

Construction Details of Volvo Electronic Throttle Module And Failure Mechanism

Initial observation:

The Electronic Throttle Module (ETM) (see figure 1) is located on the underside of the intake manifold, on the forward side of the engine, with the inlet air flowing upwards. Removing the fan provides enough working space to remove the 4 bolts holding the ETM to the intake manifold. A six conductor electric cable connects it to the engine compartment wiring harness.

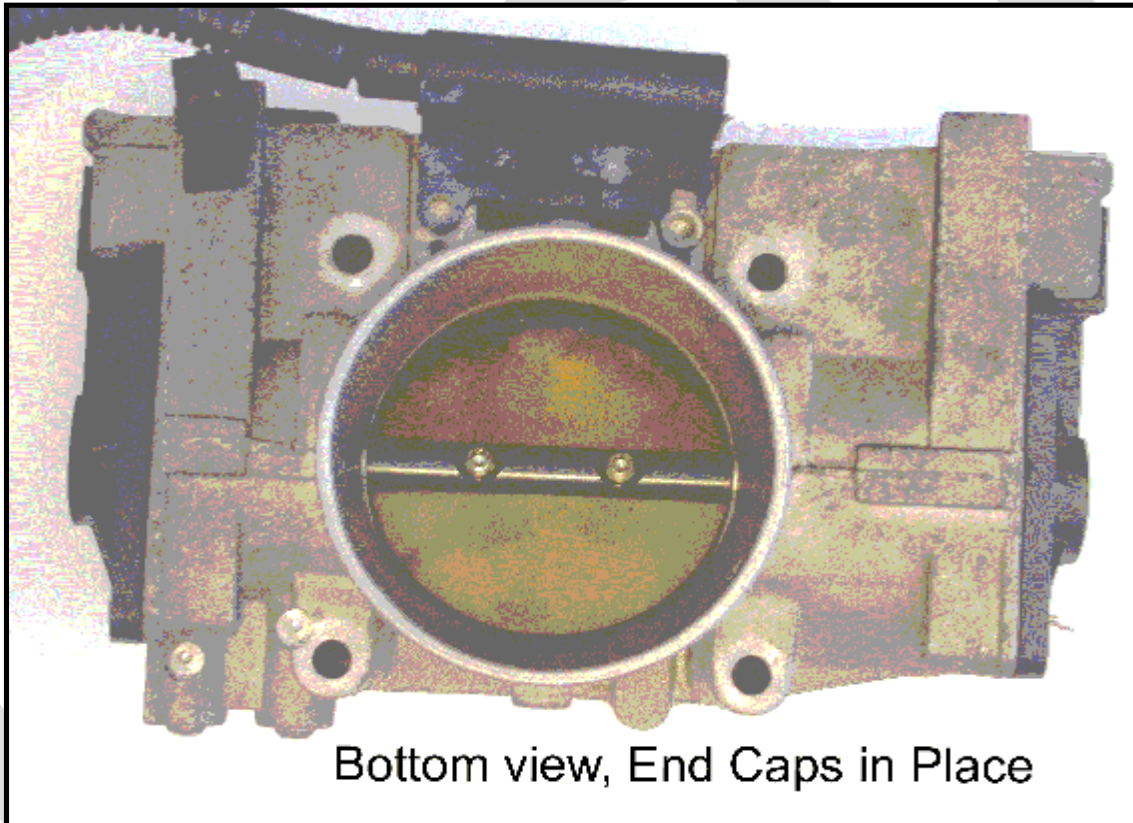
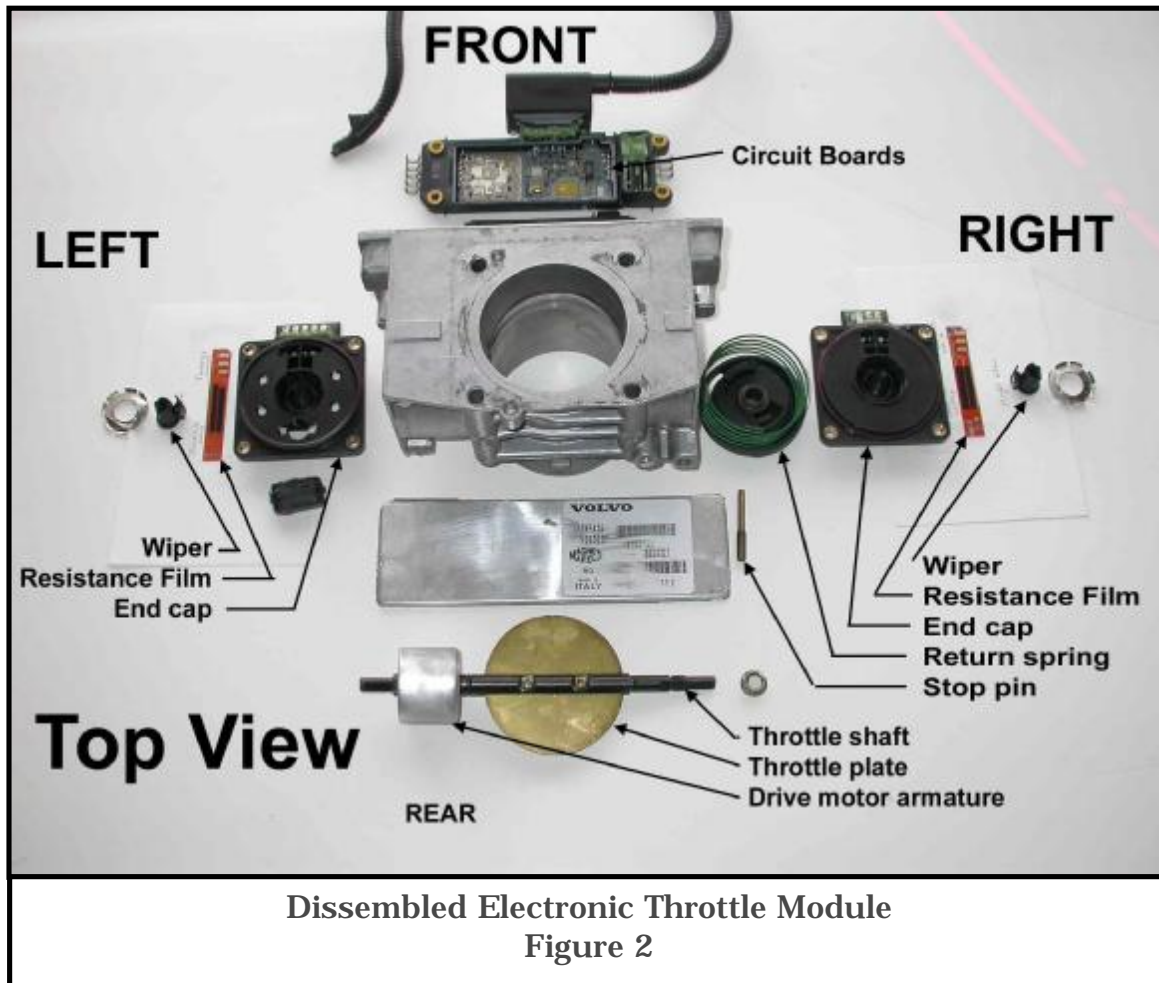


