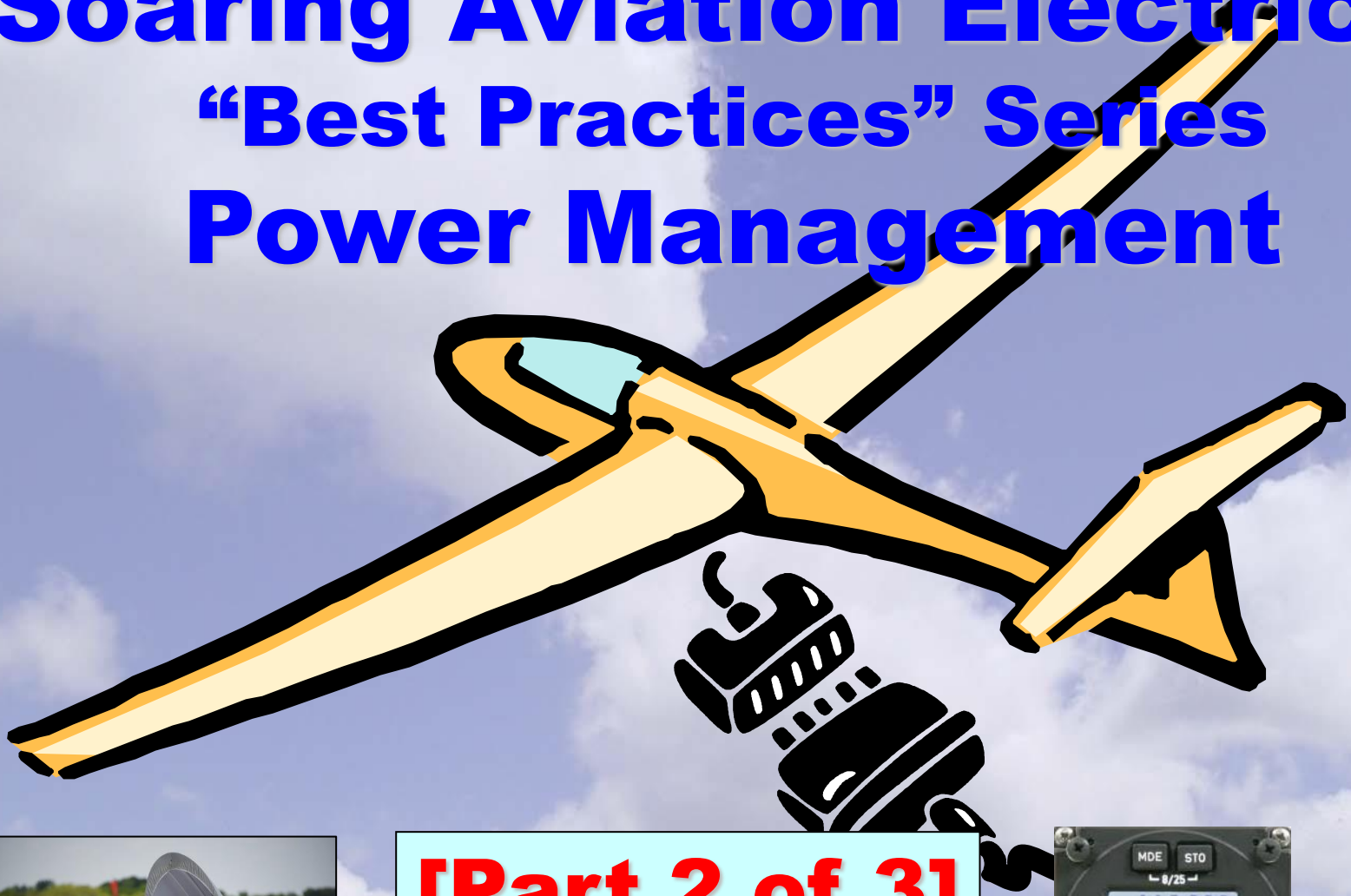
Soaring Aviation Electrical
"Best Practices" Series
Power Management



[Part 2 of 3]

