

## Functional description of Schumacher SEM-1562A battery maintainer

Mike Weir

January 12, 2022

NOTE, WHILE THERE ARE NO HIGH VOLTAGES ON THE BOARD, THE TRANSFORMER AND SWITCH HAVE FULL LINE VOLTAGE APPLIED AND CAN BE DANGEROUS. YOU HAVE BEEN WARNED.

In the following text, I have used my own reference designators for most components, as those on the circuit board are hidden below the component. Capacitors and transistors are exceptions, where I've used the reference designators on the board. The circuit diagram was drawn in Eagle 7.5, free version. When I started to extract the schematic, I was continually getting lost without reference designators, so I created an assembly drawing with reference designators in Microsoft PowerPoint. I assigned reference designators on this drawing, then annotated the circuit diagram to match. Both schematic and assembly are included in this post as pdf files.

The device supports 12 and 6 volt batteries. When I mention particular measurements, they apply to its 12 volt setting (even though the schematic shows the switch in the 6V position).

The suffix "P" on resistors is my notation for "precision," their value being given by four digits (three significant figures plus a multiplier) rather than three for the others (two plus a multiplier). I think I have read the resistor colors (values) correctly, but I may be wrong.

### Input power

Line power is stepped down by TR1 (off board), which has a tapped primary and two secondaries, one center-tapped. The primary tap is selected by the front panel 12V/6V switch to make suitable voltages at the secondary side.

The center tapped winding provides full wave rectified power by D1 and D2, filtered by C2, for charging the battery. A half wave, low power supplementary output is provided by D2 and C4 for operating the signal LEDs. These two outputs share a common ground, at the battery negative conductor, with most of the circuit. A third half wave, low power supplementary output is provided by D4 and C1, referenced to the full wave power output to provide base current for the regulating transistor N1.

### Regulation

The regulating core of the circuit is U1, a 431-type shunt regulator (I can't read the prefix). It's connected directly to the base of the regulating transistor N1, and shunts current provided through R18 away from the base to maintain the output voltage measured between the current sensing resistor R4 and the protective "fuse" PTC at a level of 2.5V times the division ratio established by R3P, R11P, R14P, R15P, and D5. The network consisting of R14P, R15P and D5 evidently provides the greater division ratio needed to give 12V (nominal) when the switch is set to the 12V position. D5 likely provides some temperature compensation: at colder temperatures, its voltage drop is reduced, giving a higher output voltage commensurate with the lead-acid chemistry's needs. I didn't attempt to quantify its contribution.

However, this voltage loop is modified when the charging current is high. In this case Q3 is biased into conduction by the drop across R4, plus a fraction of N1's base-emitter voltage. I think this latter is simply to avoid losing more voltage, and heating R4 more, if its value were

high enough to provide the 0.6 volts or so to bring Q2 into play. Q2 turns on Q7, further increasing the division ratio from output to U1's reference. In fact, when configured for 12V, and charging at around 1.25 A, U1's reference is brought down to around 2.3V. Thus, U1 is *not* conducting; N1 receives full base drive through R18; and the transformer/rectifier is giving all it can to charge the battery. Note, it's sold as a "1.5A" battery maintainer. I never loaded it to that extent, 1.25A being as much as I could easily provide.

However, as the battery charges and its voltage rises, the charging current diminishes, and eventually (around 0.3A) Q2 begins to drop out of conduction, Q7 does so as well, and the voltage regulation determined by U1 and the divider components comes into play. I suspect C3 is a "compensating" capacitor, slowing the feedback loop to prevent oscillation.

#### Indications

Concurrently, when Q2 is not conducting, there's no base drive to Q5, so the yellow LED3 in its collector provides base drive to Q4 to turn on the green LED4 indicating "charged." When Q2 is conducting, Q5 is turned on, illuminating the yellow "charging" LED3 and turning off the green.

#### Protection

Finally, Q3 appears to come into play when the output is shorted or connected to a battery in reversed polarity. The PTC will quickly assume a high resistance from the momentary high current, so that Q3 is turned on by the positive potential at its emitter with respect to the lower potential base. Current from Q3 turns on the red LED1, and also turns on Q6 to short out the supply voltage to the yellow and green LEDs to prevent them indicating. Note, in normal charging conditions, I measured about 40 mV across the PTC. I did not exercise the short circuit or reverse polarity function.

#### Modifications

I decided I wanted slightly higher voltage at the output in float or "maintain" conditions. This means increasing the division ratio to U1's reference pin. I could add resistance across R11P or R14P, convenient for experimentation, or add resistance in series with R3P. I preferred the latter, and fortunately jumper J2 (not shown on the schematic) brings the output voltage to R3P. I removed J2 and substituted a variable resistor in its place. Presently, I have the float voltage set for around 13.9 in a moderately cold environment, and will decide what voltage I want after observing several batteries' response. Then I will measure the variable resistor and solder a resistor of similar value in place of J2.