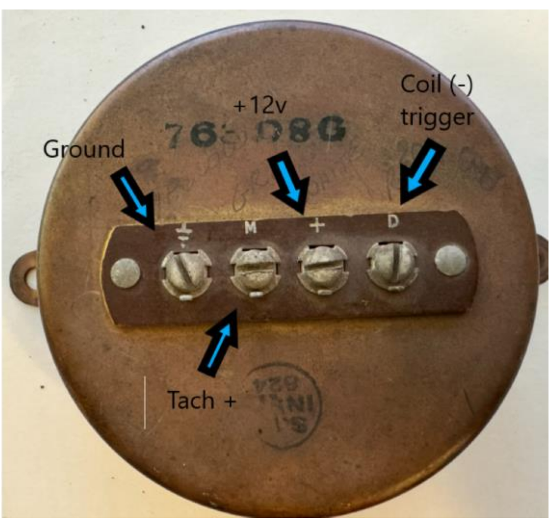
289 Cobra Tach Circuit Reverse Engineering

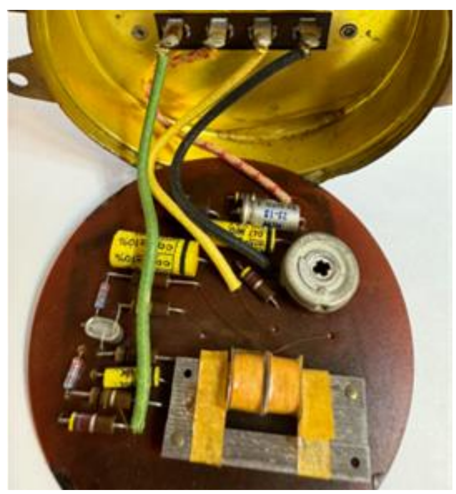
From SN 1 to 200 Shelby used Smiths or Rotunda tachometers in 289 Shelby Cobras. The remaining 289 Cobras were equipped with a Stewart Warner tachometer system. It consists of a head unit and an electronics module. Since it is too risky to disassemble a head unit, black box testing was used to surmise that the head unit consists of a diode in series with an ammeter. The terminals on the back of the tachometer are marked "+" and "-".

Head Unit

Rear of Head Unit

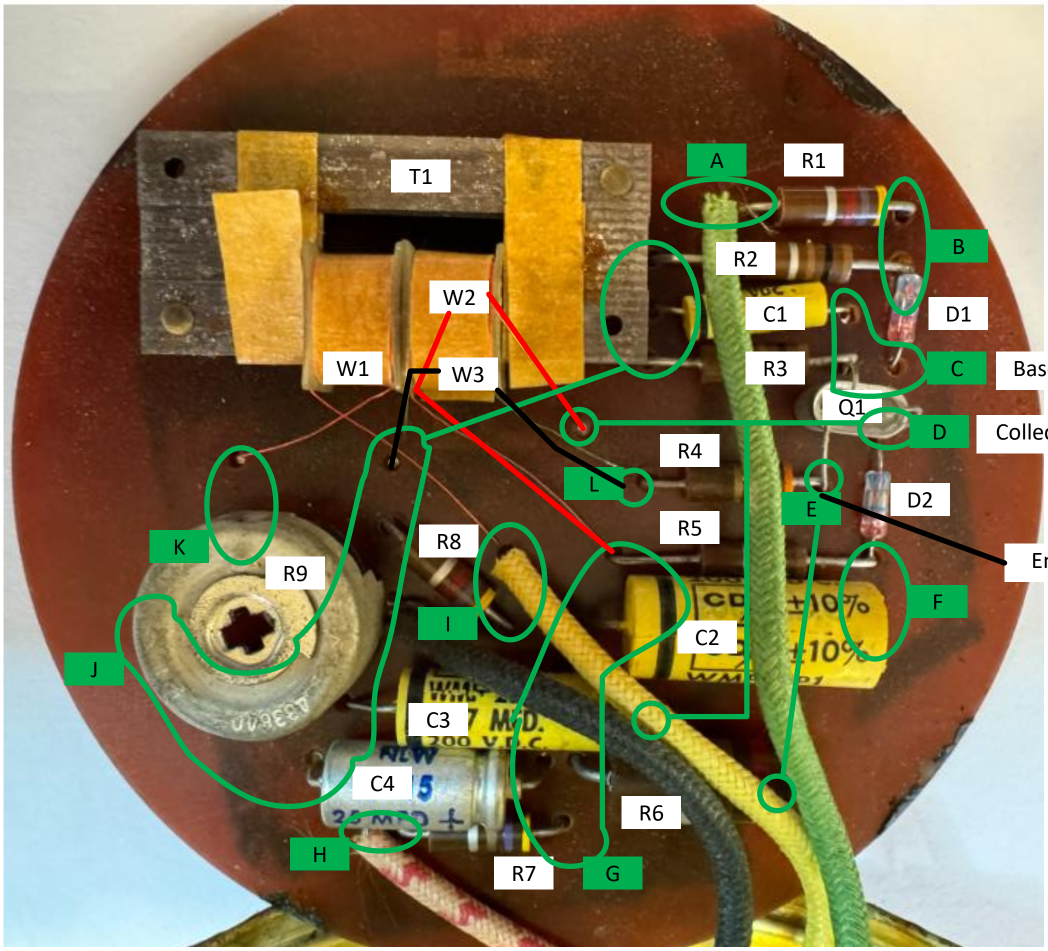
The PCB is used as the bottom of the module's case and a rubber sheet covered the bottom of the PCB to insulate it.

