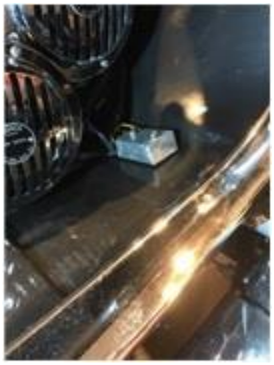
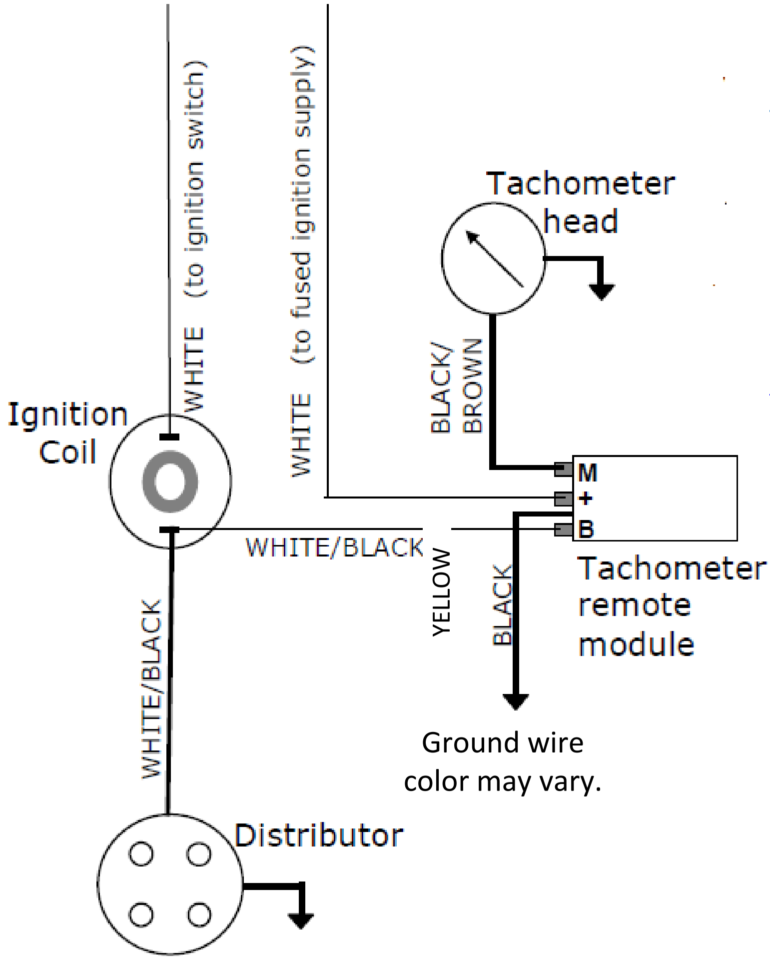
Gen 0.5 Smiths Tachometer Module Analysis
Mark Olson, Alex Miller, 2024
R. 1.4

Starting in model year 1960 into early 1964, Smiths Instruments made the model RV1310/nn tachometers for Volvo P1800 cars..
The electronics of all of the nn versions are the same. Volvo later recommended that the Gen 0.5 tachometers be replaced with Gen 1 units. In this document, we analyze the electronics in the Gen 0.5 Smiths RV1310/nn tachometers.

The head unit is a simple ammeter calibrated in RPMs. Note that one terminal is marked with a "+". The other terminal is not marked but is for ground. The electronics are contained in a potted module mounted in front of the radiator.



The negative terminal of the head unit is grounded and the positive terminal is connected to the "M" terminal of the module. The "+" terminal is connected to switched battery voltage. The "B" terminal is connected to the coil negative terminal and the yellow or black wire is grounded to one of the module bolts.