John DeRosa OHM Ω
Updated: November 9, 2025

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**

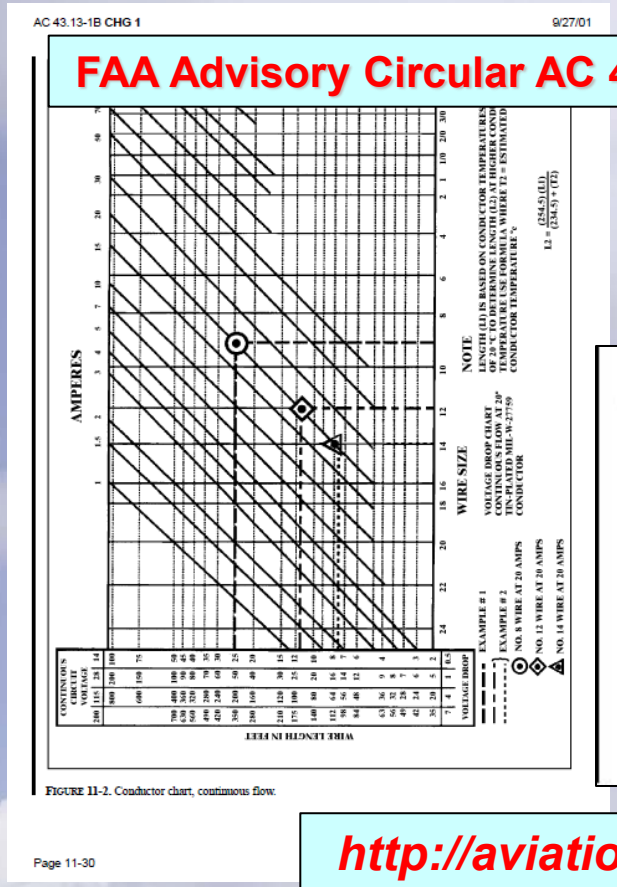
Part 3

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

AMPERES

WIRE SIZE

WIRE LENGTH IN FEET

NOTE

LENGTH (L1) IS BASED ON CONDUCTOR TEMPERATURES OF 20 °C TO DETERMINE LENGTH (L2) AT HIGHER CONDUCTOR TEMPERATURE USE FORMULA WHERE T2 = ESTIMATED CONDUCTOR TEMPERATURE °C

$$L2 = \frac{(254.5)(L1)}{(234.5)+(T2)}$$

VOLTAGE DROP CHART COPPER WIRE AWG AT 20° TIN-PLATED MIL-W-2759 CONDUCTOR

EXAMPLE # 1

EXAMPLE # 2

NO. 8 WIRE AT 20 AMPS

NO. 12 WIRE AT 20 AMPS

NO. 14 WIRE AT 20 AMPS

CONTINUOUS CIRCUIT VOLTAGE

VOLTAGE DROP

FIGURE 11-2. Conductor chart, continuous flow.

Page 11-30

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

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

“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

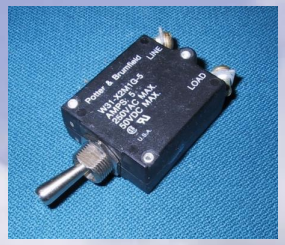
“It ain’t the current load that’s gonna’ get ya’ on that long flight. It’s the voltage drop!”

(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

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

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

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.

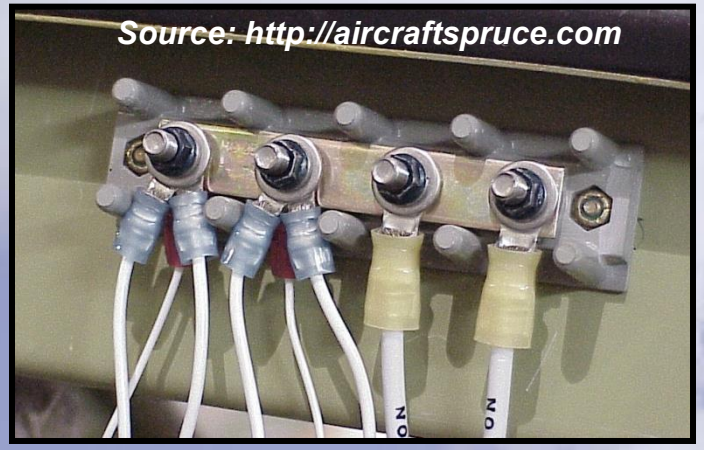
Breaker Styles

- **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*



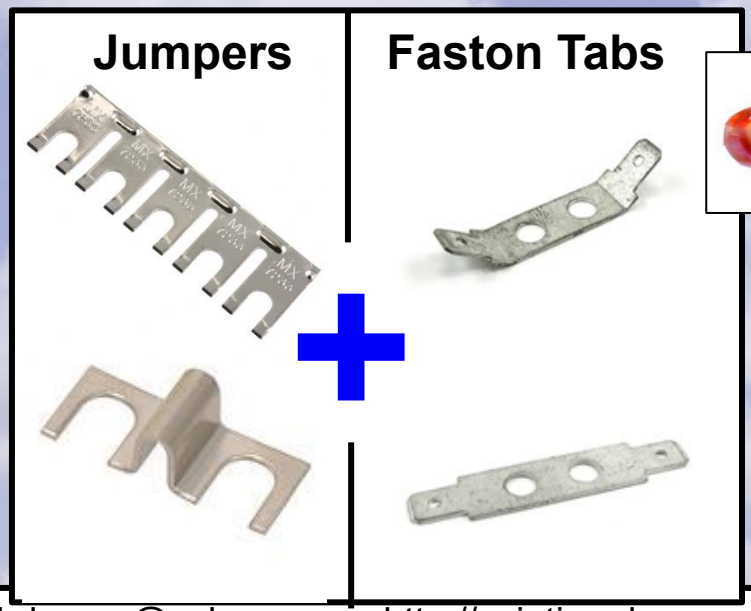
* Bus has only one “S” in it. This is a common mistake due to our familiarity to Buss (Bussman) branded devices

Terminal (Barrier) Block + Faston Connections

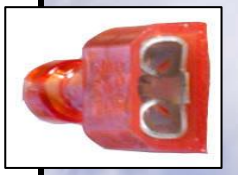
- **Pros**
  - **Robust**
  - **High Current Capability**
  - **Quick connection change flexibility (Faston type)**
  - **Adaptable to ring type crimp connections**
- **Cons**
  - **May not be certified for some aircraft**
  - **Somewhat expensive per terminal**

