HISTORICAL ELECTRONIC DYNAMO REGULATOR DESIGNS.

H. Holden 2013.

HISTORY:

The quest to build a good electronic dynamo regulator as a replacement for the Lucas RB106 unit began over 5 years ago. The task began with the construction of a Dynamo Regulator test Machine to evaluate the unit in conjunction with a real dynamo. It is not widely known that the regulator unit finds itself in a feedback loop with the electrical parameters of the dynamo and it is not possible (without a complex dynamo emulator) to adequately design & test the common variable frequency switching regulators in a Spice Simulator alone outside the confines of this loop. For example the AC filtering and positive feedback components in the regulator can only be determined experimentally on a test machine. The machine was also an absolute requirement to determine the functional equation of the original RB106 electromechanical unit. Without this a true electronic emulator of it could never have been constructed.

While the task seemed simple as regulator circuitry usually requires only a few transistors, there are special requirements which go well beyond the construction of typical circuits. This is because the regulator finds itself in a hostile environment of heat, vibration, fumes and electrical challenges such as 80volt peak dynamo armature spikes and potential reverse polarity if the battery is fitted in reverse. Also the regulator must be able to survive earth lift or other mis-wiring anomalies. On top if those threats, there is the heat dissipation issue. Replacing the cut-out with Rectifiers results in at least 8 watts dissipation, that is with a good Schottky rectifier with a forward voltage drop of 0.4V with 20A current. Although Ideal Fet rectifiers offer lower dissipation, they are more fragile with respect to the threats cited above. There was also the quest to make the electronics fit inside the original RB106 case so that the unit would look unchanged from the outside.

All of my initial designs up to regulator number 7 used a constant voltage charging model and sought to emulate the Alternator system (14.3V) and various forms off current limiting or fusing to prevent dynamo overload. Ultimately the design settled on was not like this at all, instead the original “compensated system” was deployed. Extensive study indicated the compensated system was 1) simpler to achieve with fewer parts, 2) very rugged, 3) protected the dynamo from overload well and 4) retained the characteristic behaviour of the ammeter in the car. Also the electrical functionality exactly matched the original RB106 unit being replaced. Ammeters are less informative in constant voltage systems, this is why in alternator systems voltmeters were used instead and the ammeter became obsolete.

This is a brief photographic description these regulators from my past design efforts. Each of these units has been run successfully in a TR4. Each has its various advantages and features. Clearly the way in which the problem could be solved is only limited by the imagination:

REGULATOR 1:

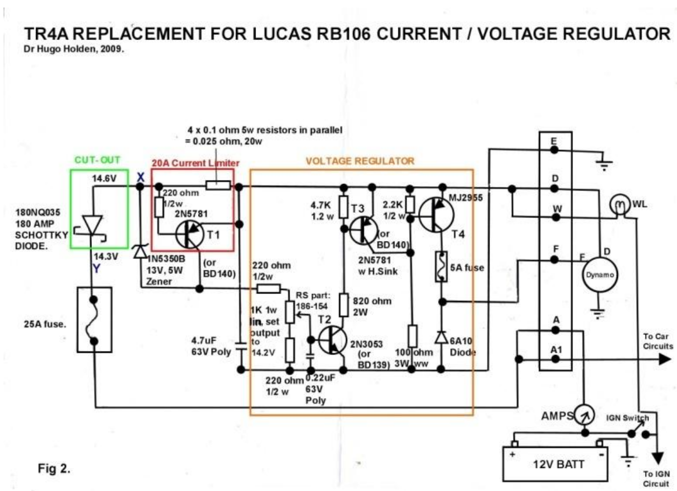
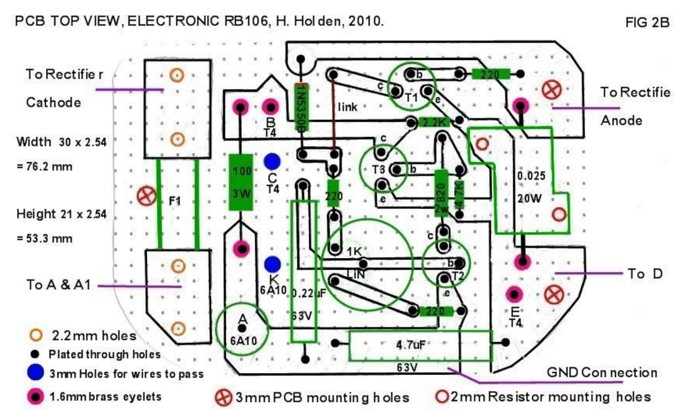


Fig 2.



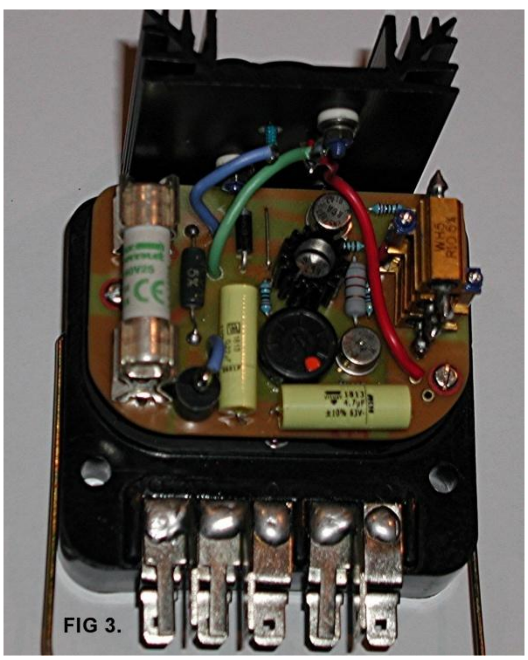


FIG 3.

FIG 4.

As can be seen, the first unit had an external heat sink assembly.