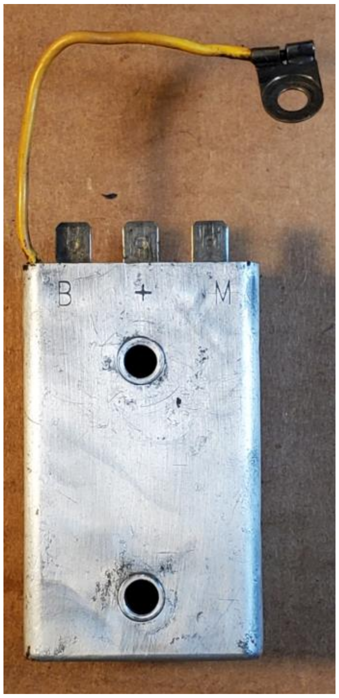


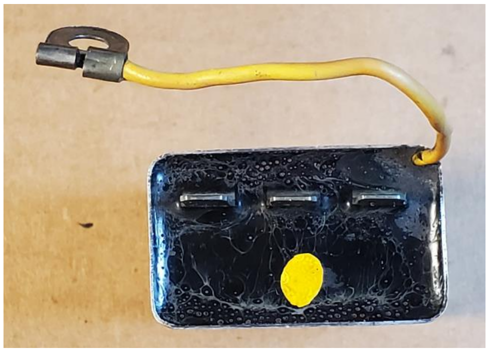
Benjamin Büttner of Hamburg, Germany asked me to help him with the failed tachometer in his 1962 Volvo P1800 Jensen. We determined that his head unit was still functional, but his remote module had failed.

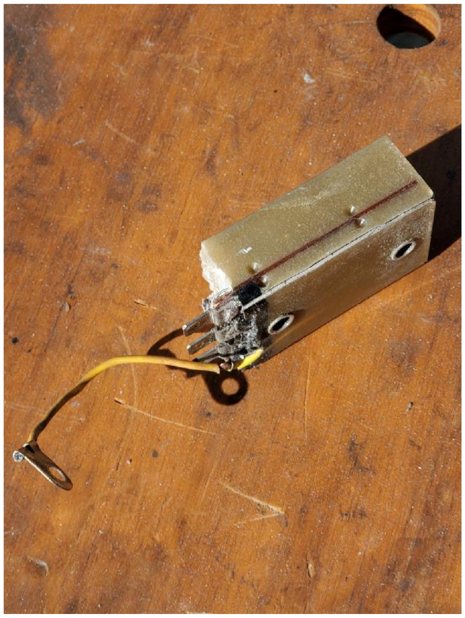
Working with Brian Laine of TechnoVersions, we determined that his TachMatch product could not supply enough current to drive the tachometer head unit. He made it possible for me to modify one of his TachMatch units to amplify the available current to where it can drive the head unit, so we were able to make Benjamin's tachometer system functional.

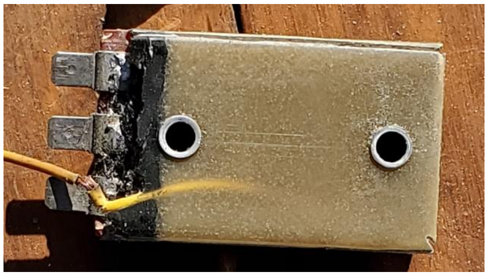
Benjamin graciously donated his failed remote module to me for tear-down. I asked Alex Miller, the author of the Gentleman's Guide to Smiths Electronics Tachometers to help with advice and analysis.

The rest of this document will describe what we were able to determine about the circuit inside of the remote module. The PCB assembly is potted in a can using some sort of potting compound which I will call epoxy in this document. The PCB assembly was first slid between the 4 dimples on each side of the can. The mounting sleeves were fitted and light epoxy was poured in to about ¼" from the top of the can. After that, the remaining space in the can was filled with black epoxy. The purpose of the yellow dot is unknown.



