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## What's all this Battery Isolator Stuff Anyhow?

Many builders are putting two batteries in their airplanes. One of the oldest incentives to install second battery is for a seaplane; it's a bummer to discover a dead battery while the wind blows the airplane further from shore! More recently, redundant chunks of lead provide independent power for the second of two electronic ignition systems. Some alternators do not run well without a battery on line; a second battery may be insurance against failure of a single battery or battery contactor that compromises the whole system. Whatever the reason, adding a second battery is no big deal.

I've read several articles in aviation journals suggesting the use of a recreational vehicle **battery isolator** for charging two batteries in an airplane. Figure 1 illustrates the **battery isolator**. Two silicon diodes in a single assembly do indeed permit charging two batteries from one alternator while maintaining 100% isolation of one battery from the other. When used as intended, an alternator may simultaneously service two batteries: one in a camping trailer, the other in a truck or other tow vehicle. The idea is to prevent the truck's electrical system from loading the trailer's battery; isolation is a good thing.

But is that what we really want for an airplane? In an

airplane, two batteries are given separate tasks in case of alternator or battery contactor failure. The presence of a second battery prevents loss of one battery from bringing down the whole system. Further, there are times when two batteries connected in parallel can help each other out . . . like cranking an engine on a cold day. A solid, high current connection is required between both batteries and the starter. The battery isolator arrangement in Figure 1 prevents use of the #2 battery for cranking.

Figure 2 shows two batteries (not necessarily the same size but either one capable of cranking the engine) simply