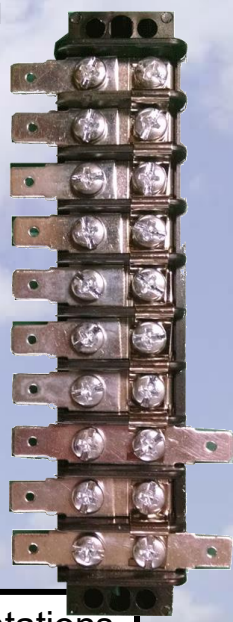
Terminal (Barrier) Block Bus Bar

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

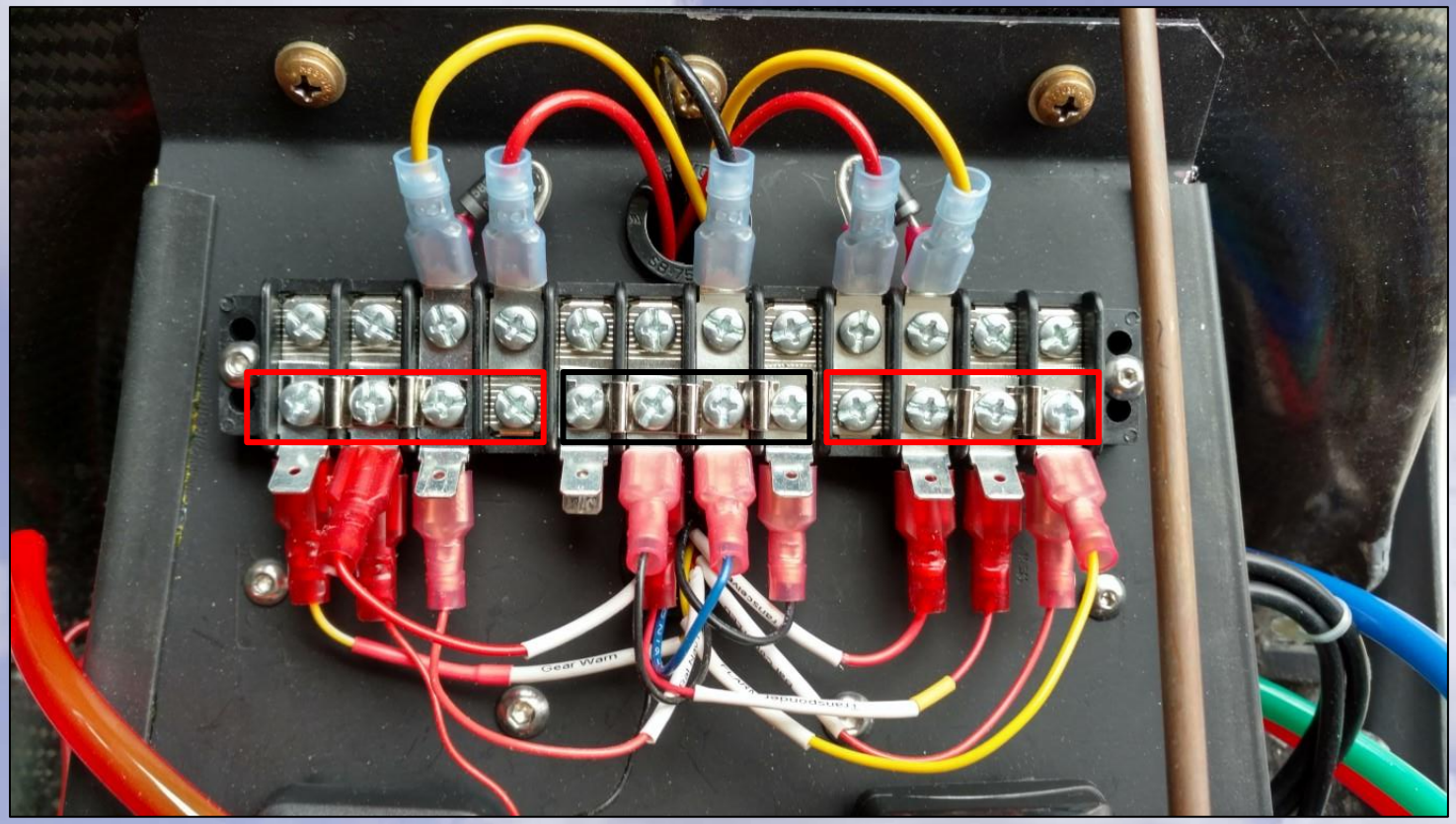


Faston Terminal





Terminal (Barrier) Block Bus Examples



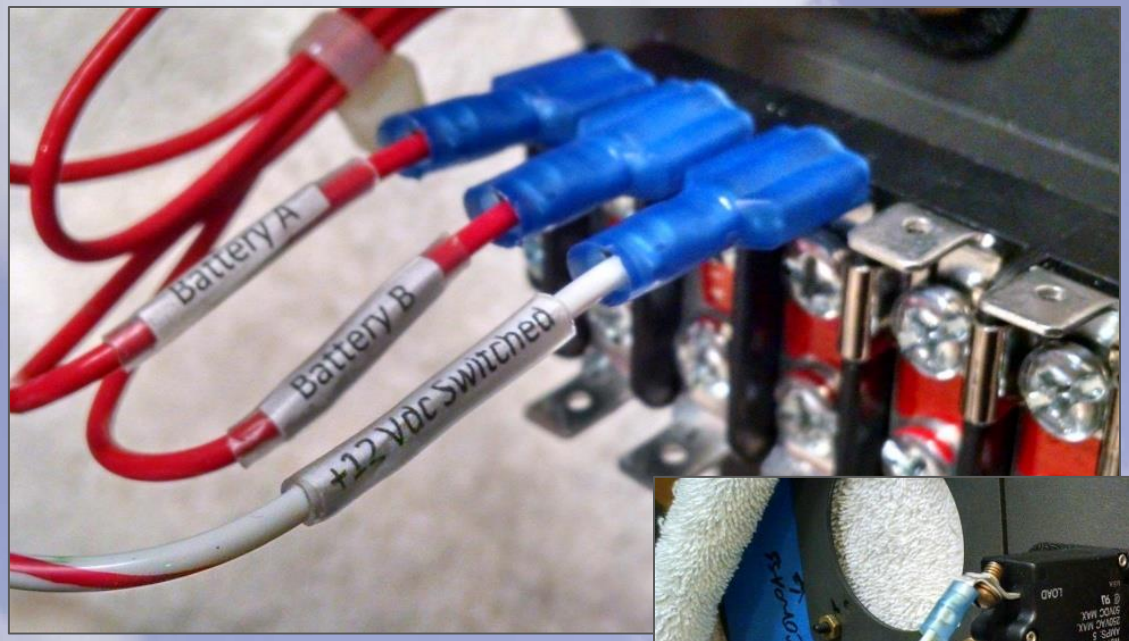
Positive Battery A Connections

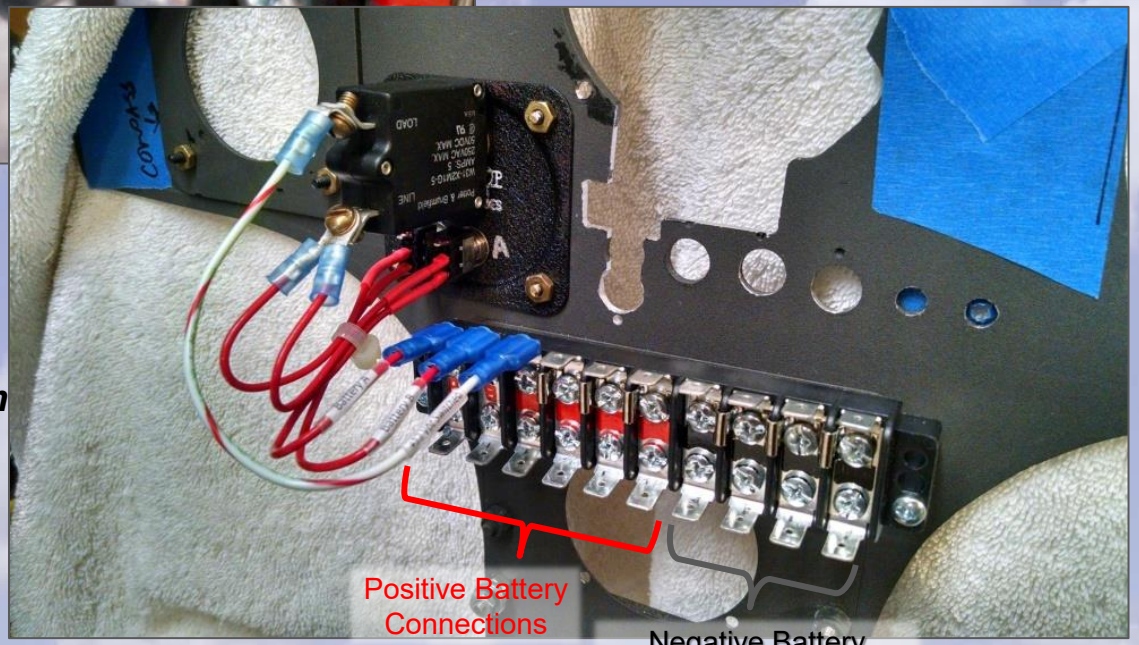
Negative Battery & Ground Connections

Positive Battery B Connections

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

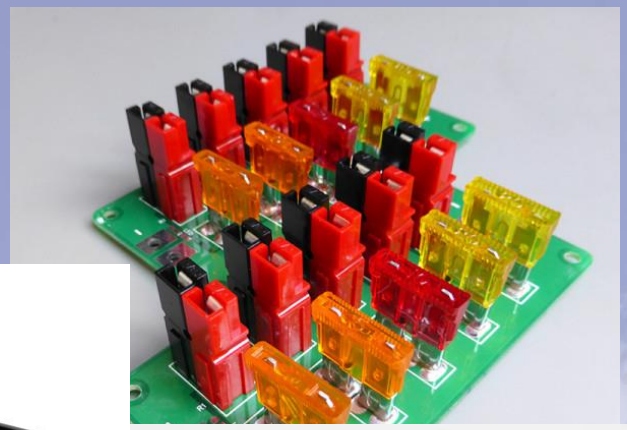