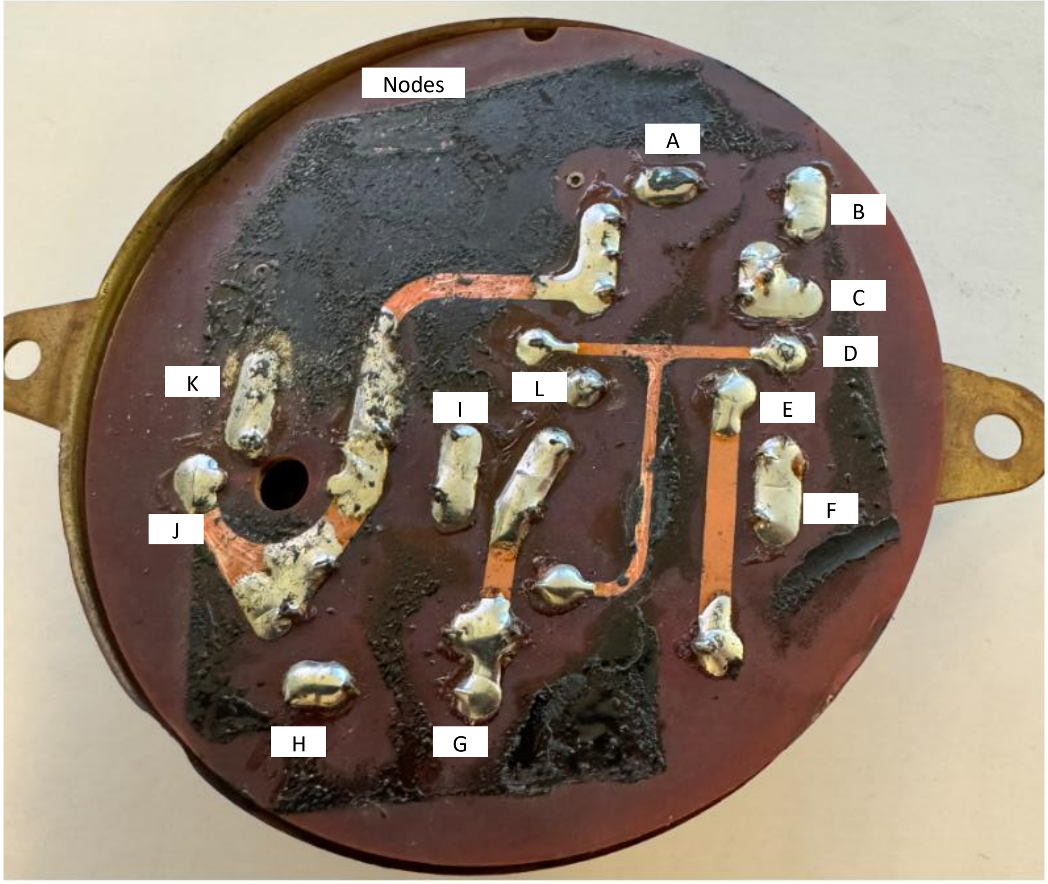




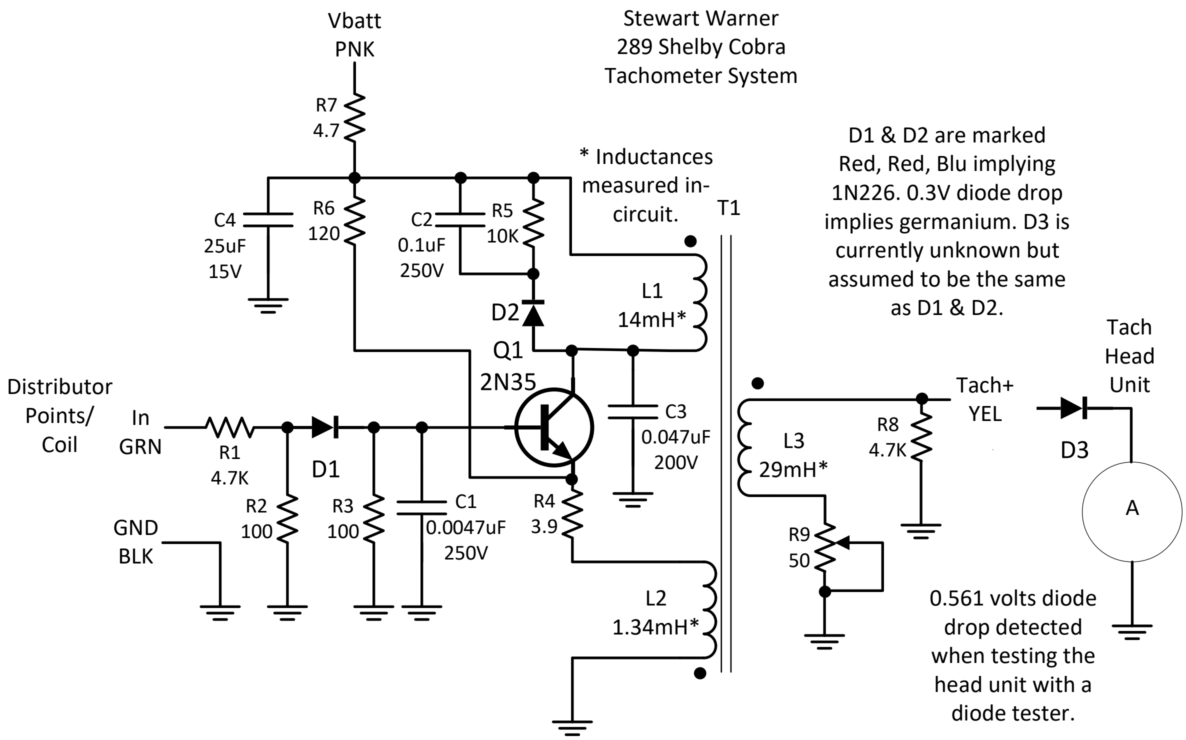
The following pages document the reverse engineering of the system.

Reverse Engineering





PCB Bottom View is Mirror Image



Theory of Operation:

Untriggered:
When the points are closed, the input is grounded and Q1 is off. No current flows through T1's L1 winding, so the collector of Q1 is at 12V (assuming a Vbatt=12V.) Winding L2 will have about 93mA flowing through it via R7, R6 and R4. That sets the Q1 emitter voltage at about 0.36V. No current will flow through winding L3 or any of the output circuit. The threshold voltage of Q1 (germanium) is about 0.3V which is added to the emitter voltage becomes about 0.66V.

Triggering:
In order to get Q1 to trigger, the input needs to get the base of Q1 up to at least about 0.66V. That puts about 6.6mA through R3 and puts the input to D1 at about 0.96V. About 9.6mA will flow through R2, with the current through R1 being the sum of the currents through R2 and R3, which is about 16.2mA. 0.016.2*4700 = 76.14V plus 0.96V is about 77V which is what is required to trigger the tachometer.

On-Shot Operation:
When Q1 starts to turn on, current starts to flow through L1. As the current flowing through L1 starts to increase, current also starts to increase through the other two transformer windings. The increasing current through L2 drives the Q1 emitter negative, which tries to turn Q1 on even harder. Current also continues to increase through winding L3 driving current through the ammeter. The feedback from L2 continues until the collector current equals the emitter current. At that point, the transistor starts to go out of saturation causing the current in L1 to start to drop. That induces a current drop in L2 which feeds back into Q1 to further turn Q1 off until the pulse has ended. As the current in L1 falls, it induces a negative pulse in L2 and L3 until the flux has dissipated. The diode in the head unit prevents the negative pulse from affecting the current in the meter. I assume that C3 and the C2/R5 network are noise filters and/or there to prevent oscillation.

