A2452 CHARGING TWO BATTERIES

By Richard Clark

Last month we covered the fact that 12 Volt lead-acid batteries need two things to properly function in a car: heat and charging potential. Heat improves the electro-chemical reaction and the extra charging voltage is required to overcome the internal resistance of the battery. Of course, a large reservoir of current is also required, but this reservoir can remain virtually untapped unless an elevated charging potential, as well as a relatively warm operating environment is maintained.

We also learned that a regulator is included within the charging circuitry to keep the output of the alternator from exceeding a pre-set value. Without a regulator the output of the alternator would be determined by the speed of rotation.

Controlling the Current

In addition to the regulator, there must be a way to limit the amount of energy produced by the alternator. There are two commonly accepted methods of controlling the amount of current flowing between a source and a load. One method is to limit the current with an "squeezer" circuit, and the other method is to limit the amount of time that the source is connected to the load.

The first method requires exceedingly large heat sinking circuit elements to dissipate the unwanted current, and is therefore impractical for general automotive 12 Volt applications.

The accepted method of current control in an automotive charging system is the on/off concept, which works by varying the duty cycle of the applied voltage to the field windings of the alternator. Recall that the output energy of the alternator's stator windings is directly proportional to the intensity of the electro-magnetic field created by the rotor.

Noise From an Alternator?

The problem with chopping the energy in the field windings is that the field current can represent as much as 5% or 6% of the output current produced by the alternator. Rapidly switching this much current on and off causes abrupt changes in the magnetic field of all conductive elements in the systems involved. Quite simply, this means NOISE to those of us in the car audio industry.

Alternator whine is primarily composed of two elements ---- a high-frequency whine accompanied by a low-frequency hum. It is this field current switching that is responsible for the low frequency hum component of the alternator whine.

The Importance of a Set-Point

The regulator in a typical charging circuit works exactly like all electronic regulators. A regulator will not permit the output voltage of the alternator to exceed some pre-determined set- point. This set-point must consider such important factors as driving habits, battery temperature, and load conditions. This set-point can mean the difference between boiling out excessive battery electrolyte and maintaining a battery at less than maximum capacity.

The set-point for a charging system is a carefully chosen voltage that should be changed ONLY when the consequences of such a modification are fully comprehended. Excessive wear on all vehicle accessories including lights, engine electrical circuits and sensitive computers will severely shorten their life expectancy. Other problems are brought on by too low a set-point. These symptoms would include slow engine cranking, dim lights, early audio amplifier clipping and general low battery energy. Set-points are very important.

Adding a Second Battery ---- In Parallel

There comes a time when a second battery is required to afford additional listening time without the hassle of a running engine. As we've stated before, one method is to simply parallel another battery, of a similar type and size, along with the stock battery.

The reason that the battery should be the same type as the stock battery is so that it can display similar charge/ discharge characteristics. For instance, there are too many compromises involved when paralleling a deep cycle sealed battery with a stock vented battery. Likewise, problems can occur when a sealed lead-acid wet cell battery is connected in parallel with a Thermo Oil lead-acid battery.

One advantage of directly paralleling two similar batteries is that the internal resistances of the batteries will also be placed in parallel. This would effectively lower the combined internal resistance. And since this internal resistance is actually in series with the power leads of the car audio system, the advantage is obvious.

Not quite so obvious is the fact that dissimilar batteries will exhibit dissimilar internal resistances. This situation can lead to uneven loading and charging problems as well as less than optimum performance. It is our opinion that less power related problems would occur if similar batteries were used in dual battery installations.

The drawback of placing two batteries in parallel is that both batteries could be reduced to a state of discharge at the same time. To overcome this problem, may we recommend a high-current electro-mechanical solenoid? For details of the wiring of such a solenoid please refer to page 12 of the April/May '91 issue of AUTOSOUND 2000 Tech Briefs.

Dual Battery Isolation

Dual battery isolators amount to little more than one-way power diodes potted within a large heat sink. Their purpose is simply to prevent the load on one side of the isolator from drawing energy from the other side of the isolator.

Typically the cathodes of each diode are connected to the positive battery post of each battery and the common anodes of the diodes are connected to the output of the alternator. No connections are fused. The cathodes and anodes are mounted in potting compound and then imbedded in a hefty aluminum heat sink to be secured to the chassis of the vehicle.

The cost of this method of isolation is two-fold: 1) The diodes will cause a potentially problematic voltage drop, and 2) Energy is lost in the form of heat. These problems are NOT trivial. The actual voltage drop across one of the isolating diodes can be as little as .2 V for Shottky diodes, but more typical is the value .7 V. Actually we have measured drops in excess of 1.2 V in extreme cases where heavy current was involved.