Terminal (Barrier) Block Bus Examples





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

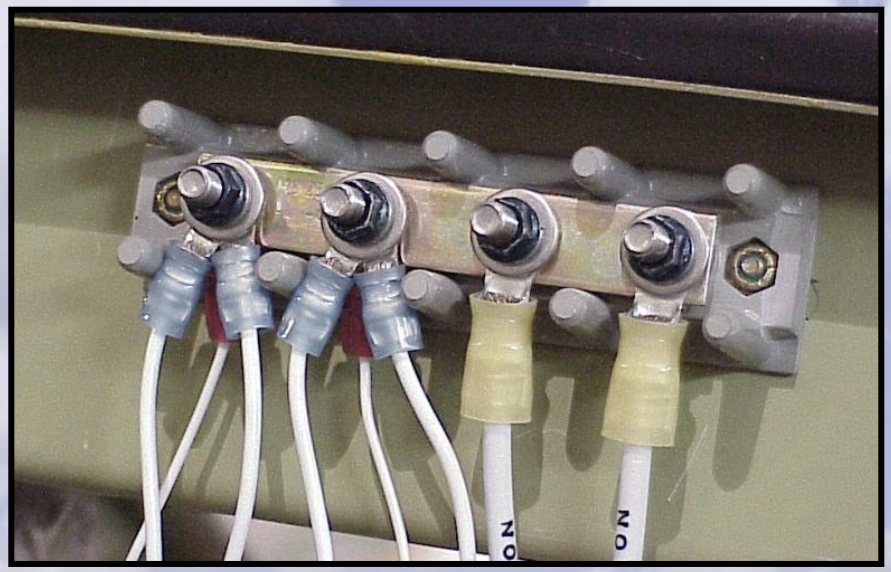
PowerPole Battery/Ground Buses



Source: http://www.powerwerx.com/ & others

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.

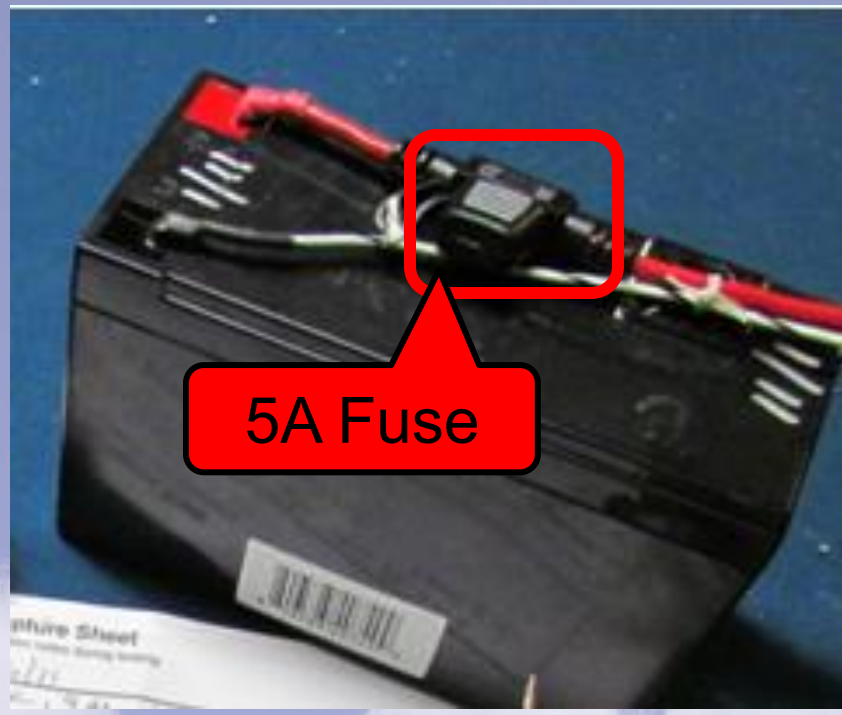


Power and Batteries

- 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)

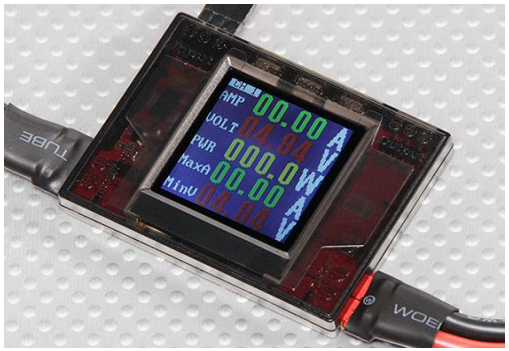
Avionics are never all at their maximum current at the same time

