must be specific to the battery chemistry
  - SLA – Often needs a “smart” charger
  - Lithium – Often has built in circuitry allowing “dumb” charger





# How Long Will My Battery Last?

- Need to know the current draw of your equipment
- Typical avionic max. current loads
  - Audio Variometer – ~0.2A max (with audio)
  - Flight Computer – ~0.4A max (with audio and charging)
  - GPS System – ~1.0A max (when charging & with backlighting)
  - Transceiver – 1.6A max (during transmit)
  - Transponder? Can be very heavy and continuous power draw (transmits often during interrogations)
- How about your system?
  - Consult your manuals and determine your maximum current needs
  - Measure your actual current load (see next slide)

**Avionics  
are never  
all at  
their  
maximum  
current  
at the  
same  
time**

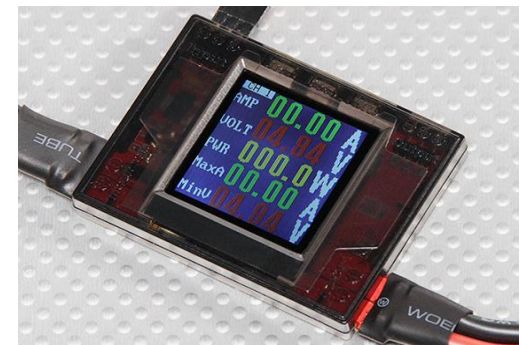


# Measuring Your Battery Load

- Use inexpensive power meters from the radio control hobby industry
- Measures voltages, currents and wattages
- Place the meter in series between battery and ship's power bus
- Measure the min/max current use for each device one (1) at a time;
  - Measure GPS/navigation device when charging and when fully charged
  - Measure with audio when OFF and when LOUD (vario, radio)
  - Measure with radio when transmit keyed and when unkeyed
  - Measure with radio when squelched and when unsquelched
  - Measure transponder when powered on and when being interrogated
- Total the minimum current values (occurs nearly all the time in actual use)
- Total the maximum current values (this never happens in actual use)

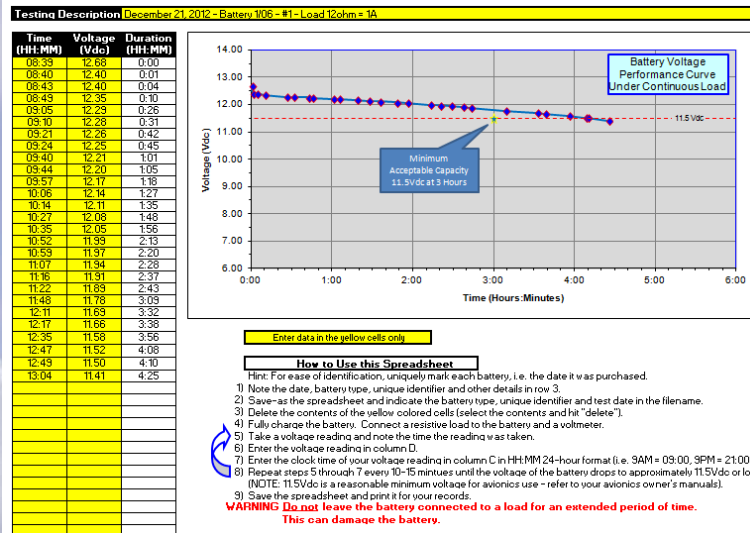
**Testing Your Batteries:** See Instructions at <http://aviation.derosaweb.net/presentations/#battery>

