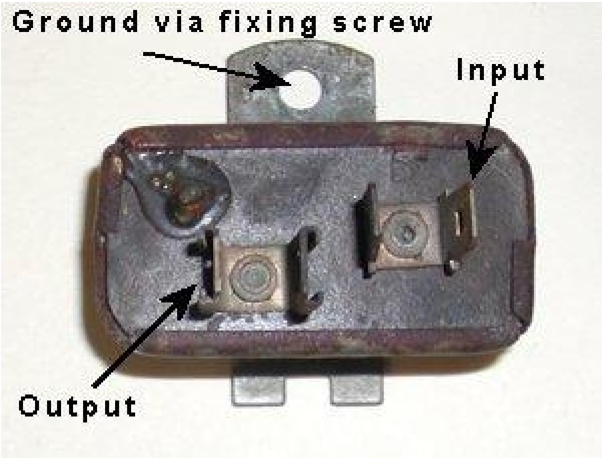
THE VOLTAGE STABILISER

Courtesy of the MG Cars Enthusiast's Club - www.mgcars.org.uk

The vehicle supply voltage varies considerably depending the state of charge of the battery, the engine speed and the loads, such as any lamps and motors, that are operating. The Fuel, Temperature and Oil gauges all work by measuring a voltage put out by a sender that responds to fuel level, water temperature or oil pressure respectively. Hence, any variation in the supply voltage will cause changes in the readings of the gauges. In order to overcome this problem, an attempt was made to stabilise the voltage supplied to the gauges using a rather crude method that was necessary before the availability of low cost and robust semiconductor devices.

The Voltage Stabiliser is intended to regulate the voltage to the gauges at about 10 Volts. It does this by monitoring the input voltage and should it find it to be higher than 10 Volts, as it normally would be, then it temporarily removes the supply to the gauges. The gauges are so highly damped, that is slow in responding, that the voltage supply can be interrupted for a few seconds without noticeable effect. If the Voltage Stabiliser were accurate, which it is not, then it would ideally maintain an average voltage of about 10 Volts although in reality the gauges actually receive full voltage for some of the time and none for the balance. For example, if the car is running with a good battery at reasonable speed, a voltage of 13.5 Volts might well be seen at the regulator. The regulator should therefore switch off for a few seconds and then switch on again so that the on to off ratio is about 74%:26% and the average voltage the gauges see is 74% of 13.5 Volts = 10 Volts. Similarly, the stabiliser should respond to a 12 Volt input, say when the vehicle is stationary with the ignition on, by being on for about 83% of the time and off for the remainder. In reality, the regulator is both not very accurate, and results in the gauges cycling up and down as it switches on and off. This is particularly noticeable when the fuel gauge is reading toward empty.

The Stabiliser is located in a particularly difficult to access position, high up in the right side under the dash.

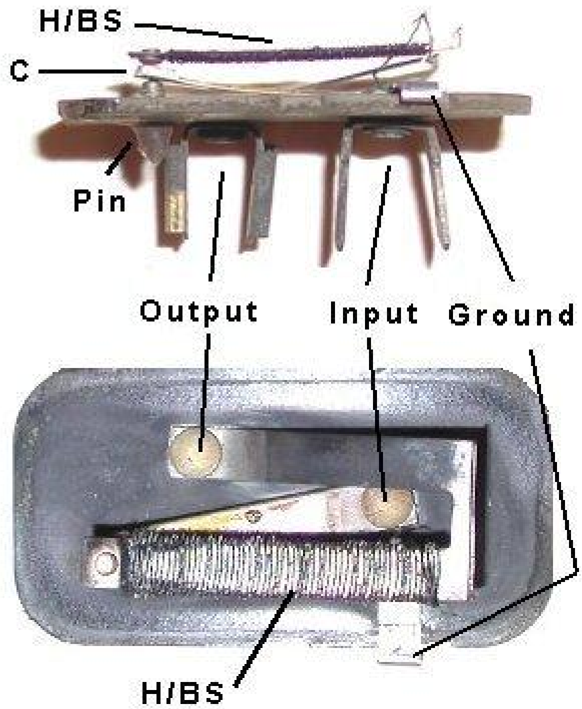


The Stabiliser requires an input to one of its its male terminals through a **Green** wire which is an ignition on, fused feed from the fuse block. The stabilised output is from one or more of its female contacts via **Light Green/Green** wires.