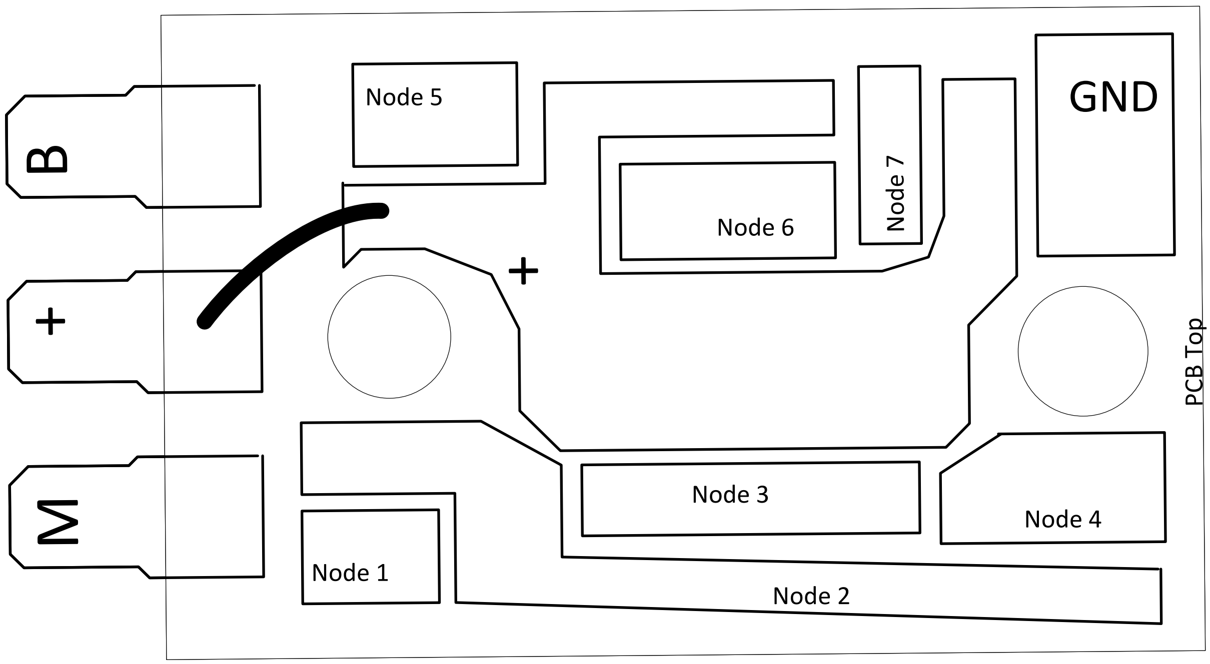




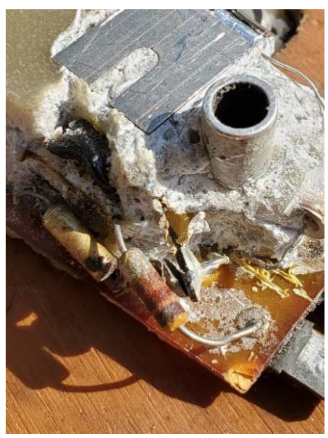


I initially used a heat gun to heat up the epoxy which made it easier to chip away the epoxy. I started with the bottom side of the PCB which was pretty easy to get clean.

I made a sketch of the copper patterns, made a mirror image and labeled all of the circuit nodes.