REGULATOR 2:

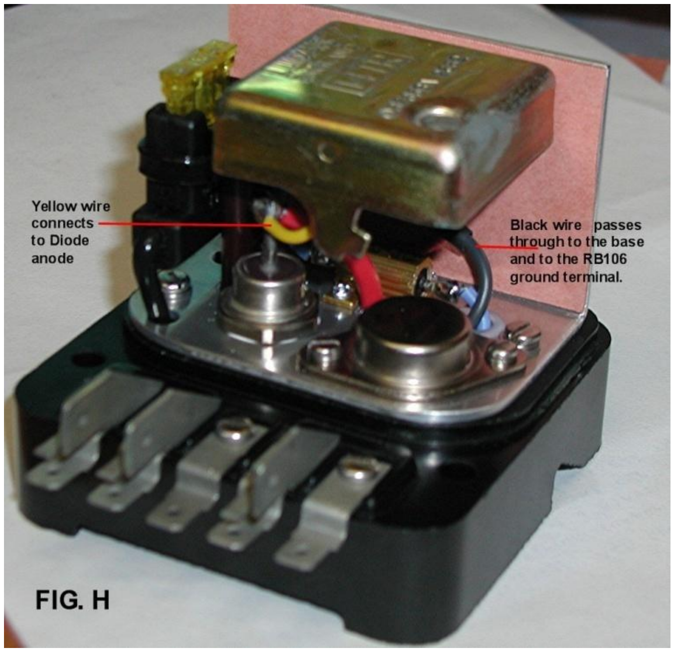
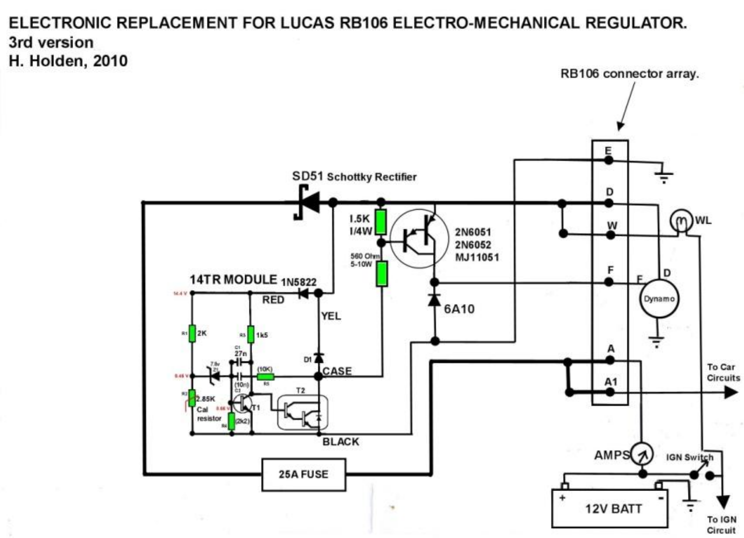
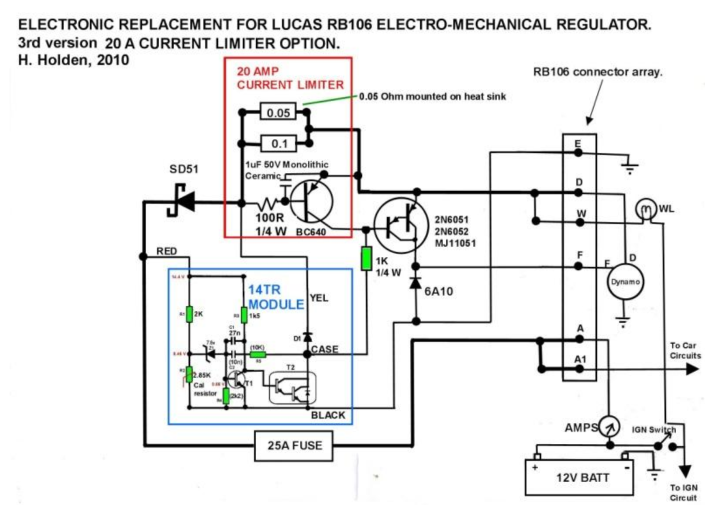


FIG. H

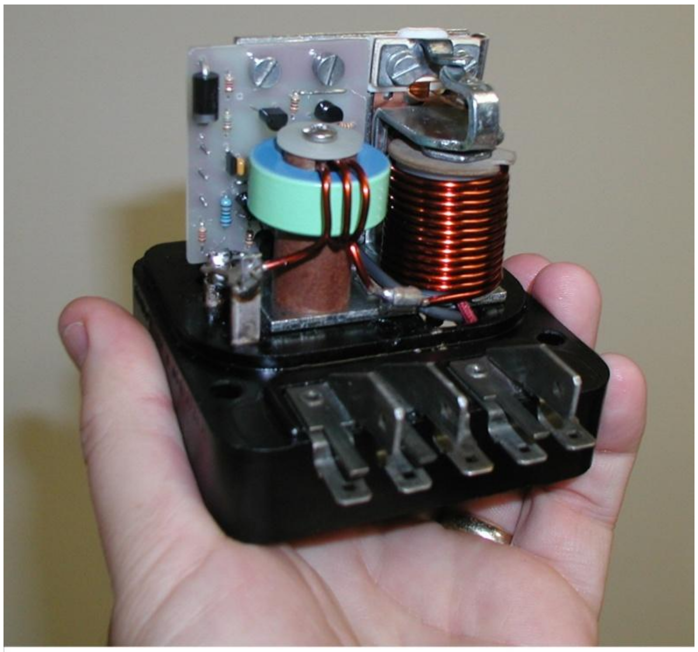
This version used a standard Lucas Alternator module combined with a transistor and a SD51 Schottky rectifier. One version had an added automatic current limiter with an added BC640 transistor:



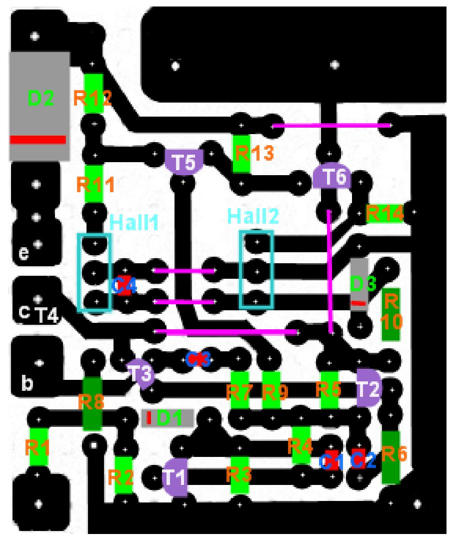


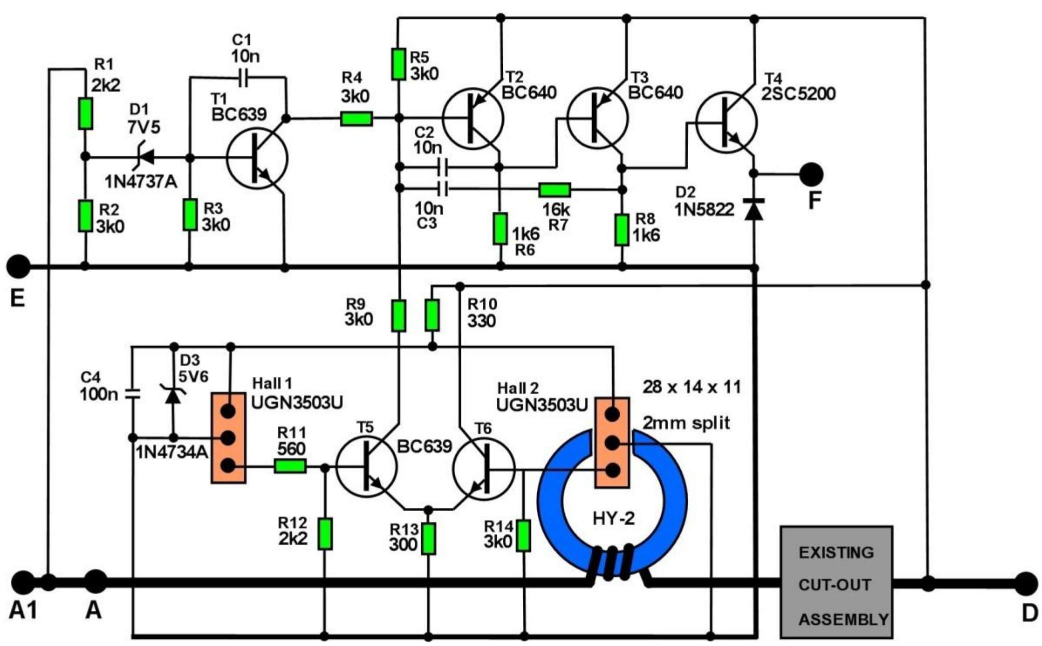
REGULATOR 3:

This version was known as the “Hybrid-Hall” because the original cut-out relay was retained and the Hall device was used as the current detector:



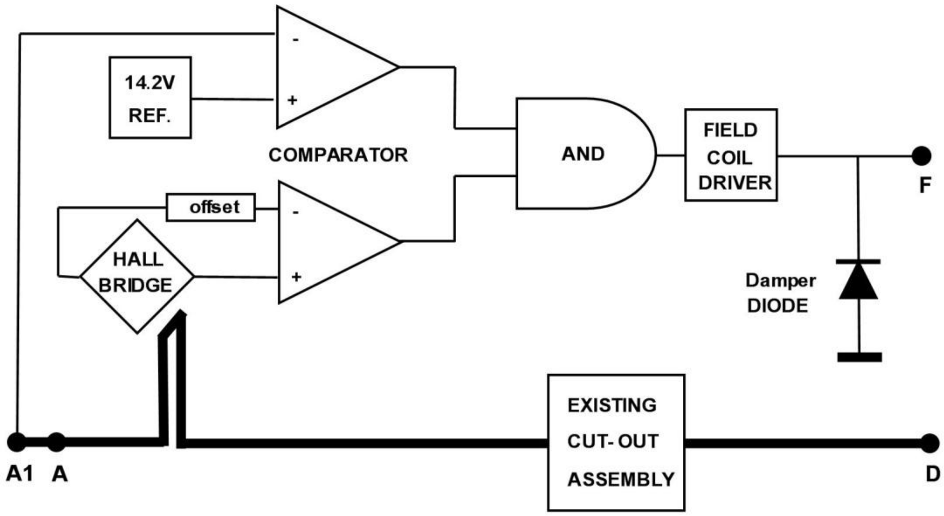
LUCAS RB106 “HYBRID - HALL” REGULATOR UPGRADE.
Dr. HUGO HOLDEN, FEB 2011.



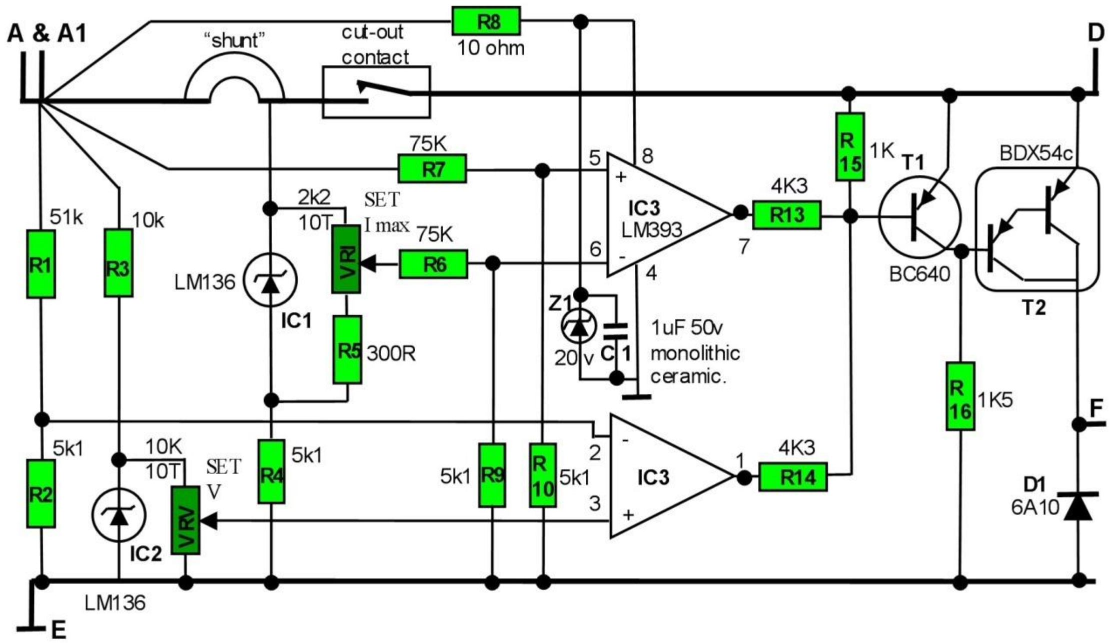


HYBRID ELECTRONIC RB106 USING HALL EFFECT DEVICES. © H. HOLDEN, Jan. 2011

HYBRID- HALL RB106 CONCEPT © H. Holden. Jan 2011.