In order to operate properly, the Stabiliser needs a 3rd termination, a **Ground**, which it gets via its fixing screw.

Some stabilisers have TOP marked on the brown base that retains the contacts on that edge closest to the fixing bracket. It is doubtful that the attitude really makes much difference to the operation, but it is probably as easy to mount it as indicated.

The metal cover can be removed from the Stabiliser to reveal the inside mechanism, although this is usually an academic exercise; the device being almost always irreparable. The example here is typical of used device.



Principle of Operation
Current enters at the **Input** terminal and travels on a brass metal strip to a contact **C.** The contact is normally closed and so current can pass on the U shaped metal strip to the **Output** terminal. The U shape strip is bi-metallic, giving it a property whereby it will bend when heated. Together with the coil around it, it forms a Heater/Bi-metallic Strip assembly here marked **H/BS**. The heater is a thin wire wound around the strip (originally white cotton insulated but here black due to years of heating). One end of the heater is terminated to the top contact **C**, the other to the **Ground** terminal. When current flows through **C** to the **Output**, it also flows through the heater wire to **Ground**. When the heater reaches a certain temperature the strip around which it is wound will bend upward, opening contact **C** . Current now neither flows to the **Output** nor through the heater to **Ground**. The heater then cools, the bi-metallic strip relaxes downward and the contact remakes, starting the cycle over again. The higher the **Input** voltage the more rapidly the heater causes the bi-metallic strip to bend, and the more often the **Output** is disconnected. In this way, although the output voltage may rise and fall, the time the Output is connected to the input decreases and increases respectively, so that the average voltage remains approximately constant.

A **Pin** is glued in the base of the Stabiliser to hold the contact **C** at a given height. This is the factory voltage adjustment device. If the **Pin** is high, the heater will have to heat the bi-metallic strip more in order to make the contact open, and so the on time and average output voltage will be higher. If the **Pin** is lower, the opposite is true.

Fault Finding

Instruments Don't Operate

No Input Voltage
Do the turn signals work?
No? Check fuses.

Using a voltmeter or circuit tester , check the voltage at the **Green** wire to the Input terminal of the Voltage Stabiliser?
No? Trace **Green** wire back and check bullet connectors.

No Output Voltage
Contact **C** is bad and needs cleaning with fine sandpaper
Strip **H/BS** has become permanently bent upwards and needs readjustment.
The **Pin** has slipped out or too low.
The rivets securing the **Input** and/or **Output** terminals have become loose.

Instrument Readings Vary with Engine Speed.
In all probability the Voltage Stabiliser is burned out and requires replacement. There is a small chance that the Ground terminal has become detached. First check that the securing screw is tight before suspecting a cause internal to the unit.

Replacement Stabiliser.
A more accurate, non cycling and short circuit protected Stabiliser can be made for about one quarter the price of a replacement unit. See:

A modern semiconductor device can be made that, compared to the original Voltage Stabiliser, features:

- Far more accurate and non varying output voltage.
- Internal short circuit current limiting.
- Internal thermal overload protection.

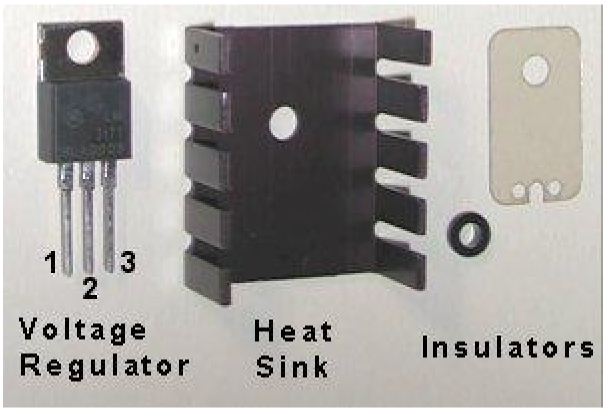
Two alternative semiconductor devices are used here.