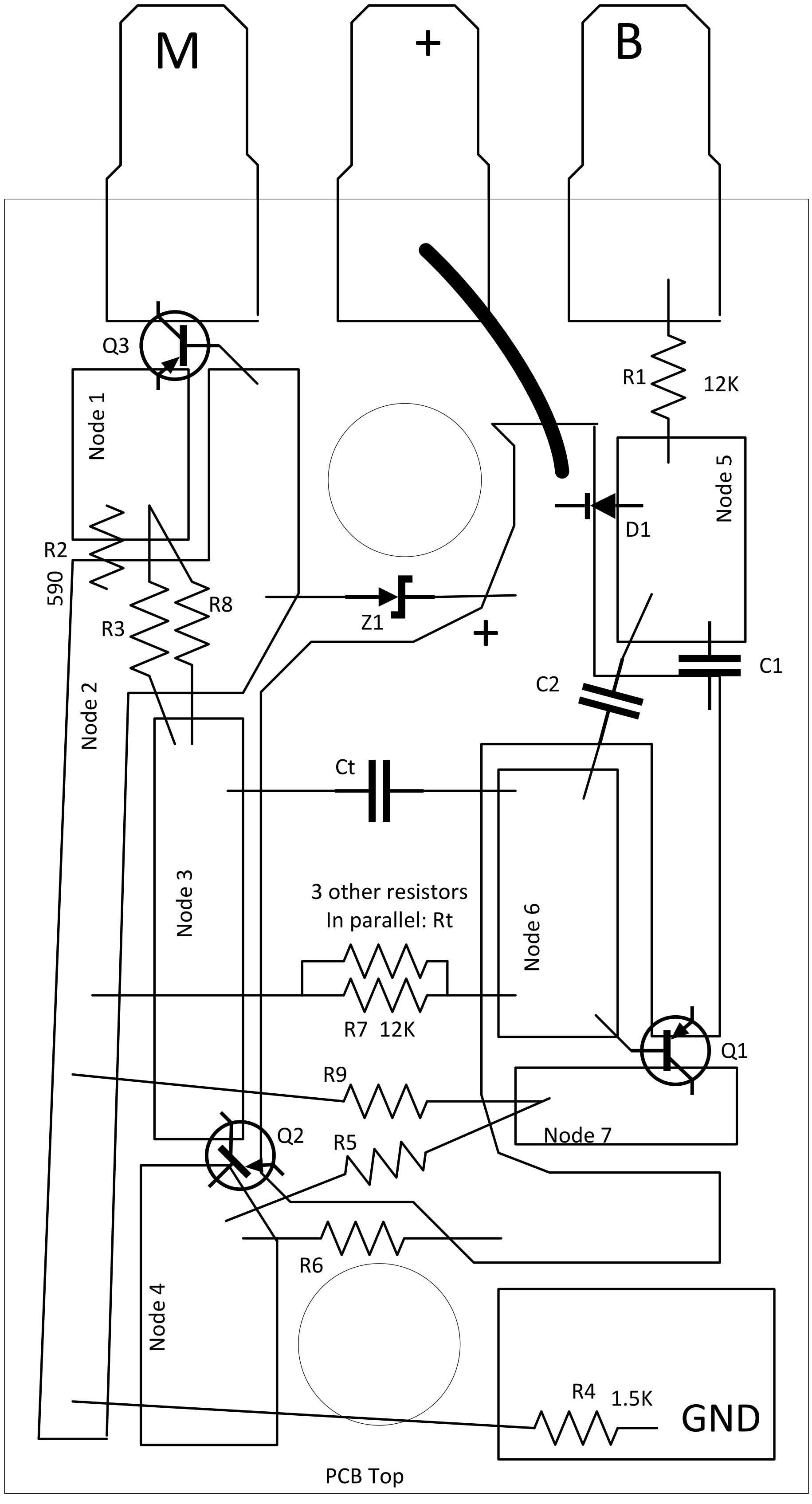


I then moved to the top of the PCBA and started removing the epoxy. Unfortunately, the heat required to remove the epoxy was hotter than the melting point of the capacitors' plastic packaging. As a result, the capacitance of each is unknown.