The actual voltage drop of a diode is a function of heat. Installing a dual battery isolator under the hood of a typical car does not usually afford much cooling for the diodes. And as for the energy losses, just look at the size of the heat sink; it is comparable to a good-sized car audio amplifier.

Concerning the Diode Voltage Drop

Now there is truth to the rumor that a typical automotive alternator is quite capable of producing more than "a few" extra volts. Our experience has demonstrated that just about any alternator can produce over 20 Volts of DC. The problem lies with the charging system's regulator.

The regulator has a "sense" lead that is normally connected to the positive battery post. For whatever reason, this sensing lead is usually connected to the lead that is going to the positive battery post rather than directly to the positive battery post. This keeps the connection internal to most factory alternators. (Most aftermarket alternators are equipped with external regulators and external sensing leads.) There is no problem with this method because the output lead of a factory alternator is usually a large gauge wire and it usually directly connects to the positive battery post.

The problem arises when a circuit element, such as an isolation diode, is placed in series with the output lead of a factory alternator with an internal regulator: No problem for the alternator; Big problem for the regulator.

The sense lead is now on the wrong side of the diode. (See diagram) This means that the internal regulator will be tricked into believing that the battery is in a much higher state of charge. Recall that the difference between a fully charged six-cell lead-acid battery and an effectively drained car audio battery is 13.05 V -11.85 V or only 1.2 Volts. But we have seen that voltage drops across isolation diodes in dual battery isolators can be in the .5 V to 1.2 Volt range. What gives?

The direct result of giving false information to the regulator is low alternator output. The battery can never get a decent charge because the regulator is reading a false status voltage. For example, if the diode drop were only .4 V, then this is the amount by which the battery will be undercharged. For all you math whizzes out there, .4 V is 33% of the entire 1.2 V range, which means that the battery can only operate at 66% capacity. What would happen if the diode voltage drop were around 1 V? WOW!

Now, on the other hand, if the sense lead could somehow be pulled from within the alternator and connected directly to the positive battery post, this diode drop problem would cease to exist. Or if the set-point of the regulator could be altered to account for the voltage drop, then the battery would theoretically get a proper charge.

The problem with this approach is that it effectively loosens the regulation of the charging system because the isolation diode is an extremely non-linear device. The voltage drop across this diode is directly proportional to both temperature and current. Anyway, the important point to remember is that the sense wire MUST be connected directly to the positive battery post for optimum performance. But to which positive battery post should the sense lead be connected in a dual battery installation?

What's the Solution?

Well, that's a good question. Obviously, the battery with the sense lead connected to its positive post will receive favored attention from the charging system. On a family car, we would always sense on the car's battery. With a dual battery isolator installation in a competition vehicle, some consideration should be given to maximizing the charge state of the secondary battery. Perhaps a SPDT switch could be connected to the sense lead to choose between the batteries. It certainly would not be beneficial to show up at a contest with a stabilized 12.2 V on your car stereo battery. Please be advised that we do not recommend activating this switch while the engine is running. Doing so could cause a momentary voltage spike.

Putting it All Together

In summation, if a second battery is to be added to a sound system, directly paralleling similar batteries is the method of choice. A solenoid can be installed to separate the batteries when the charge system is not being used. If continuous isolation is mandated, a dual battery isolator can be used, provided the regulator is equipped with an external sensing lead. The second battery should be installed in a warm location and as near to the alternator as possible. The isolator should be installed in a relatively cool area with airflow directed over the heat fins. Isn't this an interesting predicament?

All grounds are exceptionally noisy and must be as short as possible. With the addition of a second battery for the car audio system, we would recommend a direct large gauge connection between the case of the alternator and the negative battery post. Then, a smaller gauge wire connected from the same negative battery post back to the chassis of the car. This is the exact technique that General Motors used on all their full sized pick-ups and blazers from 1973 until 1989. (See drawing of battery and alternator grounding method.)

It is our recommendation that the charging system stay located within the shielded confines of the warm engine compartment. Now, we are fully aware that Corvettes used to have their battery installed behind the driver's seat and those certain BMWs still put their starting battery under the back seat. However, seasoned installers will have to admit that these cars can exhibit extraordinary noise problems due to the long and unshielded charging paths. If you want to minimize noise problems and maximize charging efficiency, keep your batteries up front!