1. A fixed voltage regulator UA7810CKC
   This can be hard to find in some territories but is preferred because of the simplicity of construction of the resulting voltage stabiliser.

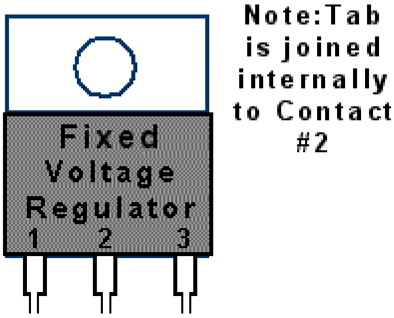
2. A variable voltage regulator LM317(T).
   This device is made by several manufacturers and is readily available. It is not ideal, needing to be isolated electrically from the car chassis, a task best achieved using a heat sink with its special insulating hardware. It also requires 2 resistors to set the output to the desired 10 Volts. The standard values and tolerances of the resistors mean that the voltage may not be exact, but nevertheless, the circuit provides far more accuracy than the original device.

Positive ground cars ground cars need a negative output regulator, but both variable and 10 volt fixed voltage devices are rare so a fixed negative 9V device like a 7809(T) is preferred.

Whether the variable or fixed voltage regulator is used, be sure the package type is described as a TO 220, usually indicated by the suffix T toward the end of the part number, this type having a fixing tab that can attach to a heat sink (or if a fixed regulator is used, directly to the vehicle chassis). If you are not sure of the package designation, just check that it looks like the Voltage Regulator shown here.



Using a Fixed Voltage Regulator
The device used here is a UA7810CKC device.
Contact your local Texas Instruments® stockist.
Stock numbers are:
Device: UA7810CKC 10 volt regulator, 1.5A
Case Style: TO220AB



Besides the regulator, you will need some 18AWG or 20AWG wire, some heat shrink tubing, a #20 (Red) male spade terminal a #20 (Red) female spade terminal and a #8 sheet metal fixing screw. The assembly is very simple, requiring neither resistors nor heat sink. Nevertheless, do insulate terminal 1 & 3, preferably with heat shrink tubing (refer to the construction instructions for the variable regulator below.

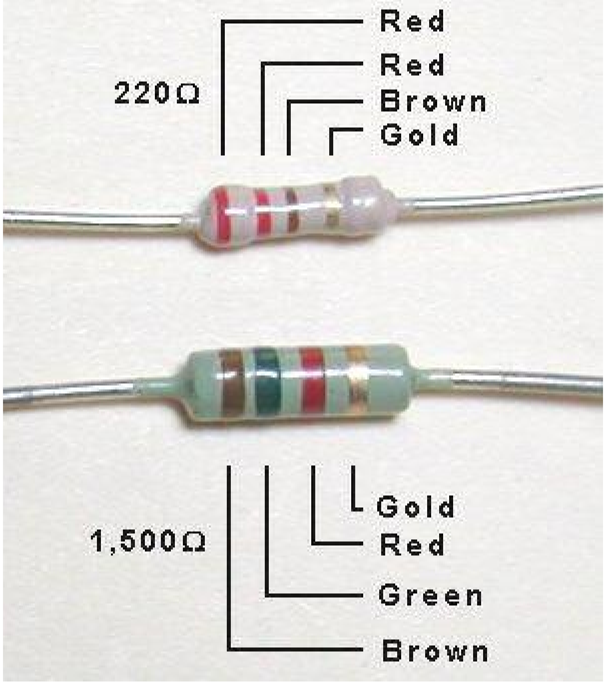
A sheet metal self-tapping screw can be used through the fixing hole to both mechanically and electrically join the tab to chassis. A shake-proof washer is recommended under the screw head to maintain a good connection. With no heat sink the car chassis metal is used to take away the heat, so the surface to which the regulator is fixed should be flat and smooth. If there is any rust, or the paint is broken during smoothing, smear some Vaseline or other petroleum jelly over the area to facilitate heat removal and inhibit further corrosion.

