Installation Instructions
3–Step Deep Cycle Regulator
Model #1021–A

Read These Instructions

Much effort has gone into the 3–Step Regulator to make it highly functional and reliable. It must be properly installed, however, before you can appreciate its performance. Naturally you wish to see how well the 3–Step operates, but do read the following instructions prior to installation of the 3–Step Regulator.

Enhancements and Pin Number Changes

The 3–Step Model #1021–A is an improved version of the older #1021 design. The unit has been repackaged to simplify manufacture and test, and some circuit components have been added to provide greater protection against high voltage transients and reverse polarity voltages. In addition, the functions of Pins 1 and 2 have been swapped to make it harder to short the battery voltage/temperature sensors to ground. ***Pin 1 is now the input line from the sensors, and Pin 2 is the enabling power input.***

Mounting the 3–Step

Choose a safe, DRY place for the 3–Step Regulator as close to the alternator as practical. If possible, select a place that is not in the direct heat of the engine compartment or other large heat sources. Do not mount the 3–Step (or any electronics) in the battery compartment of liquid electrolyte batteries, since the oxygen rich environment can hasten corrosion. The 3–Step has a terminal block for all wires. Mount the 3–Step so that the terminal block is down.

Do not block the air that flows under the 3–Step. The field driver transistors use the lower case as a heatsink and must have rising air to properly cool.

Wire Sizes

Do not use wires larger than #14 AWG in the terminal block, since larger wires may not fit in the terminals. Sometimes it is necessary to use a small screwdriver to free up the terminal hole prior to wire insertion.

Wiring Practices

Strip wires 3/16–1/4 inch (5–6 mm) prior to insertion. Do not strip the wires so long that bare wire is exposed outside the terminal block. Do not use large gauge wire and cut a few strands to make it fit in the terminal block. The cut strands will eventually rub together and the regulator will then malfunction. Do not solder (tin) any of the wires, since the terminal block is designed to grip bare wire, and dos not work as effectively on soldered wires.

3–Step Fusing

The 3–Step Regulator is protected from shorts on the field terminal by a fuse which is inside the unit. The fuse will open if the field terminal is shorted to ground. Only use an 8 Amp very fast acting fuse from Ample Power Company if it is necessary to replace the fuse.

Voltage/Temperature Sensor Precautions

The voltage/temperature sensors are permanently damaged if shorted to ground, or otherwise conduct more than 0.050 Amps. It is therefore required that the voltage/temperature sensor be attached to the battery *after* it has been connected to the regulator. If multiple batteries are sensed, connect all the sensors to a common point and then run only wire to the 3–Step Regulator. **Install the wire in the regulator before connecting any of the sensors to the batteries.**

NOTE: *If you have an occasion to replace a 3-Step Regulator, always disconnect the battery sensors as the first step, before removing any other wires.*

Proper Fusing

NOTE: The voltage/temperature sensors will not conduct much current before they open circuit. For this reason, it is not necessary to fuse the wires that go from the sensors to the regulator. **All other wires that connect directly to the battery or positive distribution should be fused as close to the battery as possible.** The wire which connects to Pin 6 should be fused at the battery or alternator with a 15 Amp fuse. A 1 Amp fuse should be used in series with the enabling voltage supplied to Pin 2. *Failure to properly fuse all wires leading from the battery may result in fire, loss of your vessel, and personal injury/death.*

Wiring the 3–Step

Remove all power from the electrical system before doing any wiring. Be sure that power is not applied to any circuits while wiring. Wire exactly according to the wiring diagram. Do not connect the field terminal, pin 5, until after testing the alternator.

Do not try to save a wire by jumpering Pins 3 and 4. Pin 3 must connect to a battery ground, and Pin 4 must go to the alternator ground. The regulator will not operate properly unless wired exactly as shown on the wiring diagram.

Note that when an isolator is used, Pin 6 is wired to a battery, which can be picked up at the isolator. When an isolator is not used, Pin 6 is wired to the alternator output.

Initial Test Procedure

If you have modified an alternator for use with the 3–Step Regulator, it must be tested by itself before connection to Pin 5 of the regulator. To test the alternator:

1. Start the engine and let it run at a fast idle. The alternator should not be charging.
2. With the engine running *MOMENTARILY* touch the field wire to battery terminal lug. Observe that the alternator charges when the field wire is connected to the battery terminal lug. If it does not, the alternator is defective, or other wiring is not proper.

After wiring the 3–Step, make the following tests. All voltage readings are referred to ground.