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

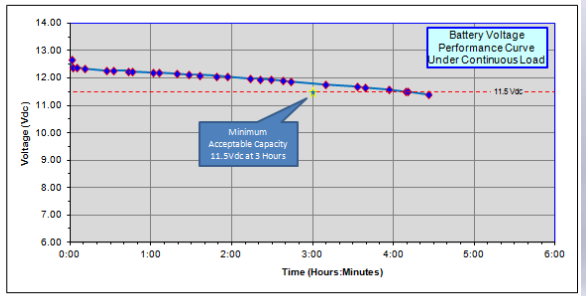


Battery Load Testing

Manual

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

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	12.23	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

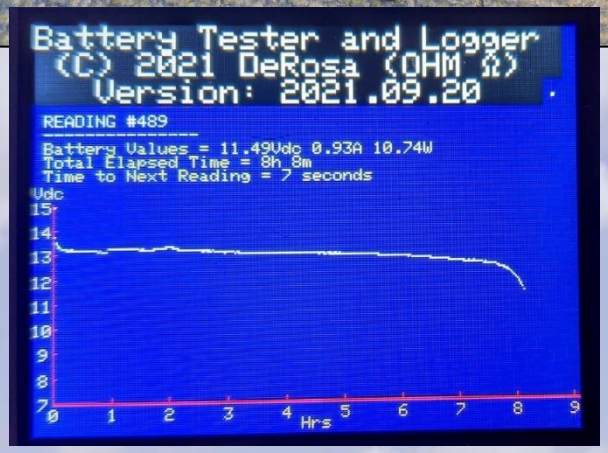
How to Use this Spreadsheet

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 mintues 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.