Sources: eBay, R/C hobby stores - Cost \$25 or Less

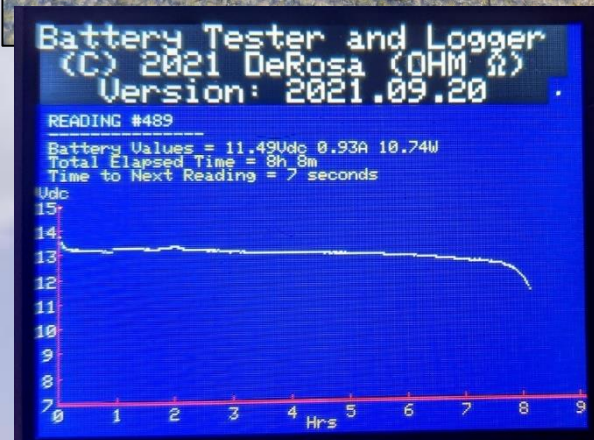


# Battery Load Testing

## Manual



## Automated





# Battery Load Testing

## Manual Method

For details on how to perform a simple battery load test see my article in *SOARING* magazine's Feb 2012 issue or go to <http://aviation.derosaweb.net/presentations>



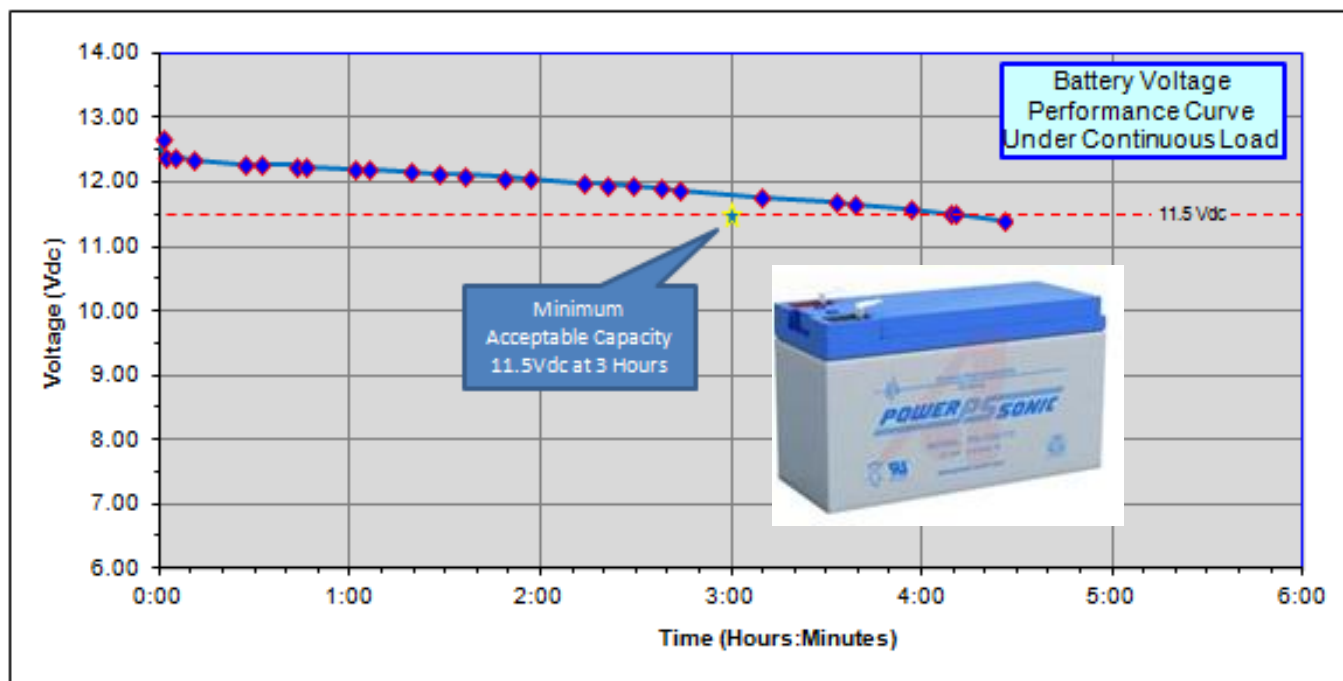


# Manual Battery Load Testing - SLA

For more testing details see *SOARING* Feb 2012 or <http://aviation.derosaweb.net/presentations>