Figure 1

Disassembly:

Removing the front cover exposes the circuit board module and connections to the end cap circuits and the external cable. At four places Potting compound covers connections at each end, to the external cable and encapsulates a 470 μ F 25V capacitor.



Circuit boards:

The cover can be removed by inserting a blade in the glue joint. The circuit boards are made using DuPont ceramic thick film technology with gold, silver and silver-palladium interconnects. An explanation of the materials of construction for this exact board is found at <http://www.dupont.com/mcm/applic/H-78296.html>. The advantage of the ceramic is low expansion with temperature extremes. The components are potted with a clear, elastic compound, similar in consistency to Jell-O. All components are visible. All connections from the boards to the outside connections are through welded aluminum wires between the board and appropriate feed-thrus. Between the power board and the control circuit board are 11 single wire connections and 3 that are doubled. All components, except resistors, are soldered down using surface mount technology; resistors are screened (painted) on and then trimmed to value by laser. Most passive components (resistors and capacitors) are connected by screened on or photo lithography traces. Welded wire bonds connect the transistors, diodes and integrated circuits. The selection of materials and



Contacts to left throttle position potentiometer and throttle drive motor field winding

Power function circuit board

Logic/computer circuit board

Contacts to right throttle position potentiometer

Front view with the cover removed
Figure 3

construction of these circuit boards is excellent and very appropriate for the application.

Mechanical construction of throttle shaft and throttle plate:

As would be expected, there is a throttle shaft that passes through the center of the throttle bore. The throttle butterfly is installed through a slot in the shaft and held in place with two screws that are staked in place. The shaft itself is supported by two precision sealed ball bearings. In this unit, with the throttle plate removed the throttle shaft was free to turn and showed no sign of roughness, wear or binding.

Removal of the end caps:

The connectors to the end caps can be viewed and opened by removing the potting compound. After the connections are exposed they can be unsoldered or breaking the joint open with a small chisel. The end caps serve three functions: First to seal the module from dirt or moisture intrusion, second, to contain the bus wires connecting the circuit boards to the potentiometer and drive motor field and third to contain the throttle position potentiometers.