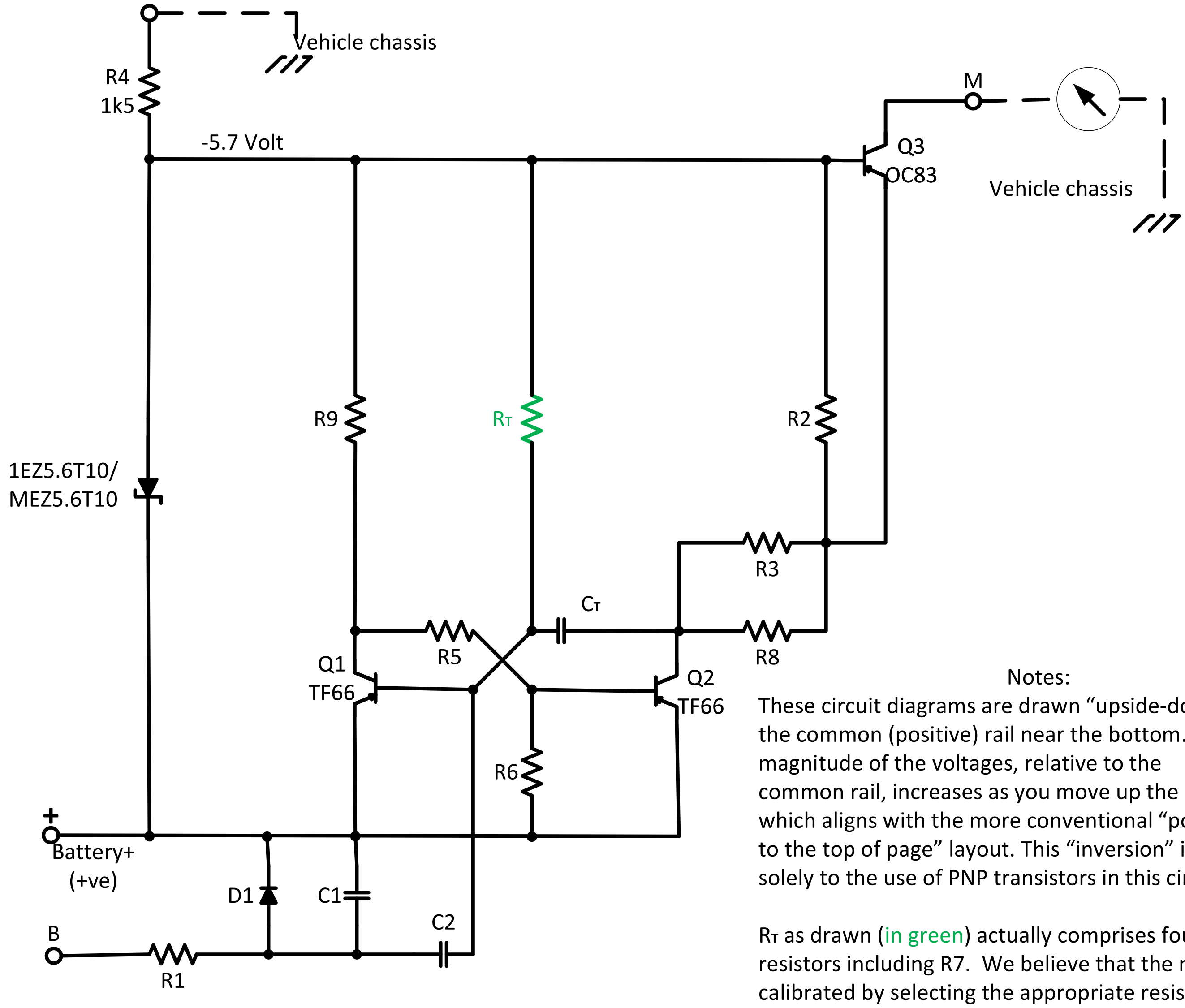




Removing the epoxy from two of the transistors also removed their markings, although part of the markings of one of them remained inside of part of the epoxy which helped us to figure out which transistor was likely used. The output transistor was protected by a heat sink, so we could read that it was a Mullard OC83. Fortunately, the Zener diode survived, but the regular diode broke during the epoxy removal process. The epoxy made it difficult to read the colors of the resistors and some of the resistors broke during the remaining epoxy removal. I switched to a heat pencil in the middle of the project, which lessened the collateral damage to the components.


As I removed epoxy from around the components, I mapped them to the nodes they were connected to.



I worked very closely with Alex Miller who developed these schematics for the remote module. His insight and knowledge was crucial to figuring out the circuit. Where the component part numbers and values were not determined, he was able to infer what they probably were from the similarities to the Smiths Gen 1 circuit design.



Notes:

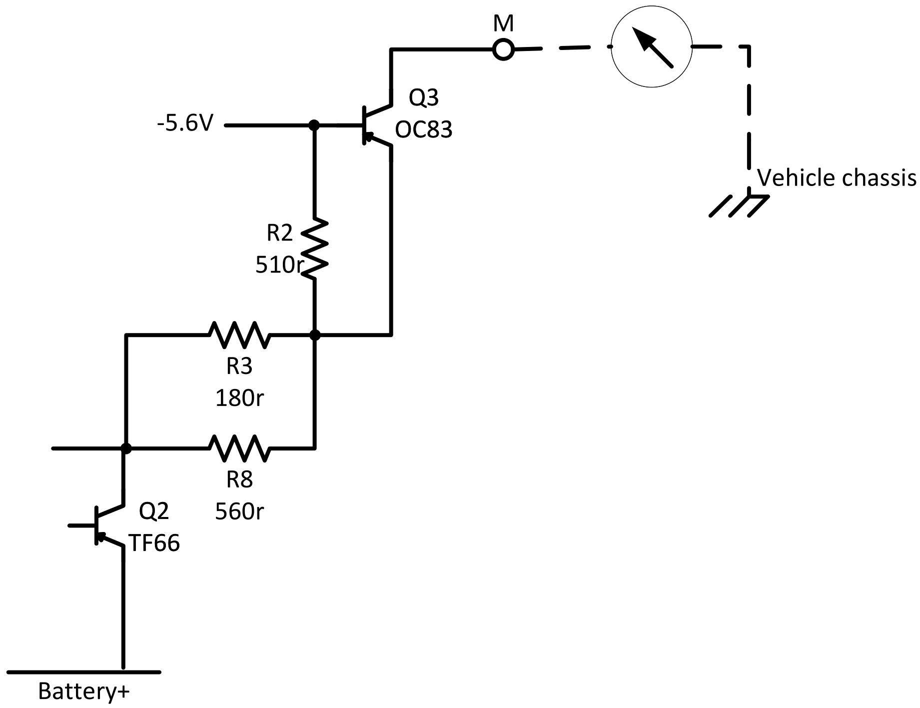
These circuit diagrams are drawn "upside-down" with the common (positive) rail near the bottom. The magnitude of the voltages, relative to the common rail, increases as you move up the page which aligns with the more conventional "positive to the top of page" layout. This "inversion" is due solely to the use of PNP transistors in this circuit.