**Testing Description** December 21, 2012 - Battery 1/06 - #1 - Load 12ohm = 1A nominal load

Time (HH:MM)	Voltage (Vdc)	Duration (HH:MM)
08:39	12.68	0:00
08:40	12.40	0:01
08:43	12.40	0:04
08:49	12.35	0:10
09:05	12.29	0:26
09:10	12.28	0:31
09:21	12.26	0:42
09:24	12.25	0:45
09:40	12.21	1:01
09:44	12.20	1:05
09:57	12.17	1:18
10:06	12.14	1:27
10:14	12.11	1:35
10:27	12.08	1:48
10:35	12.05	1:56
10:52	11.99	2:13
10:59	11.97	2:20
11:07	11.94	2:28
11:16	11.91	2:37
11:22	11.89	2:43
11:48	11.78	3:09
12:11	11.69	3:32
12:17	11.66	3:38
12:35	11.58	3:56
12:47	11.52	4:08
12:49	11.50	4:10
13:04	11.41	4:25



Enter data in the yellow cells only

## How to Use this Spreadsheet

Hint: For ease of identification, uniquely mark each battery, i.e. the date it was purchased.

- 1) Note the date, battery type, unique identifier and other details in row 3.
- 2) Save-as the spreadsheet and indicate the battery type, unique identifier and test date in the filename.
- 3) Delete the contents of the yellow colored cells (select the contents and hit "delete").
- 4) Fully charge the battery. Connect a resistive load to the battery and a voltmeter.
- 5) Take a voltage reading and note the time the reading was taken.
- 6) Enter the voltage reading in column D.
- 7) Enter the clock time of your voltage reading in column C in HH:MM 24-hour format (i.e. 9AM = 09:00, 9PM = 21:00).
- 8) Repeat steps 5 through 7 every 10-15 minutes until the voltage of the battery drops to approximately 11.5Vdc or lower (NOTE: 11.5Vdc is a reasonable minimum voltage for avionics use - refer to your avionics owner's manuals).
- 9) Save the spreadsheet and print it for your records.

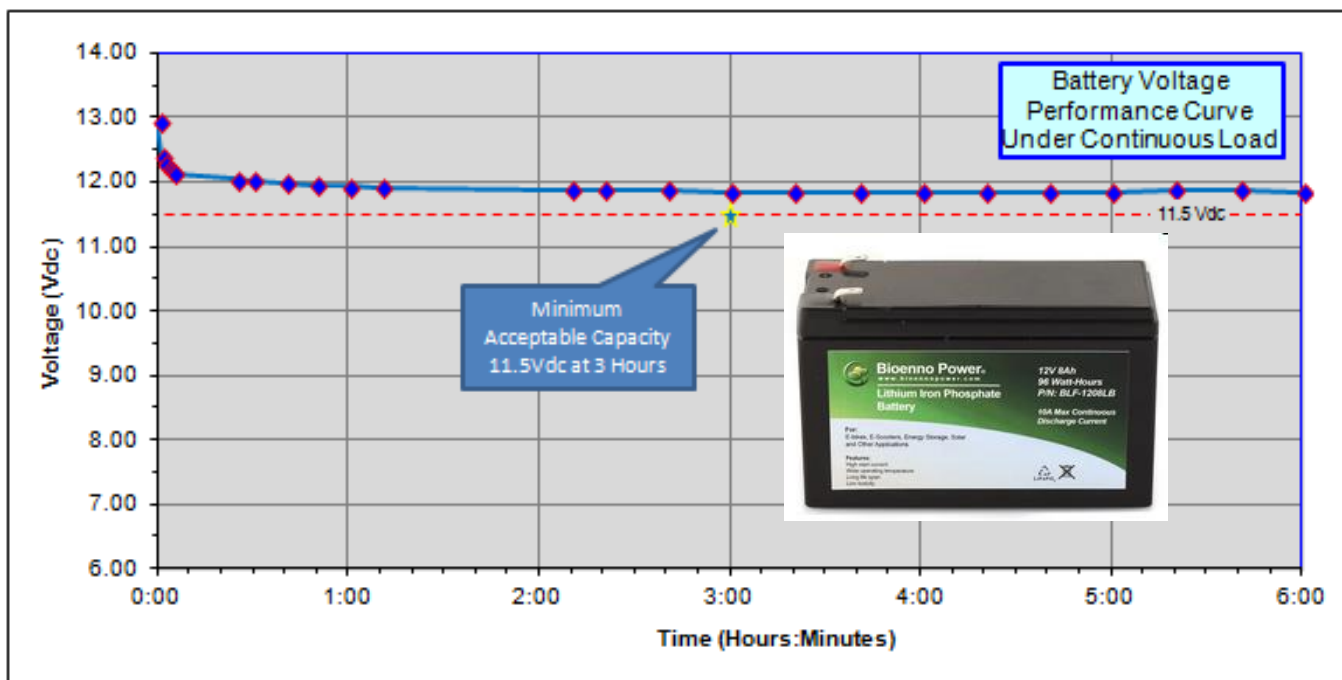
**WARNING Do not leave the battery connected to a load for an extended period of time. This can damage the battery.**