Automated



Battery Load Testing

Manual Method

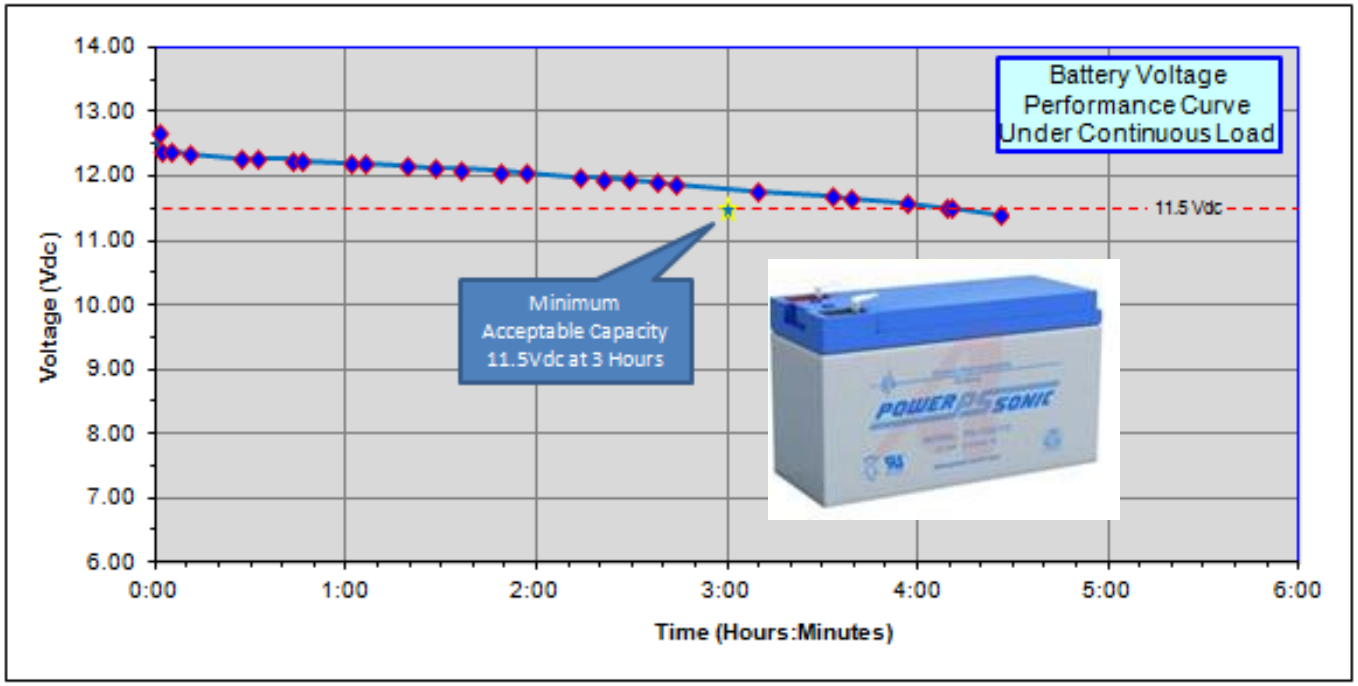
For details on how to perform a simple battery load test see my article in *SOARING* magazine's Feb 2012 issue or go to http://aviation.derosaweb.net/presentations

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 mintues until the voltage of the battery drops to approximately 11.5Vdc or lowe
(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.

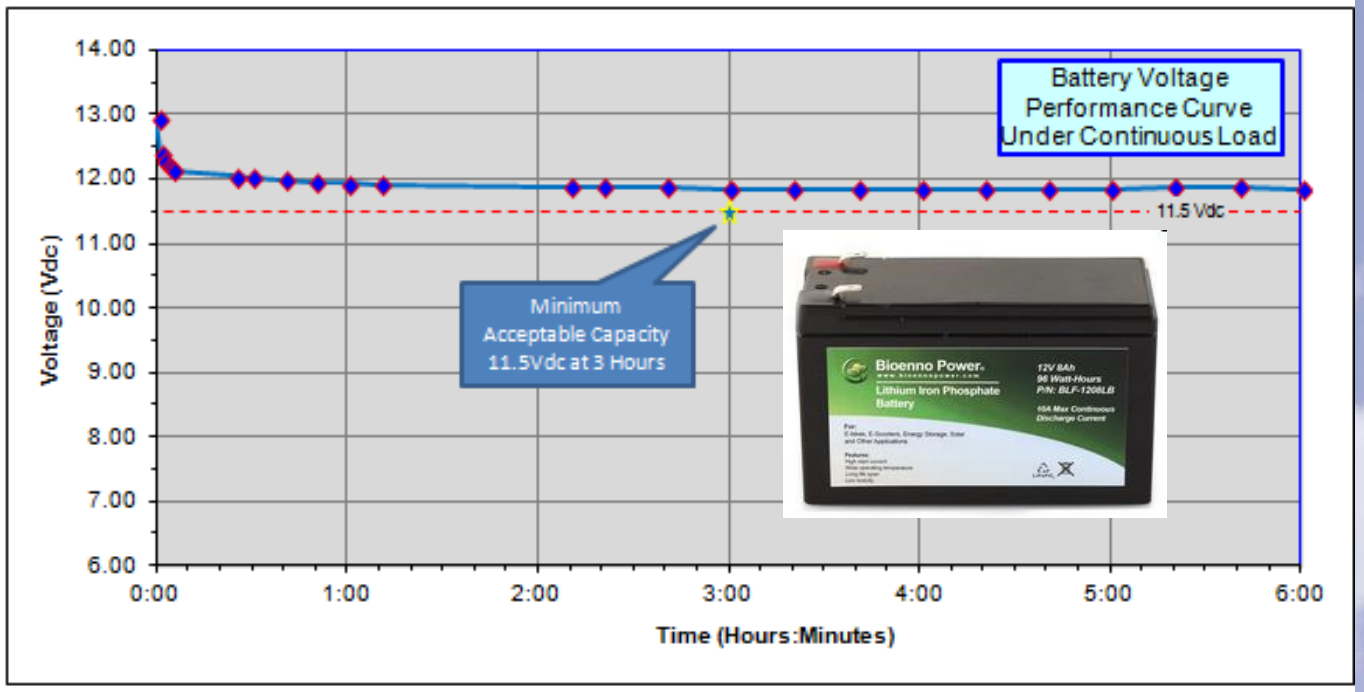
WARNING Do not leave the battery connected to a load for an extended period of time. This can damage the battery.