Column 1 Temperature ($°F/°C$)	Column 2 Absorption Voltage	Column 3 Float Voltage
37/3	14.66–14.72	13.96–14.02
47/8	14.60–14.66	13.91–13.96
57/14	14.55–14.60	13.85–13.91
67/19	14.50–14.55	13.80–13.85
77/25	14.45–14.50	13.75–13.80
87/31	14.39–14.45	13.71–13.75
97/36	14.34–14.39	13.65–13.71
107/42	14.28–14.34	13.61–13.65
117/47	14.23–14.28	13.55–13.61

Table 1: Liquid Electrolyte Batteries

1. Measure the voltage at pin 1. It should read about 2.4 Volts less than the highest battery voltage; i.e. 9.6 for a 12 Volt battery reading.
2. Measure the voltage on Pin 5. It should be about 0 Volts. There should be no power applied to Pin 2 for this test.
3. Now apply power to pin 2 by turning on the ignition switch or other enabling switch. Measure the voltage on pin 2, and verify that the voltage is close to that of the battery being used to supply power to the regulator.
4. Measure the voltage at Pin 5. It should read close to the voltage on Pin 6, battery voltage.
5. Start the engine, enabling the 3–Step regulator by applying power to pin 2. Rev the engine slightly to get the 3–Step to *kick in.*
6. Adjust the 3–Step Regulator according to the adjustment instructions which are given below.
7. Bundle all the wires to the 3–Step together, and use a cable tie to securely fasten the bundle to the same mounting surface as the 3–Step Regulator. Be sure that the wires can not vibrate against any sharp objects.

Column 1 Temperature ($°F/°C$)	Column 2 Absorption Voltage	Column 3 Float Voltage
37/3	14.40–14.50	13.96–14.02
47/8	14.35–14.40	13.91–13.96
57/14	14.30–14.35	13.85–13.91
67/19	14.25–14.30	13.80–13.85
77/25	14.20–14.25	13.69–13.80
87/31	14.15–14.20	13.58–13.69
97/36	14.10–14.15	13.47–13.58
107/42	14.05–14.10	13.36–13.47
117/47	14.00–14.05	13.25–13.36

Table 2: Sealed Batteries

Adjustment Procedure

Introduction

There are two adjustment potentiometers on the 3–Step. One of them adjusts the absorption voltage, and the other adjusts the float voltage.

The absorption and float voltage should be adjusted according to Table 1, or Table 2. For conventional flooded electrolyte batteries, use Table 1. For sealed batteries, use Table 2. To make the adjustments, you need a digital voltmeter, such as the Electrical System and Amp Hour Monitor, and an accurate thermometer.

The adjustment procedure should be done when the 3–Step is installed or whenever a new Battery/Temperature Sensor is added to the system.

Voltage Adjustments

Proceed as follows:

1. Measure the temperature(s) of the batteries to be charged. Measure the temperature of electrolyte, or the positive battery post.
2. Look in Column 1 of the appropriate table for the closest temperature to that of the batteries. Read across from the temperature in Column 1 to find the proper absorption voltage and float voltage.

3. R1, on the far left side of the terminal block adjusts the absorption voltage and R2 on the right of the terminal block adjusts the float voltage. Absorption voltage, R1 is adjusted first.
4. Run the engine with the 3-Step enabled (Voltage applied to Pin 2).
5. Adjust R1 until the voltage on the batteries reads in the range of voltage given in Column 2 of the appropriate table.

   NOTE: An alternator may not be able to raise the battery voltage immediately. You should perform this adjustment after the batteries are almost charged so that the battery voltage tracks your adjustment both up and down on the voltmeter. Be sure to have an accurate, up-to-date battery temperature measurement. **Note:** If the regulator trips to float voltage before you make the final adjustment, then disable the regulator momentarily by removing power to pin 2, and re-enable it. This will restart the charge and absorption cycles.
6. After adjusting the absorption voltage, wait until the regulator trips to the float cycle. This will occur in 30 to 60 minutes after the absorption voltage is reached.
7. You may have to wait a few minutes before adjusting the float voltage if the battery is not loaded. Turn on lights or other equivalent load to lower battery voltage before making the following adjustment.
8. Adjust R2 to obtain the voltage read from Column 3. If you normally run for several days at a time, lower the float voltage values from 0.1 to 0.3 Volts for extra battery life.
9. Place a small amount of sealant around the adjustment potentiometers R1 and R2 to lock in your adjustment settings.