R_T as drawn (in green) actually comprises four parallel resistors including R7. We believe that the module is calibrated by selecting the appropriate resistors for Rt.

SOURCE LIST: (HOW THE VALUE WAS DETERMINED)

R1 = 12k – (Measured and color bands)
R2 = 510 – (Measured and color bands)
R3 = 180 –(Color bands and back-calculation of circuit values)
R4 = 1k5 – (Measured)
R5 = 510 – (Measured and color bands)
R6 = 180 – (color bands)
R_T = compound calibration resistance – varies between units
R8 = 560 – (Measured & rounded to nearest E12 value)
R9 = 1.2k – (Measured & rounded to nearest E12 value)
C1 = Unknown
C2 = Unknown
C_T = 0.22uF? – (plausible? - assumed from Gen-1 circuit)
D1 = 2E4 ? – (Most probable type from databooks)
Z1 = 1EZ5.6T10 – (Most probable type from measured Volts and databooks)
Q1 = TF66 – (plausible? Based on markings left in epoxy)
Q2 = TF66 – assumed same as Q1
Q3 = OC83 – Read from transistor case (protected from epoxy by heat sink)

VOLVO GEN-0.5 OUTPUT STAGE CIRCUIT DIAGRAM



OUTPUT STAGE ANALYSIS:

Assumptions made:
All resistors are assumed to have their marked resistance, or for measured values, the nearest E12 series value is used.
Zener voltage = 5.6V is assumed from databook data.
Any leakage currents through the transistors have been ignored.

Values used:
TF66, V_{CEsat} = 0.5V from databook
OC83 V_{be} =120mV @ 30C – from databook
The parallel resistors R3 and R8 have a combined resistance of 136 Ohms (136.2162 Ohms).
R2 is present to limit $V_{BE\ max}$ (= -3V) for the OC83.
The current of 0.235mA through R2 with Q3 ON is ignored in the following calculations.
"||" means "in parallel with"

Initial conditions:
With Q2 OFF, no current will flow through R2, R3||R8 or Q3. Both the base and emitter of Q3 will be at -5.6V

Operation:
At the instant Q2 turns ON, Q3 will also turn on as the supply voltage -0.5V is applied between Q3 base and emitter. Current will start flowing and increase to a value where 0.12V (V_{be}) exists between the base and emitter of Q3. The current at which this occurs is that which causes a voltage drop of 5.6-0.5-0.12V or 4.98V across R3||R8 and is equal to 4.98/136 = 36.6mA. Q3 is operating in its active region and maintains 0.12V between base and emitter thus this current through R3||R8 is maintained at this value. That is, Q3 is a constant current source that is independent of load resistance. Provided only that the external voltage is sufficient to drive this current through the load. (≥ -8 Volts relative to circuit common rail.)

V_{be} will vary by about 1V over the range 20 - 60C (from datasheet). There is no temperature compensation provided and with the (assumed) Zener having a temperature coefficient of +0.03%/C, the output to the indicated rpm will increase slightly with temperature.

We hope that you find this bit of historical automotive information interesting. Feel free to share this information, but please give credit to the authors.