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.

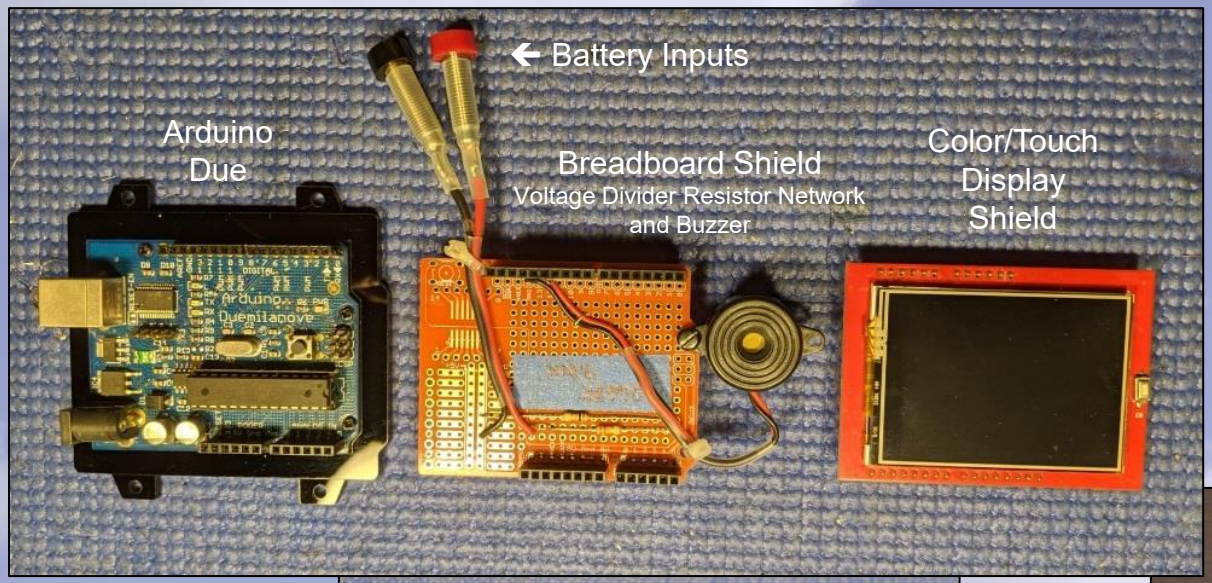
1) Note the date, battery type, unique identifier and other details in row 3.
2) Save-as the spreadsheet and indicate the battery type, unique identifier and test date in the filename.
3) Delete the contents of the yellow colored cells (select the contents and hit "delete").
4) Fully charge the battery. 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 mintues 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.

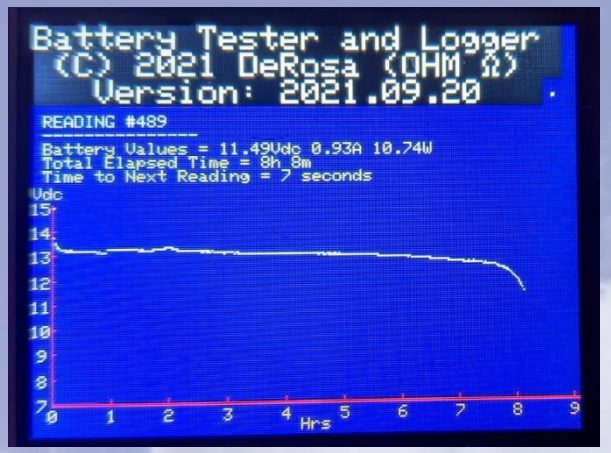
WARNING Do not leave the battery connected to a load for an extended period of time. This can damage the battery.