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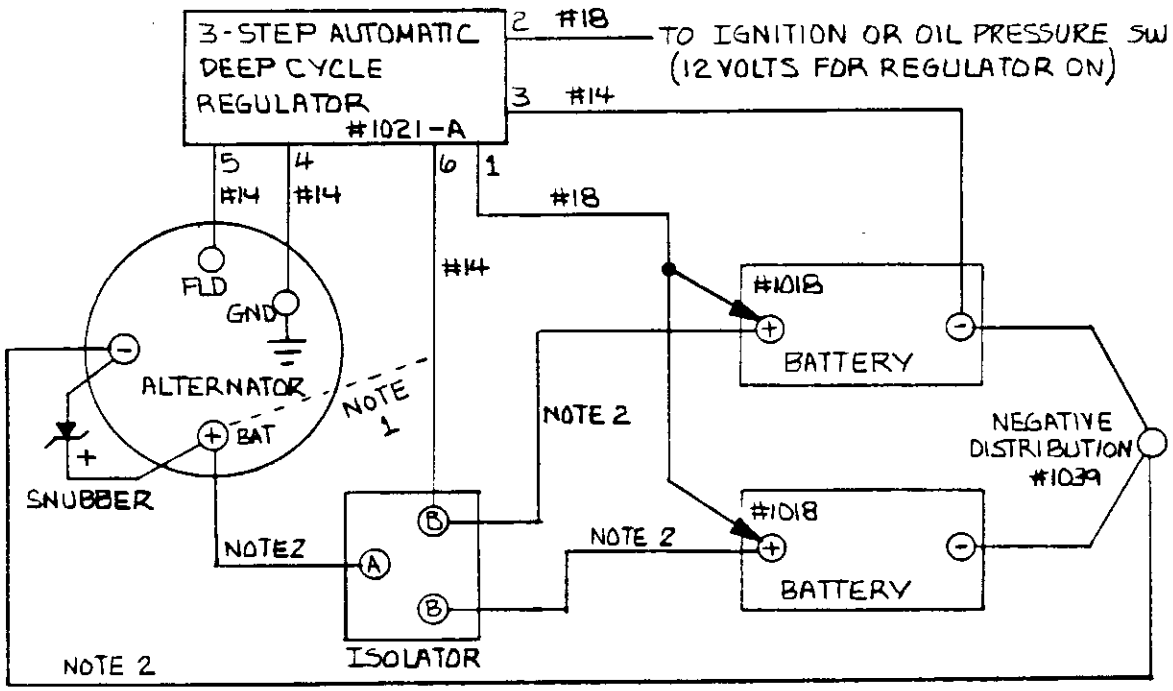
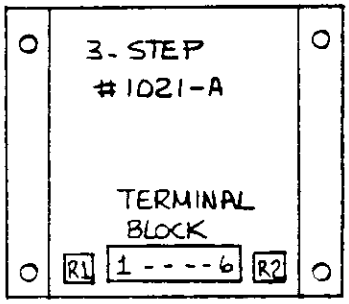


NOTES:

1. IF ISOLATOR IS NOT USED THEN PIN 6 ON 3-STEP CONNECTS TO ALT. ⊕
2.

ALT. AMPS	WIRE SIZE
50	#6
70-90	#4
90-130	#2
130-200	#00



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SMEAD

3-STEP WIRING DIAGRAM
FOR
#1021-A

Application Note 119:
Converting an Alternator for the 3-Step.

P and N types alternators are discussed in Application Note 103 and our book *Living on 12 Volts with Ample Power.* The majority of alternators are P type, and any alternator can be converted to a P type easily.

Even P type alternators with internal regulators must be modified to operate with the 3-Step Regulator. Modification consists of removing the internal regulator and bringing out a field terminal for hook up to the 3-Step.

A P type alternator is one which has one field wire connected to the negative terminal (usually the case), and the other field wire free for regulator hook-up. Field wires are the wires from the rotor that connect via brushes, to either terminals mounted on the case, or directly to the internal regulator.

Motorola alternators with internal regulators are easily converted to operate with a 3-Step. To modify these alternators, remove the small case at the back end of the alternator which houses the regulator. The regulator is potted inside the small case. With the regulator case detached, the brushes are visible. Remove the two wires from the brushes, and insulate the wire terminals with heat shrink tubing so that no shorts can occur. Now, choose one of the brushes and wire it to ground. Small frame Motorola alternators use the case as ground, while some of the larger units have isolated negative terminals. In this latter case, connect one of the brushes to the negative terminal. The second brush is then wired to Pin 5 on the 3-Step Regulator. *Often, one wire is already wired to ground.* This can be determined by a visual inspection, or an ohmmeter. Typical resistance of a field winding is 2 to 6 Ohms, so a cheap ohmmeter may indicate that both field windings are grounded.