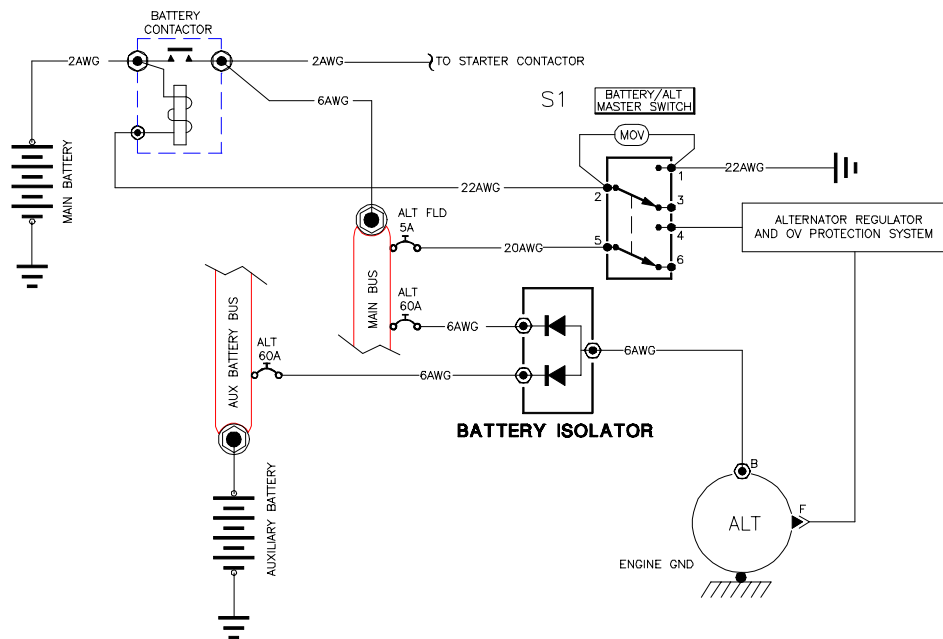


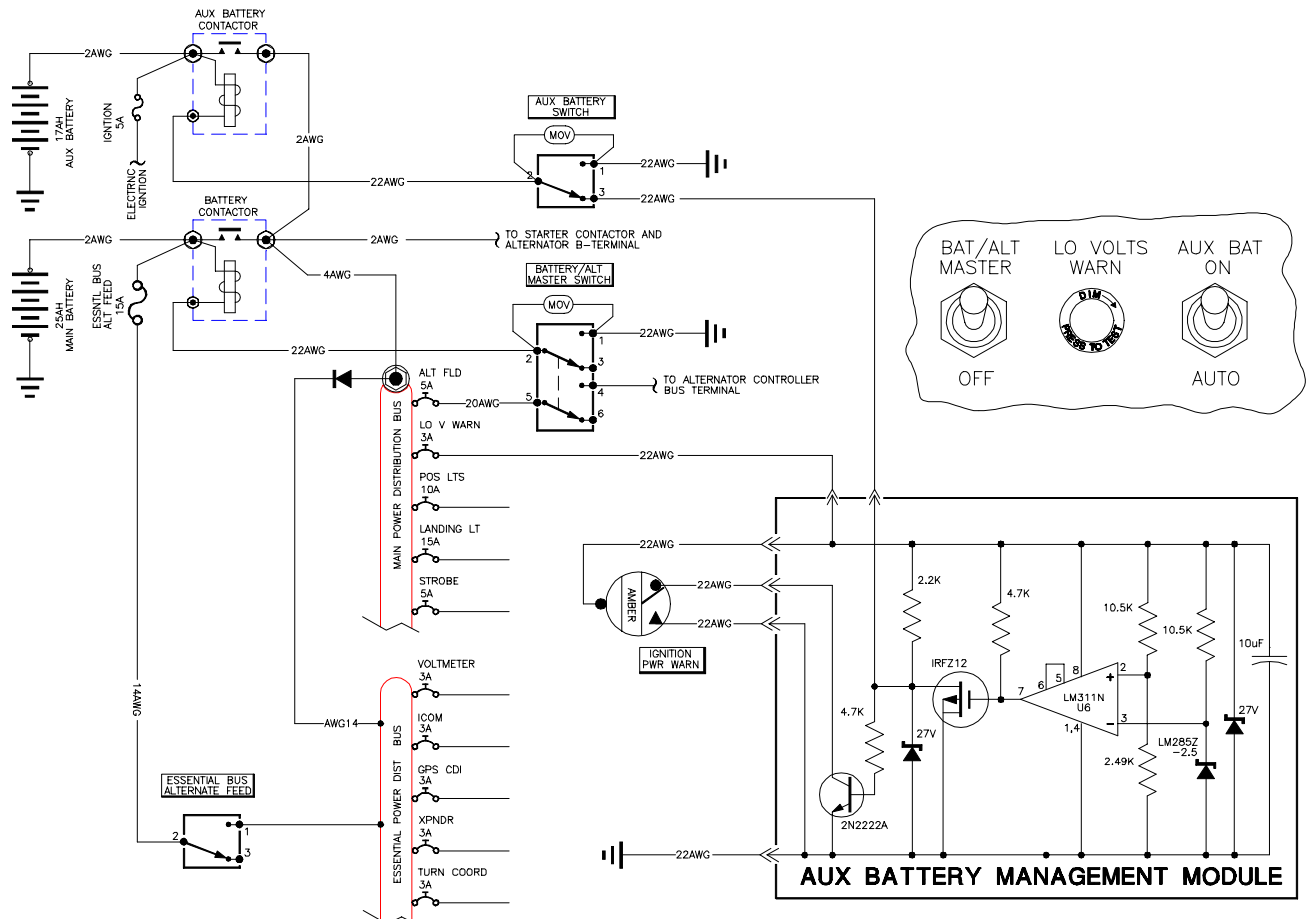
Figure 1. Typical Battery Isolator Wiring.

connected in parallel by means of separate battery contactors. Note that the #2 battery contactor has a control switch labeled AUTO/ON. The little box with some

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electronic devices in it is designed to carry out two important tasks. The circuit shown automatically bring the #2 battery on line any time the bus rises above 13.0 volts. Either or both battery master switches may be ON during engine cranking. After starting, return #2 battery switch to AUTO. When the alternator comes on-line, the battery management circuit closes the aux battery contactor. The low voltage warning light will go out. Both batteries will be on-line for proper maintenance by the alternator. If the alternator fails, two things happen; (1) the #2 battery is automatically isolated from the bus and (2) A low voltage warning light illuminates giving the pilot active, timely notification of alternator failure. The recommended action at this point would be to close the essential bus alternate feed switch and open the main battery contactor as well. Recall that contactors take about 10 watts of power just to keep them closed. When you're down to battery only operations, you don't want to throw away power warning

up contactors! The duties for each battery under alternator-out operations are accomplished via direct connections using in-line fuses right off the hot side of the battery contactors. Automatic switching for the #2 battery isn't necessary, manual auxiliary battery control is possible and practical. Simply eliminate the electronics in Figure 2. However, you still need timely notification of alternator failure. Low Voltage Warning is an integral feature of the aux battery manager. Many integrated instrumentation packages include some form of low voltage warning. Some alternator controllers (like the B&C products) feature low voltage warning. If you already have low voltage warning, you may opt for manual control of the aux battery. During normal operations simply close both battery contactors. When a low voltage warning shows alternator failure, open both contactors leaving only power critical items necessary for comfortable termination of flight taking needed power directly from the batteries.



**Figure 2. Dual Battery Installation w/Aux Battery Manager (Optional).**

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**Battery isolators** are heavy critters that dump approximately 6% of your alternator's output in wasted heat. Depending on how they are wired, **battery isolators** may interfere with alternator regulator performance. If you want to make the #2 battery available for cranking, then a hard connection to bus by way of a battery contactor is required. When an aux battery contactor is present, then no **battery isolator** is needed to maintain the #2 battery right next to the main battery. Given timely notification of alternator failure, separation of #2 battery from the bus can be effected either manually or automatically. RV **battery isolators** may work well on RVs with wheels but their use on RVs with wings is totally inappropriate!

If you'd like to add an aux battery to your airplane, use the following rules of thumb for estimating weights: Figure approximately 1 pound per ampere-hour for weight. Ten ampere-hours is about the smallest battery that will crank an engine. Batteries in this class are available both from Concord and B&C Specialty Products. Figure approximately 1 pound for a contactor installation and 0.25 pounds per foot for 2AWG wire.

A number of misconceptions about paralleling batteries are routinely circulated on the Internet aviation interest groups. Here are some excerpts from a conversation I had recently with a builder.