# Manual Battery Load Testing - LiFePO4

For more testing details see *SOARING* Feb 2012 or <http://aviation.derosaweb.net/presentations>

**Testing Description** 2/1/15 - N101RP Lithium #1 - labeled Jan, 2015 12Ω resistive load = 1A nominal load

Time (HH:MM)	Voltage (Vdc)	Duration (HH:MM)
00:00	12.93	0:00
00:01	12.37	0:01
00:02	12.26	0:02
00:03	12.20	0:03
00:04	12.15	0:04
00:05	12.14	0:05
00:25	12.04	0:25
00:30	12.03	0:30
00:40	11.97	0:40
00:50	11.95	0:50
01:00	11.93	1:00
01:10	11.90	1:10
02:10	11.89	2:10
02:20	11.89	2:20
02:40	11.86	2:40
03:00	11.85	3:00
03:20	11.84	3:20
03:40	11.83	3:40
04:00	11.83	4:00
04:20	11.83	4:20
04:40	11.83	4:40
05:00	11.85	5:00
05:20	11.88	5:20
05:40	11.86	5:40
06:00	11.85	6:00
06:20	11.78	6:20
06:30	11.74	6:30
06:40	11.55	6:40
06:50		6:50
07:00		7:00
07:10		7:10
07:20		7:20
07:30		7:30
07:40		7:40
07:50		7:50
08:00		8:00
08:10		8:10
08:20		8:20
08:30		8:30



Enter data in the yellow cells only

## How to Use this Spreadsheet

Hint: For ease of identification, uniquely mark each battery, i.e. the date it was purchased.

- 1) Note the date, battery type, unique identifier and other details in row 3.
- 2) Save-as the spreadsheet and indicate the battery type, unique identifier and test date in the filename.
- 3) Delete the contents of the yellow colored cells (select the contents and hit "delete").
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- 5) Take a voltage reading and note the time the reading was taken.
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- 8) Repeat steps 5 through 7 every 10-15 minutes until the voltage of the battery drops to approximately 11.5Vdc or low. (NOTE: 11.5Vdc is a reasonable minimum voltage for avionics use - refer to your avionics owner's manuals).
- 9) Save the spreadsheet and print it for your records.