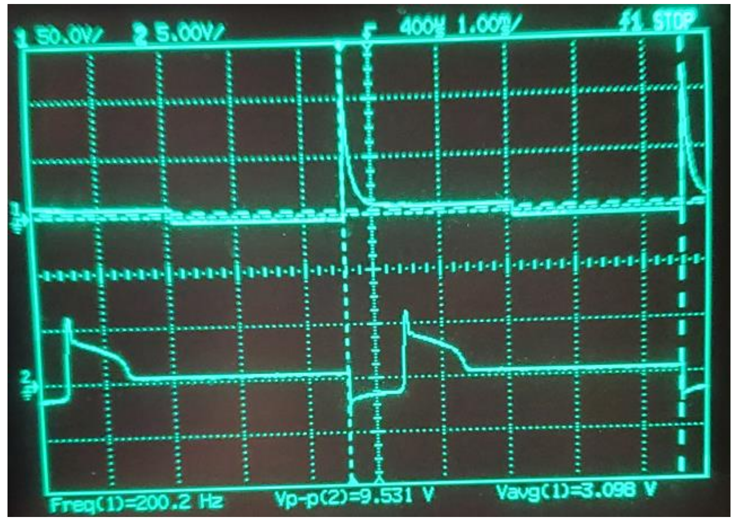
One interesting thing to note is that nothing controls the amount of energy in each one-shot pulse as battery voltage changes, so the accuracy of these stock tachometers will fall off a bit as the battery voltage varies from the calibration voltage in the car. With a 4000 RPM reference signal, it read 4100 with Vbatt=8.5V and 3900 with Vbatt=16V. With 12V Vbatt, freezing the circuit had no effect, but heating it up with a hair dryer on high, it dropped to 3900, so heat has a small effect too.

When bench testing the sender, you must use it to drive a high voltage module such as a TechnoVersion V-Boost Module to generate a pulse with at least 70V. Ensure that the function generator is set to about 75% duty cycle. If the high side of the calibration signal is shorter than the one-shot pulse width, the sender will not trigger.

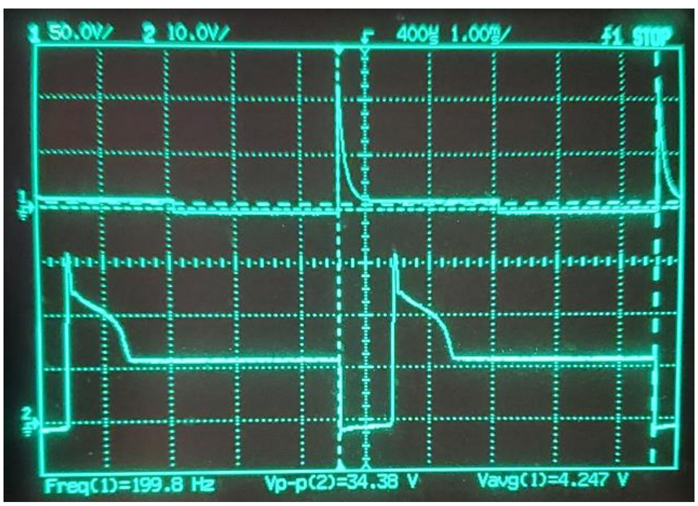
Scope Traces:

The top trace is the input signal in all of these photos.