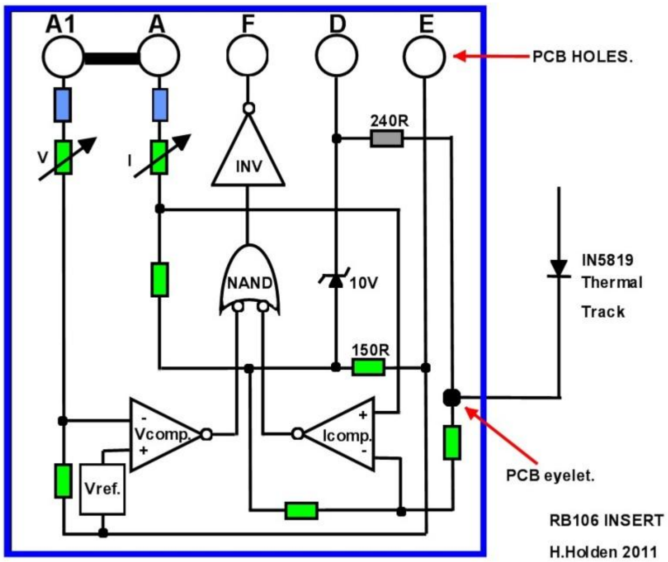


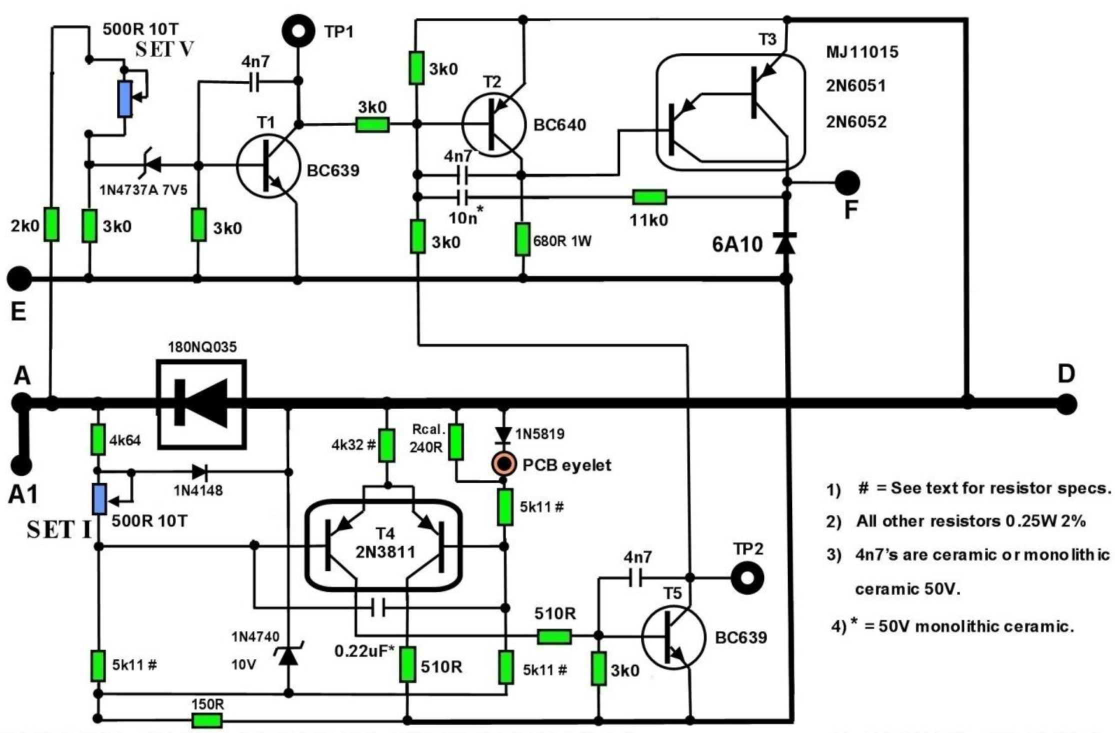
Another Hybrid circuit, without a Hall device, was built and tested in the test machine, but not used in the car:



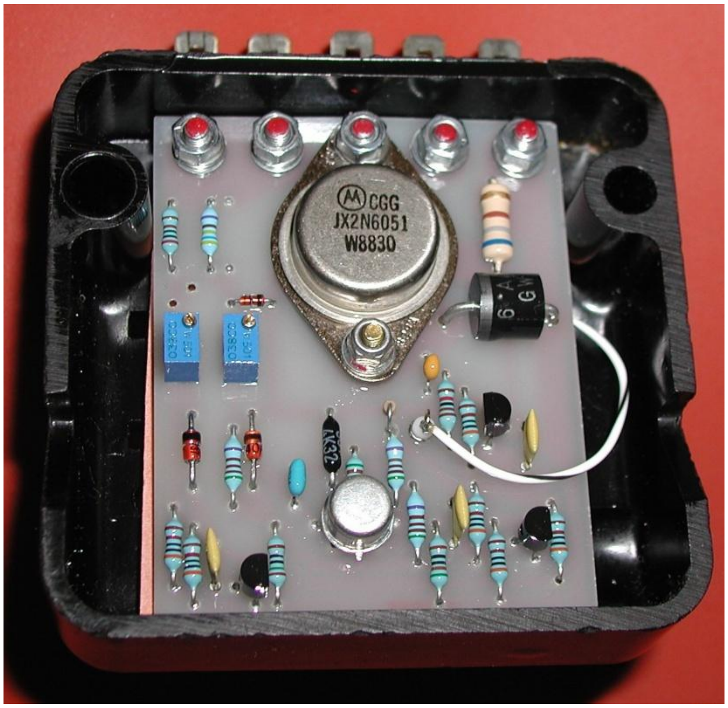
REGULATOR 4:

This regulator was based on the idea of having the control electronics in the unit's base and the power Schottky inside the main unit and again with separate current limit & voltage controls. A small Schottky rectifier was used to track the main rectifier temperature:

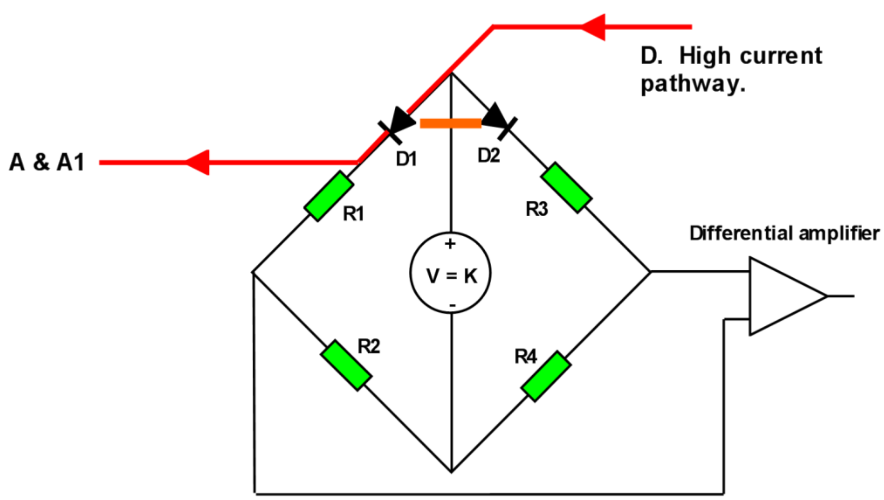




UNIVERSAL ELECTRONIC RB106, INSERT VERSION 1.0 H. HOLDEN, JULY 2011.



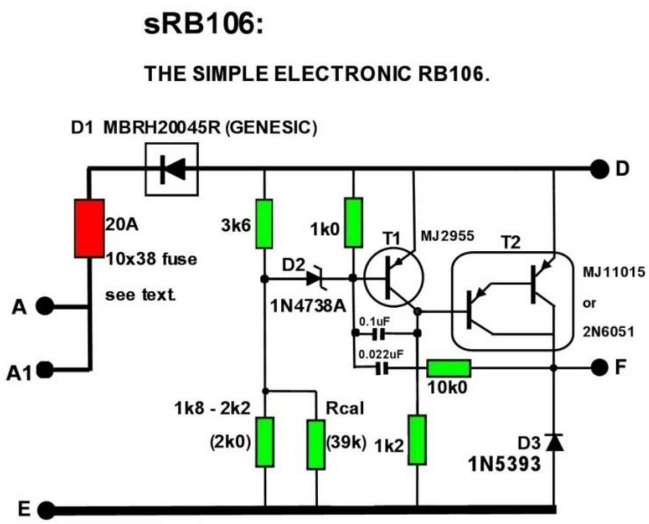
The current detection in this regulator is interesting. It is achieved by monitoring the voltage drop across the power rectifier. As this varies significantly with temperature then a thermal tracking diode D2 is use to cancel that effect in a bridge circuit:

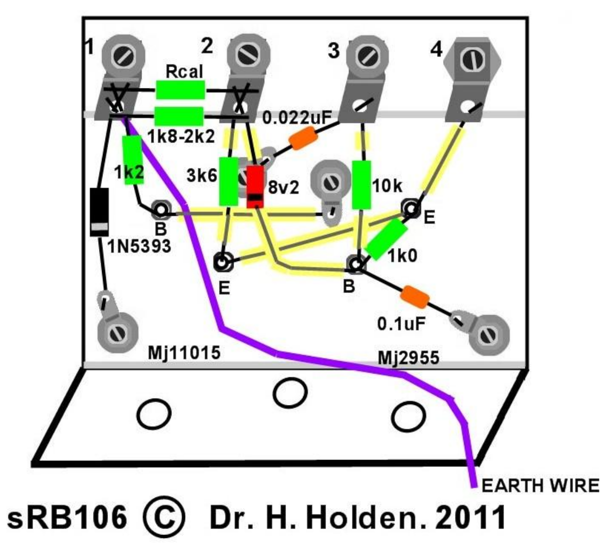


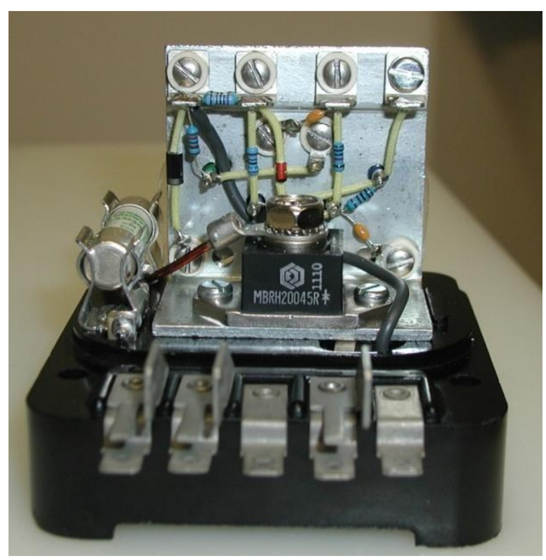
DIODE AS CURRENT DETECTOR ELEMENT.
© H. HOLDEN, June 2011.
D1 power diode, D2 reference diode.
= THERMAL COUPLING.

REGULATOR 5:

At this point I sought to simplify the design with a range of regulators called the simple RB106's The MK1:





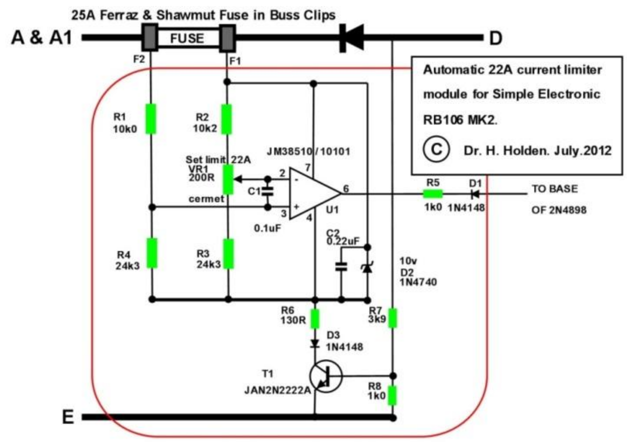


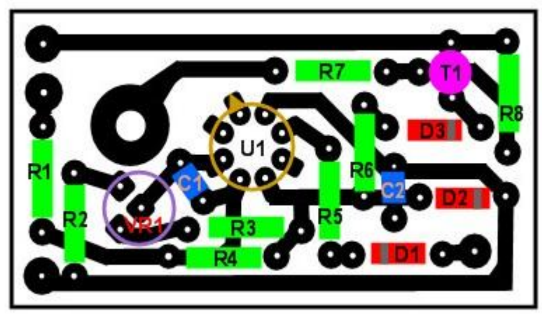
REGULATOR 6:

At this point I settled on the concept and advantages of moving the power Schottky rectifier into the unit's base with an added copper or brass conductor & cooling fin and the unit became the S**imple Electronic RB106 MK2**. Both the MK1 & MK2 were purely voltage regulators and had no current limiters, just fuse protection. The MK2 unit also used TO-66 cased transistors:

The MK2 regulator then went on to have an automatic current limiter added, there were three variations ; one used an OP amp, the other a current detector using an unbalanced current mirror and a third type using a reed relay inside a fuse body to make a current detecting high speed relay. Also one resettable fuse version using ployswitch devices was tried:

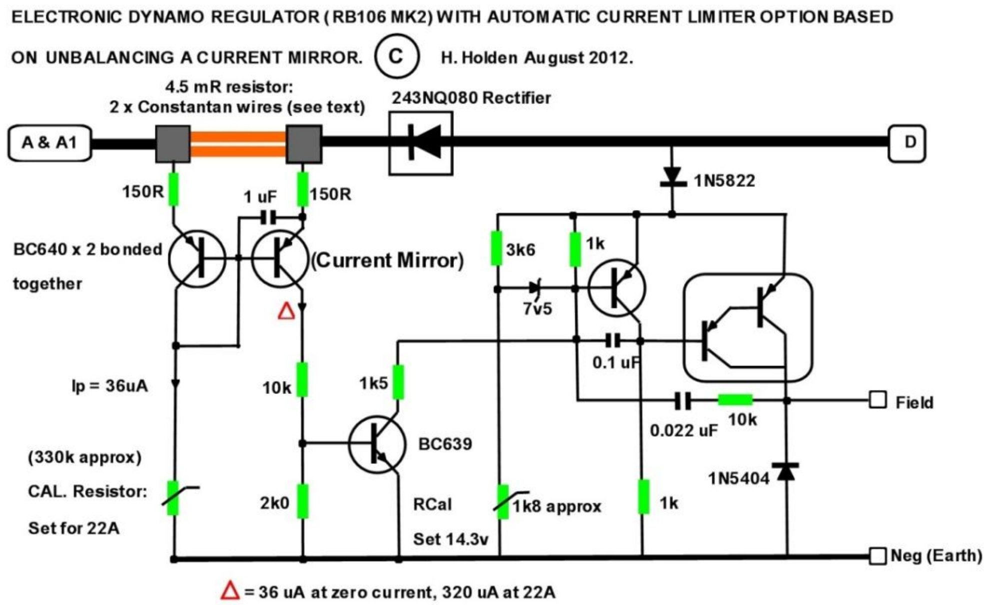
POLYSWITCH OPTION



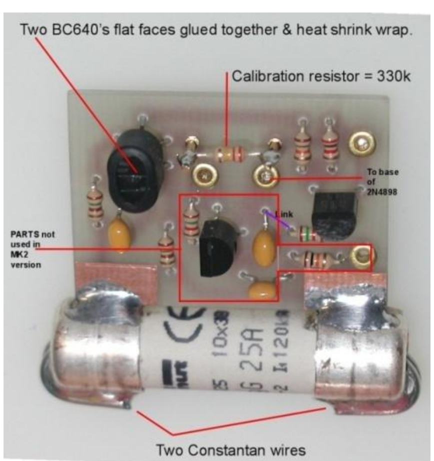


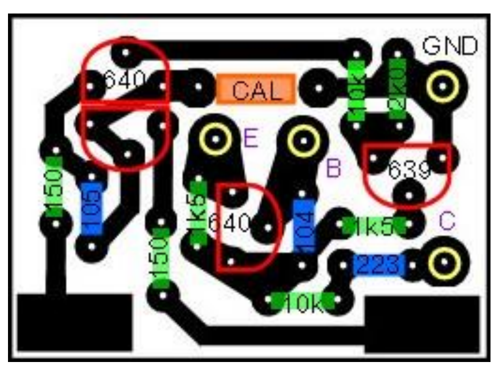
MK2 UNIT FITTED WITH A VINTAGE MIL SPEC 741 OP AMP BASED AUTOMATIC CURRENT LIMITER:

CURRENT MIRROR OPTION FOR THE MK2:

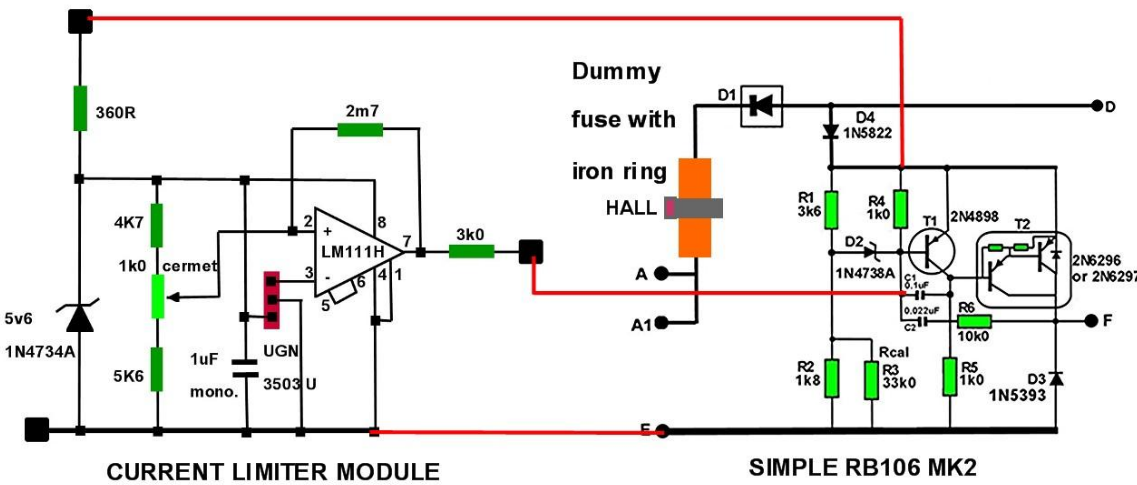


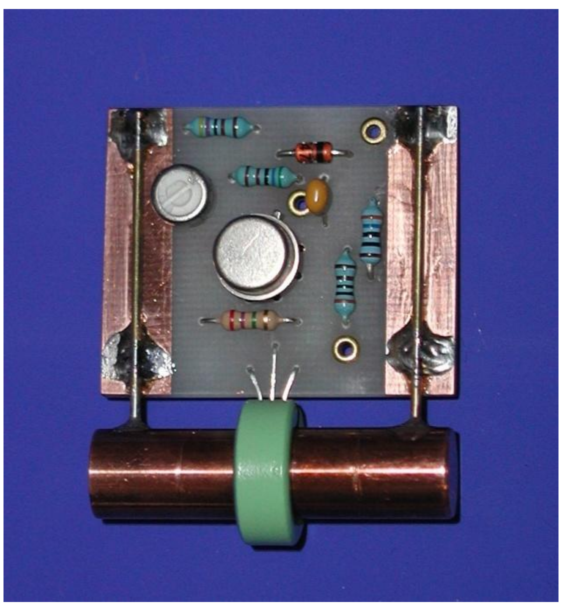
The current mirror method was a very successful & simple method to monitor a high side current and ground reference it. In addition it was made to plug in place of the fuse. The fuse internals were replaced with two pieces of Constantan wire to make a 4.5mR resistor:

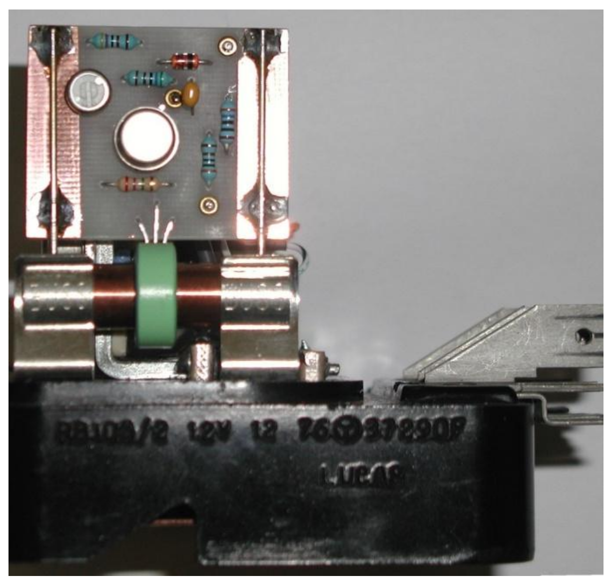




This was by no means the end of the current limiters/detectors used in the MK2 regulator. Another version used a Hall device to plug in, in place of the fuse:



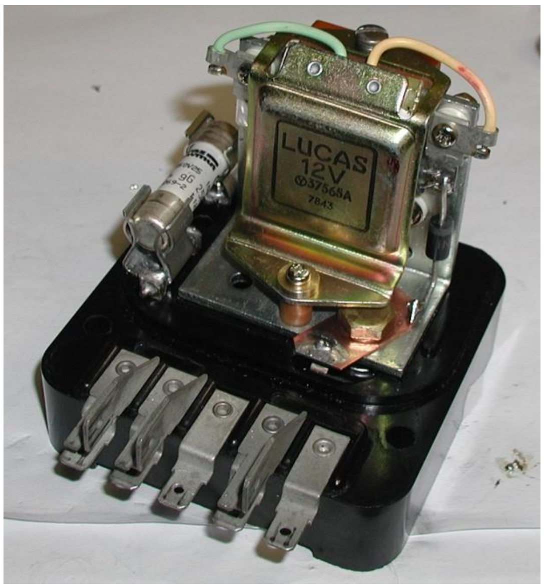




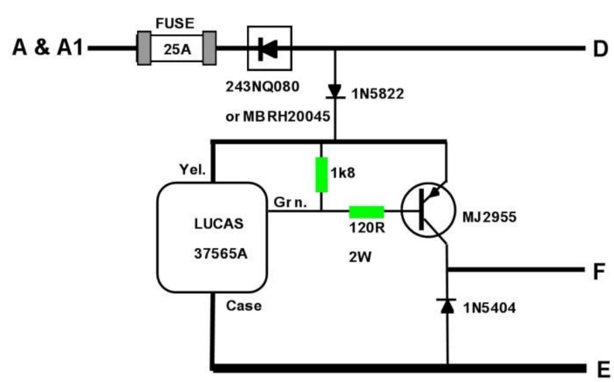
The green ring is a split iron toroid. Ultimately the Simple Electronic RB106 MK2 evolved into the final design, the True Compensated RB106, which was much more simple & elegant with very few parts.

REGULATOR 7:

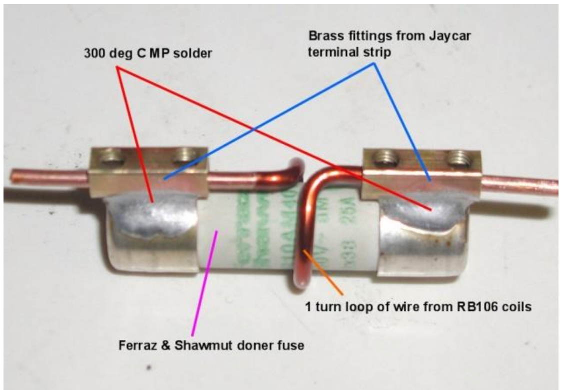
After the MK2 and its variations a MK3 unit was built. This unit used the same schottky rectifier assembly in its base as the MK2, but went to a vintage Lucas 37565A thick film regulator module as the control device. This is still one of my favorite units due to its simple and rugged nature. Four methods of over-curremt protection can be used 1) Fuse, 2) Polyswitch, 3) Current mirror, 4) Reed relay:

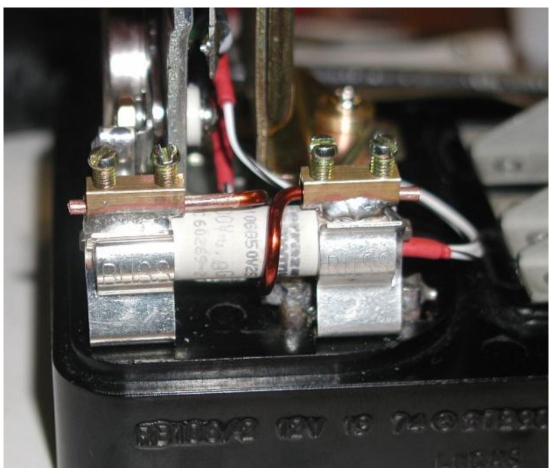


Negative Earth version s3RB106. Dr. H. Holden 2012

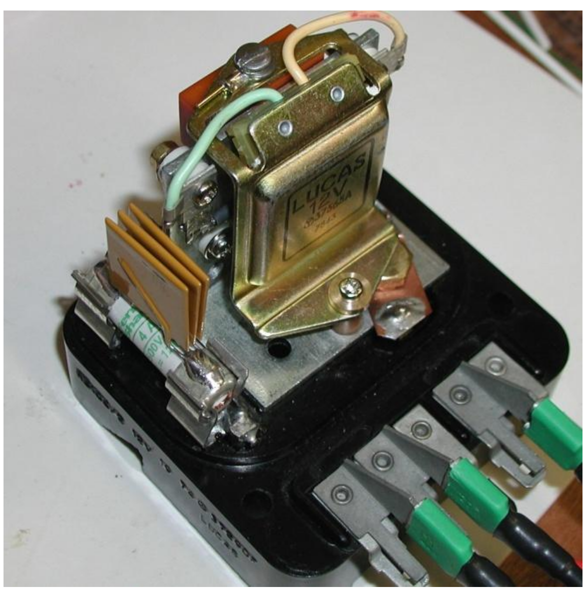


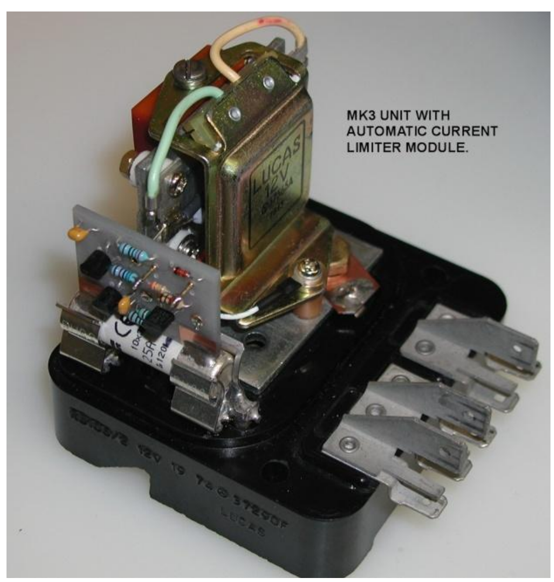
The MK3 unit was later fitted with a reed relay built inside a fuse body. This makes an automatic current limiter. The relays action is fast enough to operate the current limiting function at a frequency of about 30 to 50Hz. The current limiting point is adjusted by sliding the coil along the fuse body. The reed simply connects across the base and emitter of the MJ2955:

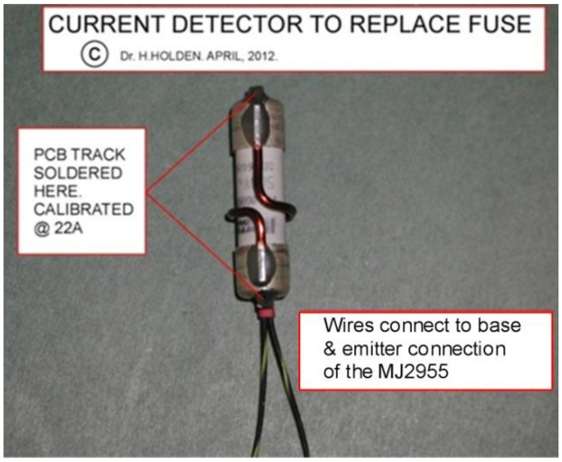




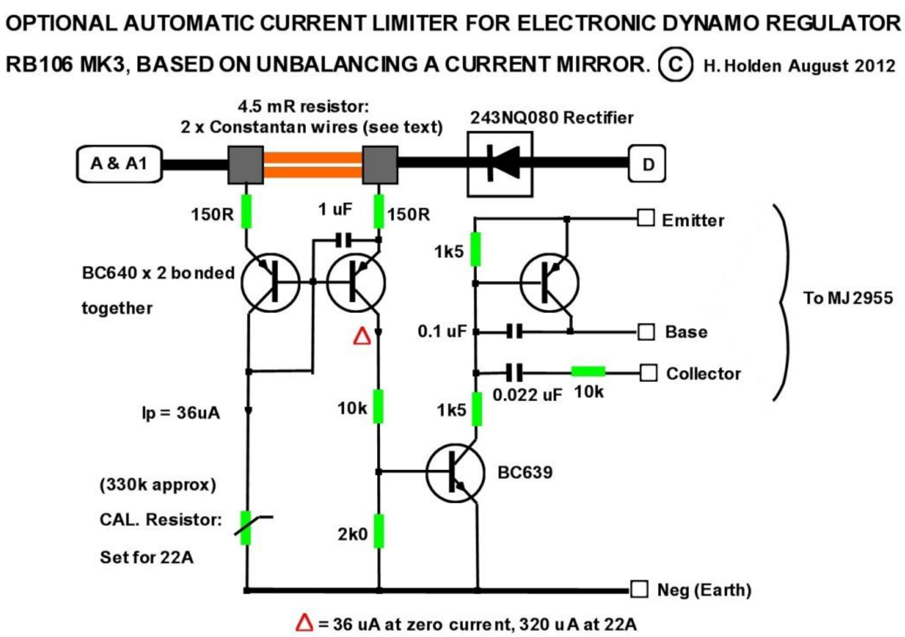
The MK3 can also use the polyswitch fuse instead or the current mirror style limiter:







Another version of the reed current limiter, in this version the adjustment was achieved by sliding the pcb (and reed) position and the coil was fixed.



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The full design details of Regulator 8 (the True compensated electronic RB106 emulator) and regulator 9 (the Germanium RB106) are available on the www.worldphaco.net website.