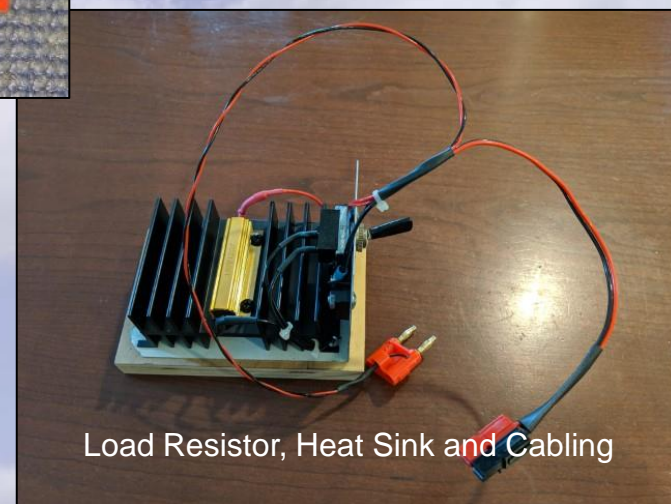
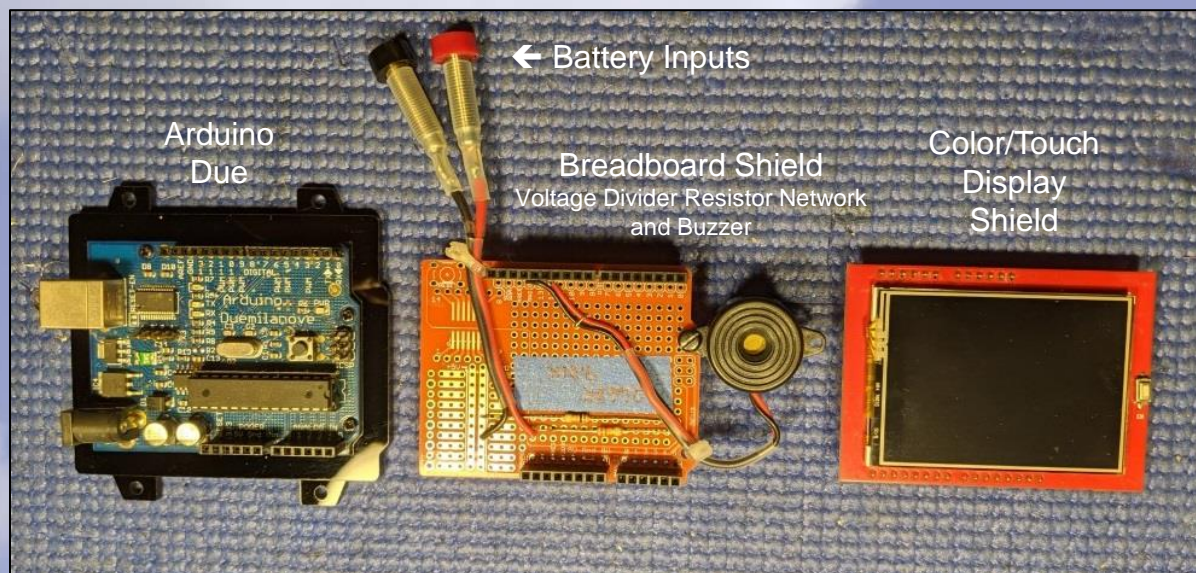
**WARNING** Do not leave the battery connected to a load for an extended period of time.  
This can damage the battery.



# Battery Load Testing

## Arduino Based Automatic Data Logger

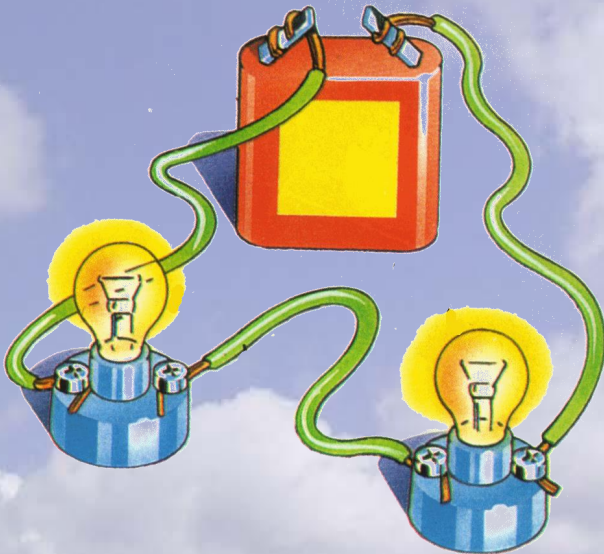
Information Available at <http://aviation.derosaweb.net/#batterytest>



