Abstract:

This is a circuit for regulating the output voltage on small engines. This circuit will work on engines that were originally equipped with a shunt type of voltage regulator. It is common on motorcycles, skidoos, ATVs and other recreational vehicles. This circuit was tested out on a Suzuki GS400E motorcycle and seems to function fairly well.

How to identify if this circuit will work on your engine:

There are 2 main types of voltage regulation system used in engines today. The first one is where the generator/alternator has a set of stationary windings (stator windings) and a set of windings wound around the center armature. The magnetic field created by the windings in the armature control how much current is induced into the stator windings. This circuit will not work with this type of regulation system.

The second type of voltage regulation system uses a permanent magnet in the armature to create the magnetic field. For this reason, the amount of current generated in the stator windings is close to constant. In this type of system, the voltage is regulated by shorting out windings when the output voltage gets too high. The shorting needs to be done before the rectifiers to prevent the regulator from shorting out the battery.

How does the circuit work:

The first part of the circuit is a simple rectifier pack. I used a couple of 12A 200PIV bridge rectifiers. The GS400 engine has 3 phases on it. A lower voltage can probably be used but since there is no cost savings, I went with the higher voltage. This will just rectify the AC coming back from the stator windings.

To perform the action of shorting out the windings, each of the windings is connected to an SCR (SCR1, SCR2 and SCR3) that will short the winding to ground. The rectifier pack will have the ground being the lowest voltage of each of the windings so it is not necessary to directly across each winding, just from the winding to ground. The SCR's used were 8A 200V devices. The current rating of the SCR will depend on the amount of current your engine will produce. It is possible to do a short test where all the phases are connected together and the current on each phase measured. The other way to guess based on the electrical load on the system. Some systems do not need to have an SCR on each phase. They are OK with only 1 or 2 phases having an SCR. The systems that do not need tight regulation usually have a large static load on them (such as headlights, tail lights, etc)

To detect the battery voltage (which indicates when to reduce the output current), a differential pair of transistors is used. This has a number of advantages over using a zener diode to directly trip the gate of the SCR. These are:
1)If the battery voltage is forced above 13.5V, the circuit limits the current into the gate of the SCR preventing damage to the regulator when changing the battery
2)The circuit is more stable over temperature.

The main drawback is that the circuit is leaky. The differential pair should be connected after the ignition switch to prevent the battery from draining when the engine is not used for a long period of time. This connection is shown as MONITOR in the schematic. The output of the bridge rectifier ties to the battery at the BATTERY connection.

With the differential pair, the base input for Q2 is connected to a voltage reference consisting of D1 and R9. The base input for Q1 is connected to a voltage divider that monitors the battery voltage. When the voltage on the base of Q2 is higher than the voltage on the base of Q1, Q1 will turn on shunting all of the current from R5 to ground. When the voltage on the base of Q2 is lower than the voltage on the base of Q1, then Q2 will turn on. This will shunt the current of R5 through the limiting resistors to the gates of the SCR. The SCR will turn on and short out the phase. Since the stator voltages are AC, the SCR will reset at the end of the cycle when the voltage reaches 0.

Construction

The low current circuitry (differential pair transistors)was built up on a small piece of perf board. The other parts (bridge rectifier and SCRs) were mounted on the plate where the original rectifier/regulator was located. The rectifiers and SCR's need to have a heat sink on them to prevent them from getting too warm.

Testing/Alignment

Before the circuit can be put into service, the trip point for the differential pair needs to be set. A DC power supply should be connected from the positive on the perf board to the negative. The DC supply should be set to 13.5V+/-0.1V. Now adjust the pot R8 such that the circuit just starts firing the gate of the SCRs.

The DC supply should be removed and the positive of the perf board should be connected after the ignition switch.

When the vehicle is in service, if the battery does not recharge sufficiently, then the trip voltage can be increased by .1 or .2V to provide a quicker charge. If the battery needs to have water added too often, the voltage can be decreased. by .1 or .2 V