If the correct sex for each of the contacts is used, the wires can be connected into the original vehicle wiring. Test the device using a voltmeter or by simply observing the operation of the instruments.

Using a Variable Voltage Regulator

The regulator is the ubiquitous LM317(T), which is readily available from electrical wholesalers and retail outlets including RadioShack® and Tandy®. The tab, at the top of the regulator is joined to Pin 2 and has to be insulated from the heat sink so that it does not short circuit to the car's chassis. A kit is available that includes a mica insulator to go under the regulator and a stepped washer, the narrow section of which passes through the fixing hole so that the attachment screw is insulted from the tab. These are shown in the picture above. Note the contact numbers for the regulator. They will be referred to in the circuit diagram

Also needed are some 18AWG or 20AWG wire, some heat shrink tubing, a #20 (Red) male spade terminal, a #20 (Red) female spade terminal and small ring terminal, a small nut and bolt (maybe supplied with the insulating kit) and a #6 sheet metal fixing screw .



The variable voltage regulator has to be set to 10V output using 2 resistors. Both are 1/4 watt devices and need to be 5% tolerance, as indicated by the gold band on them. A silver band would indicate 10% tolerance and might mean that the regulator voltage is less close to the ideal 10 Volts.

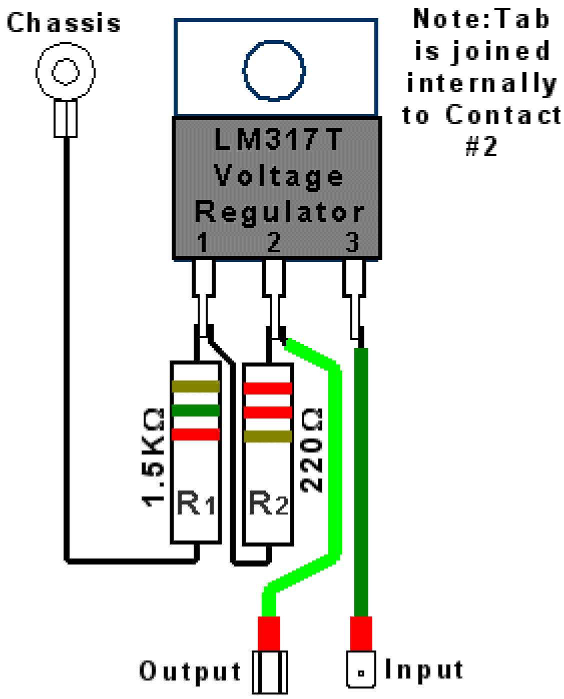
The 220 ohm resistor has colour bands:
Red indicating digit 2
Red indicating digit 2
Brown indicating 1 zero
2,2 and 1 zero thus gives the value 220
The gold band indicates the value is within 5% of the indicated resistance

The 1,500 ohm resistor has colour bands:
Brown indicating digit 1
Green indicating digit 5
Red indicating 2 zeros
1,5 and 2 zeros thus gives the value 1,500 ohms

The gold band indicates the value is within 5% of the indicated resistance.

For reference the full colour code is: Black = 0, Brown = 1, Red = 2, Orange = 3, Yellow = 4 Green = 5, Blue = 6, Violet = 7, Grey = 8 and White = 9.
No metallic colour band = 20%, Silver = 10% and Gold = 5% tolerance.

Circuit Layout for the Variable Voltage Regulator
Use this diagram as a reference.



The Input from the car's fused ignition switched supply, carried on a **Green** wire, goes to the **Input** terminal.

The Output to the instruments, carried on a **Light Green/Green** wire, goes to the **Output** terminal.