The builder begins, *"You can indeed put two batteries in parallel. You will wind up with the total capacity of both units combined. I.E. Two 50 amp hour batteries in parallel will give you 100 amp hours of capacity. The problem with doing this is that two batteries never have the same capacity."*

I replied, "Having the same capacity isn't a problem. Batteries paralleled as redundant power supplies can be markedly different in size. Figure 2 suggests a 24 and 17 a.h. batteries. In fact, we can parallel a 10 a.h. battery with a 32 a.h. battery if we so choose."

*..... If the off line float voltage of one is say 12.65 volts and the second was 12.25, then the first battery would discharge itself into the second and assume the capacity of the second.*

In order to charge a battery, we're obligated to raise its terminal voltage quite a way ABOVE the open circuit terminal voltage. Batteries DELIVER energy at 12.5 volts and below and just begin to accept significant charge at 13.5 volts and above . . . this is why the alternator's output voltage is adjusted to 13.8-14.2 volts. . . one may measure

tiny "leakage" currents between the two batteries hypothesized above but no significant amount of energy will transfer between them. Besides, the reason we wanted two batteries in the first place is to assign them separate tasks. Our system is designed to CHARGE them in parallel but LOAD them independently. During alternator failure, the batteries are separated from each other. Therefore, differences in terminal voltage and/or capacity are irrelevant

*..... Also, while you have increased the total capacity of the system and significantly lowered the battery impedance (good things) you have also increased the probability of a battery system failure.*

There are lots of ways the system can fail including dried out cells, shorted cells, open cells, worn out cells, etc. The "battery system failure" alluded to is undefined . . .

*..... The probability of failure goes up proportionately with the number of batteries in the string. It matters not whether they are in parallel or series.*

The image painted by these words says a single failure kills everything. The reason we choose to run two batteries in the airplane is to cut the probability of failure in half, not double it. It's the INDEPENDENT utilization of two batteries to power one or more critical tasks is the key concept here.

*..... A way around this is to diode isolate the two batteries. This would allow both batteries to see the same \_voltage\_ when in the charge mode (99.99% of the time), but be isolated when not being charged.*

I've illustrated your concept in Figure 1 of this paper. But Figure 2 accomplishes exactly the same thing. Both batteries see same voltage in charge mode and they're isolated when not being charged. While the alternator is working, concerns for battery capacity and condition are irrelevant as long as you have a way to separate each battery to its respective task -OR- isolate a failed battery from the bus . . . The big advantage of Figure 2 over Figure 1 is that the batteries can share cranking duties too!

*..... They would effectively be in parallel except during times of no current flowing into or out of them. The charge \_current\_ would be determined by the state of charge of each battery independently.*

From a 13.8 volt bus, it matters not whether there are 1, 2 or 20 batteries on the bus . . . each battery will always accept a charge according to its needs. Fully charged

batteries will draw very little, discharged batteries will draw a lot. Figure 2 operates in exactly the same manner as you describe for the diode isolator system . . .

*. . . . . In a properly designed and operating electrical system the alternator supplies all of the aircraft's electrical requirements. The battery should never be supplying any energy for your airplanes electrical system while the engine is running.*

Exactly. Since a battery delivers energy at 12.5 volts and below, a bus carried at 14.0 volts by the alternator absolutely guarantees that no battery in the system is doing anything but taking a charge . . . or is fully charged and waiting to be loaded should the alternator fail and the bus voltage fall . . .

*. . . . . One of the neat things that I have designed over the years is a diode system as just described. It consists of a dual Schottky diode rated at 80 amps per leg with a peak rating of around 400 amps. The voltage drop would be about 0.6 volts at max rated current. All that means is that the voltage regulator should be set up 0.6 volts higher than normal. Telephone companies do this all the time. They have two separate battery systems diode summed so that if one battery goes down the load is absorbed by the other remaining battery. Viola! The best of both worlds. Ain't electricity neat?*

Except for some minor points of battery folklore, we don't

disagree on anything. Irrespective of the number of alternators or batteries in the system The key to the use of contactors for paralleling is ACTIVE NOTIFICATION OF ALTERNATOR FAILURE. Every system I design has this feature . If the pilot is notified within seconds of an alternator failure, then any number of batteries may be UN-paralleled by opening their respective contactor. Continued operation with a failed alternator is possible when each battery delivers power to its assigned task by way of alternate, power paths independent of the normal power distribution system.

If contactors are provided to parallel for CRANKING and CHARGING batteries, then the need for diodes is eliminated. Further enhancement to system reliability is achieved when the owner either (1) does periodic capacity tests to all batteries on board to make sure that they'll carry their assigned loads for the required time or (2) exchanges out one of the batteries for a new one every year. The new-battery-a-year philosophy makes it possible to run dual electronic ignition, electronic fuel injection and all electric panels with great confidence. This is where it's nice to use a pair of identical batteries in the main and auxiliary positions. Each year, the fresh battery of KNOWN capacity takes on duties for running the essential bus while last year's battery is tasked with less stressful backups of things like a second ignition system. Best yet, no battery is more than two years old making them the most reliable sources of power on board the airplane.