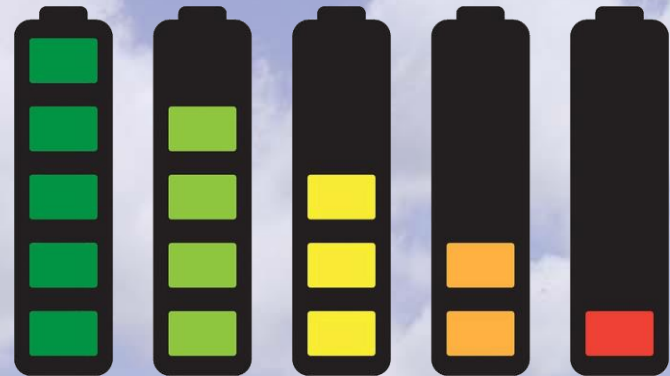


# Continued in Part 3 ...

## Chapter 7 Examples of Battery Circuitry



## Chapter 8 Minimizing Lost Volts



# Electrical Parts Sources

<http://aircraftspruce.com>

<http://www.hi-line.com>

<http://wagaero.com>

<http://wingsandwheels>

<http://www.wicksaircraft.com>

<http://craggyaero.com>

<http://cumulus-soaring.com>

<http://www.steinair.com>

<http://www.airsuppliers.com>

<http://waytekwire.com>

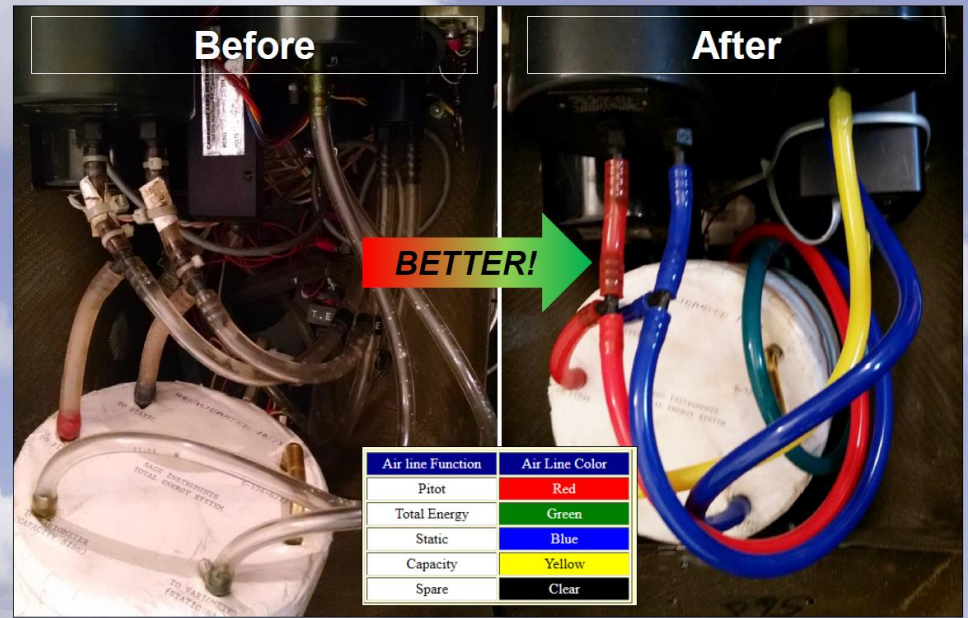
# Working with Air Lines

## *Working With Glider Pneumatic Air Lines*



*See My  
Presentation for  
More Details*

### Air Lines – Use of Colored Tubing Using color coded airlines eases type recognition





# See My Other Presentations

- Transceiver Troubleshooting
- Oxygen Systems
- Working with Glider Air Lines
- Sailplane Wiring
- Trailer Wiring & LED Lights
- Pilot Relief Systems
- Battery Testing
- Open Glider Network (OGN)
- Spar Alignment Tool
- L'Hotellier Fittings
- Carbon Fiber Panels
- IGC Filename Decoding
- Blanik L-23 Strut Work
- Landout Survival Kits
- Removing Painted Lettering
- Emergency Location Devices

**<http://aviation.derosaweb.net/presentations>  
[jhderosa@yahoo.com](mailto:jhderosa@yahoo.com)**