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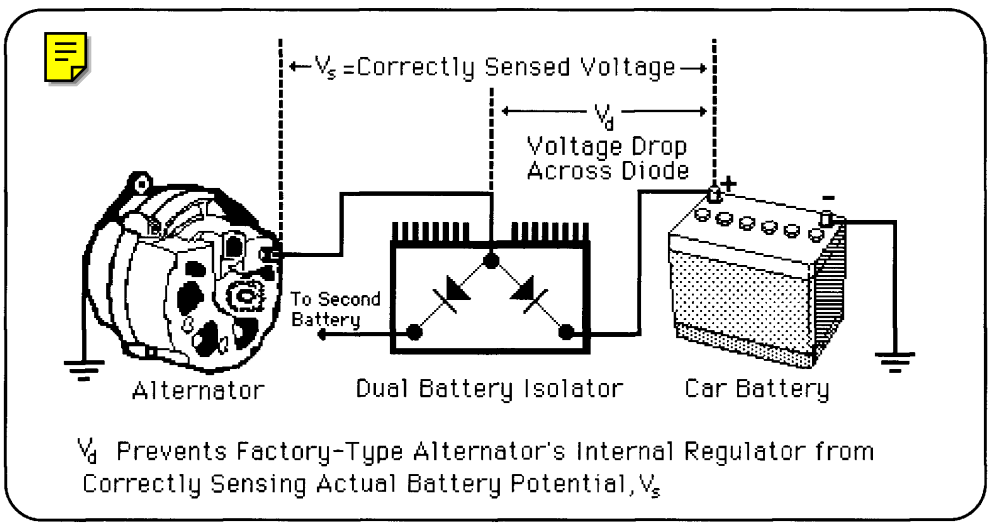
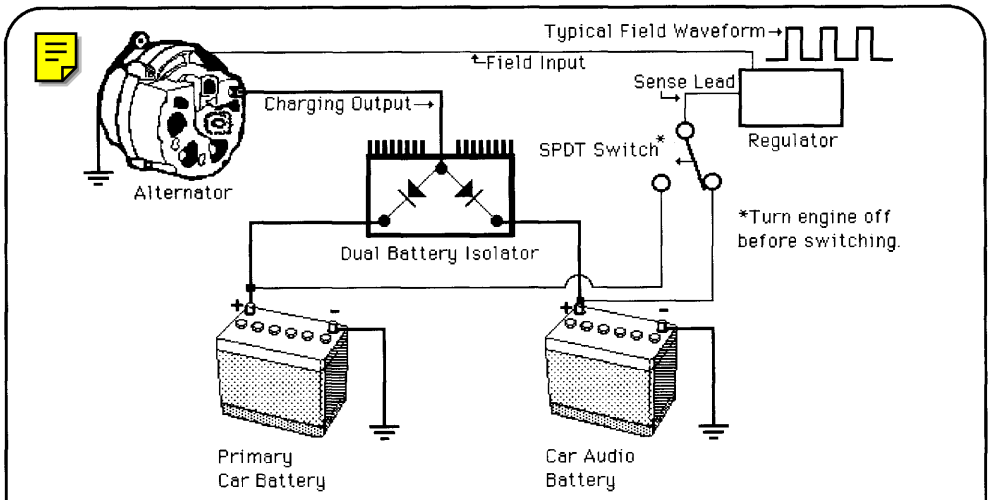
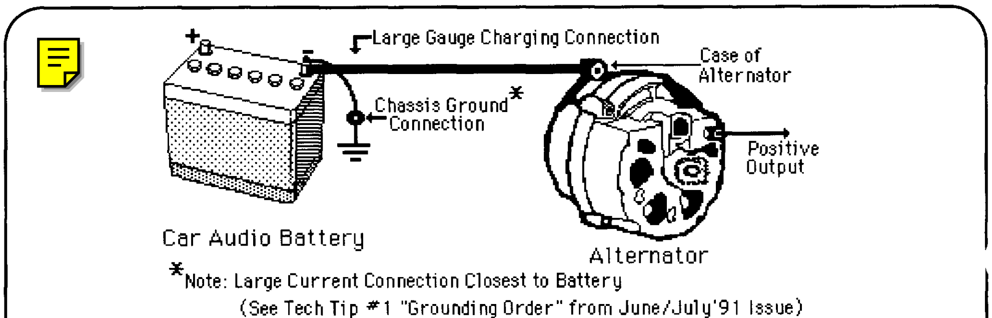
Three Diagrams follow:





Installation of Switch for Selecting Sensing Point in Dual Battery System



Correct Grounding Method for Charging System Connection