Q1 Base

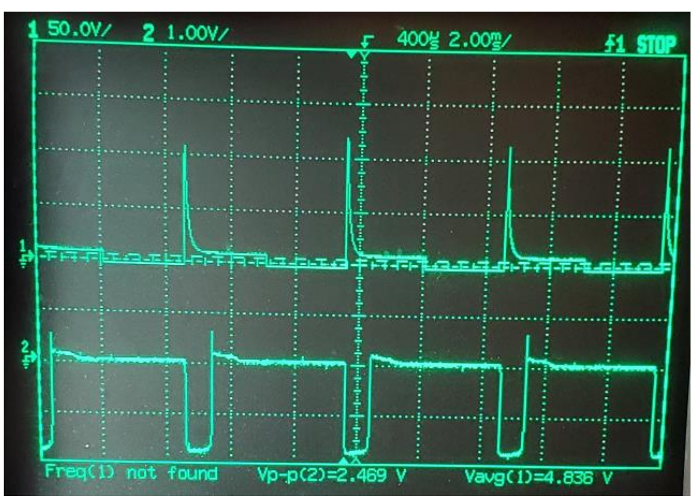


Q1 Emitter



Q1 Collector

R4/L2

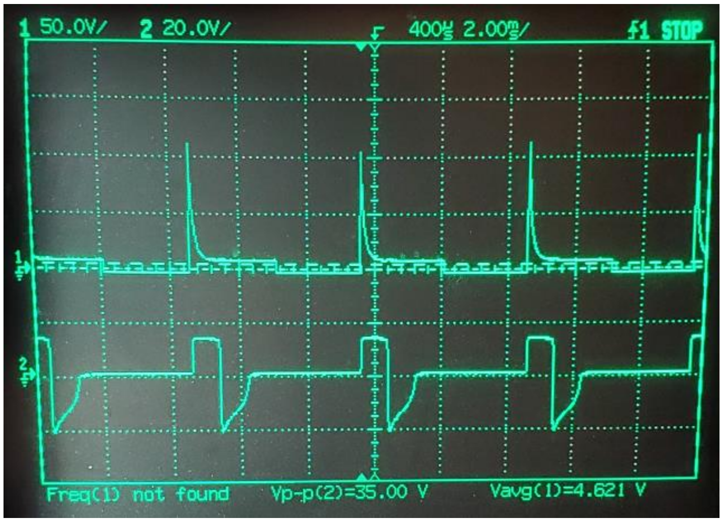


L3/R9

L3/R8 (PCB Output)

Scope Traces Continued:

The top trace is the input signal in all of these photos.

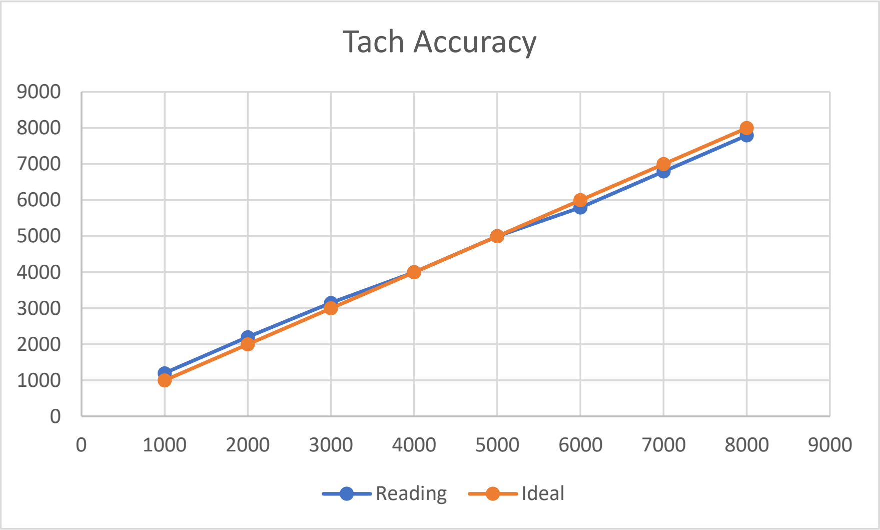


L3/R8 (PCB Output)

Ammeter Input (D3/Ammeter)

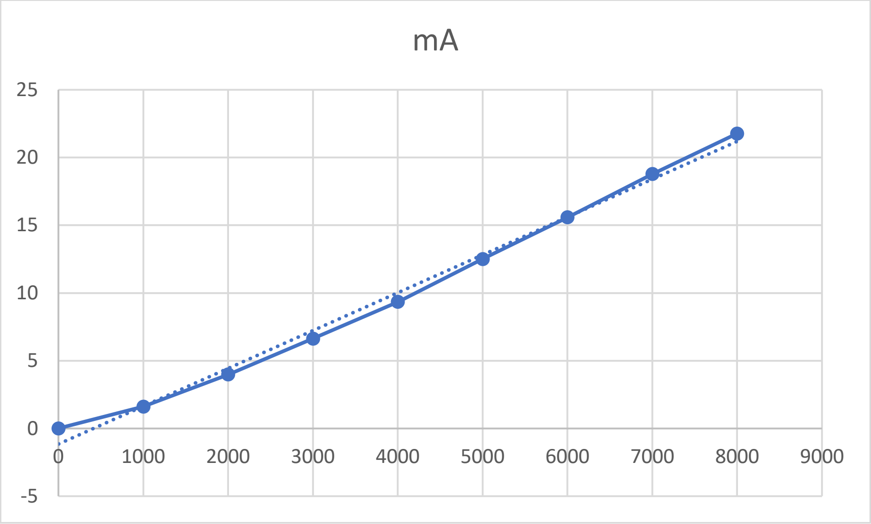
Calibration Data:

Signal	Reading
8000	7800
7000	6800
6000	5800
5000	5000
4000	4000
3000	3150
2000	2200
1000	1200



Head Unit Characterization:

Reading	mA	V
8000	21.77	4.6
7000	18.78	4.13
6000	15.58	3.53
5000	12.5	2.94
4000	9.34	2.34
3000	6.63	1.82
2000	3.98	1.29
1000	1.61	0.8
0	0	0



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