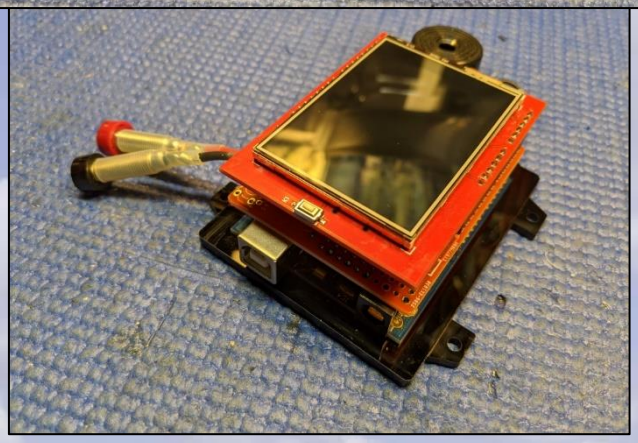
Battery Load Testing

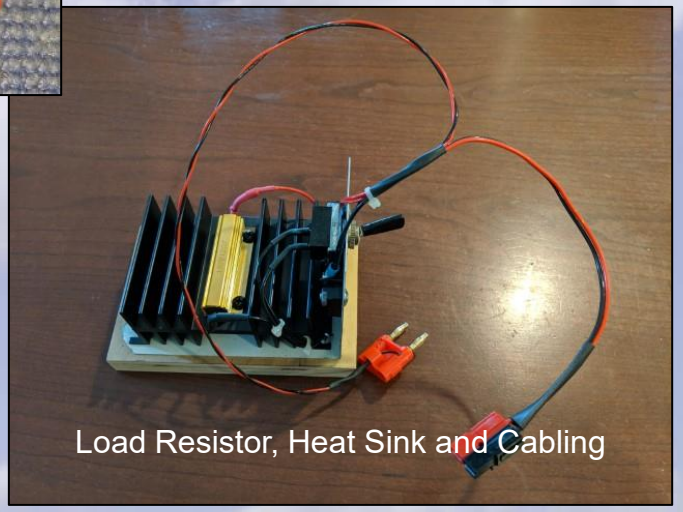
Arduino Based Automatic Data Logger

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





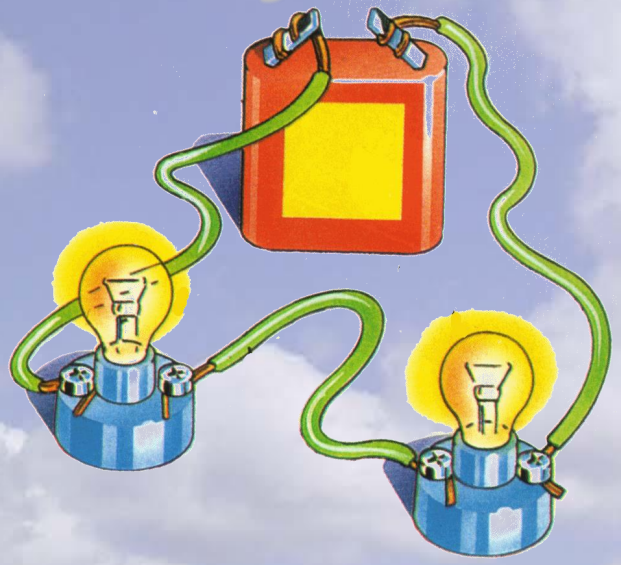




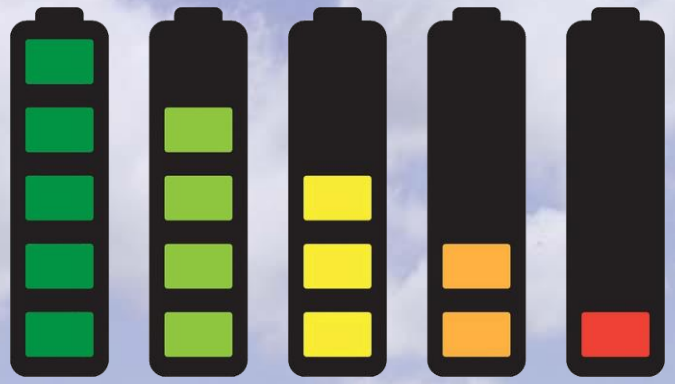
Continued in Part 3 …

https://aviation.derosaweb.net/presentations/documents/Soaring_Aviation_Electrical_Best_Practices_Part_3.pdf

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

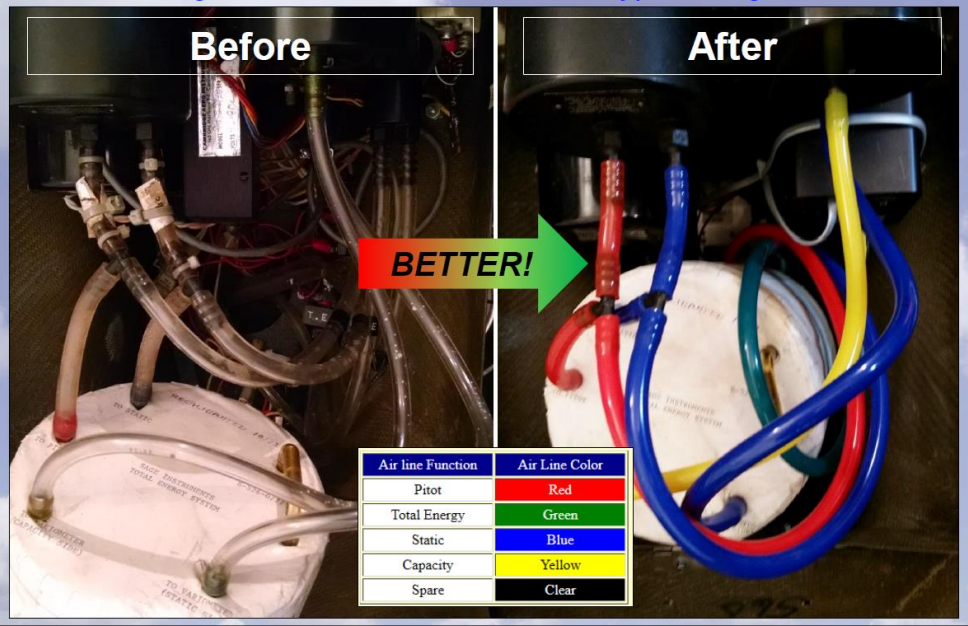
Working with Air Lines

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