On old alternators with dirty brushes and slip rings, an ohmmeter is not a reliable way to measure field resistance. An ohmmeter imposes a low current through the resistance under test, and with dirty contacts, the field resistance appears much greater than it is under use. In such cases, determining which end of the field is grounded is best done by inspection.

The Japanese alternators which we have encounterd on Yanmar engines are N type with an internal diode trio. The regulator is inside the cases, and thus conversion is more difficult. Before proceeding, it is a good idea

to mark the cases with a felt tip pen, indexing the cases for re-assembly. The screws which hold the two cases together can now be removed, and the cases separated. The rotor will stay with the fan/pulley, and the stator winding will be part of the rear case.Once the cases are separated, gently clamp the rear case in a vise *by a mounting foot* to allow soldering inside the case.

To relieve the tension on the brush wires, place a large socket inside the rotor well to force the two brushes up into their holder. Now, unsolder the two brush wires from the regulator posts. Splice two wires, (#14–#16 AWG) to the brushes and, after double insulating the splices with heatshrink tubing, route the two wires through the back case. Connect one wire to the negative terminal, and the other wire to the 3-Step. *Note that the ground terminal on some Japanese alternators is marked with an "E".*

The cases are now ready for re-assembly. On the back of the alternator, locate the small hole directly behind the brushes. This hole allows a stiff wire such as a bent paper clip to be inserted. Push the clip through in such a manner as to hold the brushes up in their holder. The forward case with the rotor can now be inserted. Remember to line up the index marks, and before the cases are fastened, remove the paper clip so that the brushes contact the slip rings.

Some of the Delco alternators must also be split to gain access to the field. Modification of them is very similiar to that just described above.

All alternators operate by the same underlying principles, and thus the 3-Step Regulator can be used with any alternator. As noted above, some modification is required. Before connecting the 3-Step Regulator to an alternator, be sure to run the pre-tests described in the installation instructions.

Ample Power Company has high output alternators already wired for direct 3-Step hookup.

Application Note 117: Alternator Temperature Control.

The standard alternator was not designed to be operated under a continuous full load. When installing an Automatic 3-Step Deep Cycle Regulator on a standard alternator, you must be mindful of the temperature of the alternator. You should be able to hold your hand on the case of a standard alternator. If the temperature is greater than about 140 to 150 degrees Fahrenheit, failure is likely.

Adequate ventilation is the best measure for an alternator which is being worked hard, such as the case when a 3-Step Regulator is used. Be sure that the engine compartment has plenty of airflow, and if possible, supplement the airflow past the alternator with a fan.

If the alternator can not be kept below the temperatures indicated above, then the engine RPM must be limited so that less alternator current is produced. As a rule of thumb, don't run the standard alternator continuously at more than 65% of the alternator rating.

Even if you limit alternator output by running at fewer RPM, the 3-Step Regulator will put a full charge on the batteries. Once the battery voltage has risen to the absorption voltage at about 14.4 Volts, the battery accepts current at its natural absorption rate. The engine RPM can generally be increased at this point without alternator overload.

Remember, the alternator will run for years if not overheated. The 3-Step Regulator does demand that the alternator work hard. Even 'hot' rated alternators can be destroyed without adequate ventilation. For the longest life, keep the alternator cool.

Application Note 118: Using an Emergency Alternator Bypass Switch.

In Figure 4.7 of our book, "Living on 12 Volts with Ample Power", we show the schematic for a switch and diode that can be used in an emergency to control an alternator. Such a switch would be used in the event of regulator failure.

When the toggle switch is in the on position, current flows through the alternator field winding. Output current from the alternator is proportional to field current, as well as alternator RPM. Since it is impossible to adjust field current with a switch which is either on or off, the alternator output must be controlled by varying the engine RPM.

To use the emergency switch properly and avoid battery overcharges, it is necessary that close attention be given to both the alternator current and the battery voltage. Adjust engine RPM to attain sufficient alternator current. Remember, unless you have a 'hot' rated alternator, limit RPM such that the alternator does not overheat from excessive current.

Monitor the battery voltage often, and when the voltage rises to 14.4 Volts with a battery temperature of 77 Fahrenheit, lower the engine RPM to maintain this voltage. At this point in the charge cycle, constant attention is required. Continue to lower RPM, maintaining 14.4 Volts, until the battery current falls to about 5% of the Ampere hour rating of the batteries under charge. The charge can be terminated now, by turning off the switch.

Note: For battery temperatures other than 77 F, or for control voltages for sealed batteries, refer to our book, or to Application Note 109.

Ample Power Company does make a switch and diode assembly suitable for emergency charging. The assembly comes pre-wired to a terminal block which may be permanently installed nearby the alternator, or wired up when needed. Order Catalog Number 1061.

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