The 220 ohm resistor between terminal #2 and terminal #1, and the 1,500 ohm (also written 1.5K ohm) between terminal #1 and **Chassis**, set the output voltage.

The actual formula for output voltage is:

$V_{out} = (1.25 \text{ X } (1 + R_1/R_2)) + (0.0001 \text{ X } R_1)$

If it were possible to get exact values resistors the output voltage would be 9.92 Volts.
In reality, with 5% tolerance resistors the voltage will be between 9.1V and 10.8V
Using 10% tolerance resistors, the voltage will be between 8.4V and 11.8V.

Resistors are so inexpensive, they may come in quantities of 5 or more. If an ohm meter is available, try to select the two resistors that will give the nearest ratio between R_1 and R_2 of 7 to 1.

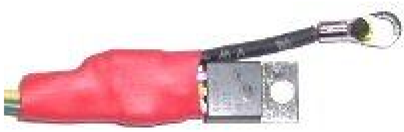
The voltage output does affect the gauge readings. However, there is so much variation car to car in gauges, sensors, and normal temperature and oil pressure that what is really important is to get to know what is "normal" on any particular car, so that any changes in gauge readings can be properly interpreted. The constant voltage output from these regulators helps greatly to that end.

Assembly
The following is a suggested method and order of assembly.

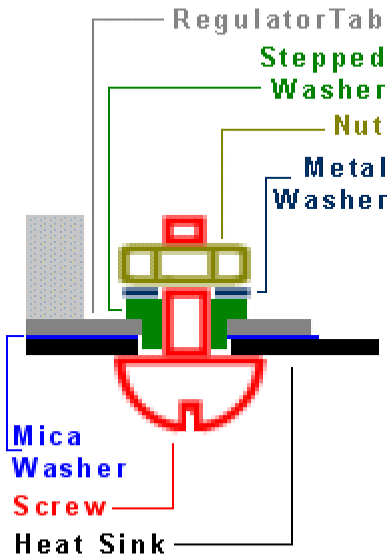
1. Cut the regulator contacts to about half their length.
2. Solder the **Input** wire to contact 3 of the regulator.
3. In a single operation, solder the **Output** wire and R_1 to contact 2 of the regulator.

4. Add a short length of heat shrink tubing to the **Output** wire.
5. Shrink a short length of tubing over both the **Input** wire and part of R2.

6. Bend the other end of R2 over toward contact 1 and cut off the surplus wire leaving a slight overlap with contact 1.
7. In a single operation, solder R1 and R2 to contact 1.
8. Bend R1 as shown.
   Apply heat shrink tubing to the free end of R1 leaving about 1/4" (6mm) uncovered.



9. Strip off the red insulator from the crimp ring terminal and *solder* the terminal to the end of R1 (solid wire does not crimp well).
10. Cover the whole assembly below the the regulator body with a single piece of heat shrink tubing.
11. Drill a clearance hole for the #6 sheet metal screw in the centre top edge of the heat sink.



12. Place the mica insulator under the regulator.
13. Insert the stepped washer into the hole in the tab.
14. Secure the the assembly to the heat sink using a screw through with a nut and washer on the top.
15. Crimp the male # 20 (Red) spade terminal to the **Input** wire.
16. Crimp the female # 20 (Red) spade terminal to the **Output** wire.
17. Secure the assembly in the vehicle using the sheet metal crew passed through the ring terminal and the newly drilled hole in the heat sink. To keep the assembly level, it is advisable to place a small nut or other spacing device, of about the same height as the regulator securing screw head, between the heat sink and the car chassis.
18. If the correct sex for each of the contacts is used, the wires can be connected into the original vehicle wiring. Test the device using a voltmeter or by simply observing the operation of the instruments.

19. The contacts of the regulator were not intended for the rigours of being connected directly to a vehicle wiring harness, so care should be taken in attaching and moving wires. If some method of strain-reliving the wires can be devised, then all the better.