Throttle Position Feedback Potentiometers

The function of the potentiometer is to feed back the position of the throttle to the ETM computer. The throttle plate is stamped “86°” which appears to be the total angle that the throttle plate moves from fully closed to fully open. On each end of the throttle shaft is a plastic collar that is keyed to the throttle shaft by a “D” shaped cavity that fits onto the flat of the shaft. To this is fastened the wiper. The wiper is a single piece of conductive spring metal (material unidentified) that is divided into two sections, each further divided into 4 fingers. The wiper tips are bent at right angles so that the tips ride on the resistance film See Figure 4.

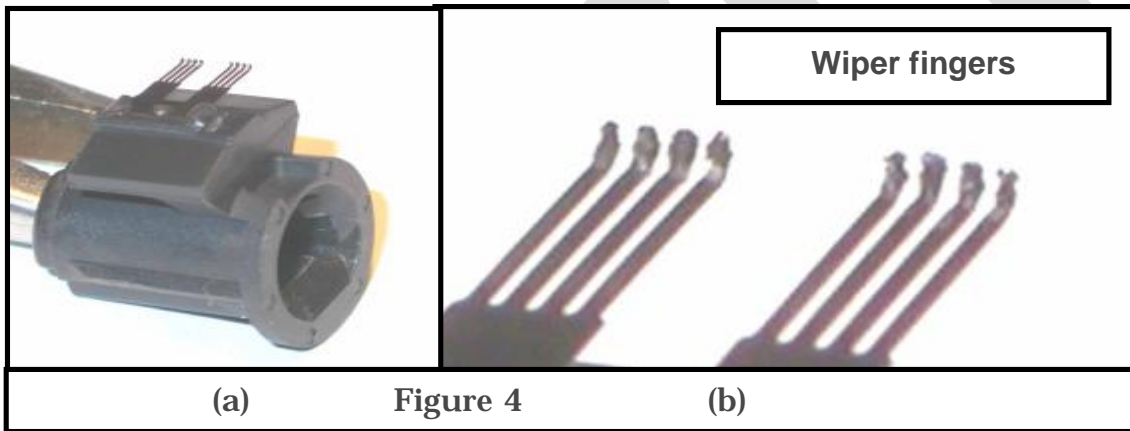


Figure 5 shows the position of the resistors in the end caps. The resistors are thick film carbon resistors screened (painted) on a plastic film, 0.006” thick, 0.414” wide and 1.161” long. Note the grooves that are worn into the thick film carbon resistor.

As shown in the schematic in Figure 6, the wiper picks a voltage off of the lower resistor and carries it to the upper resistor.

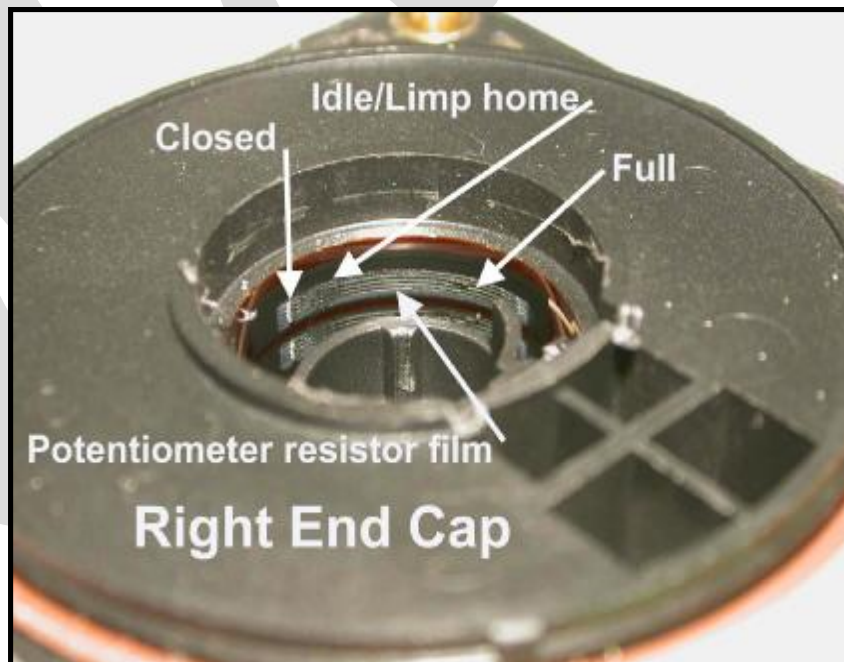
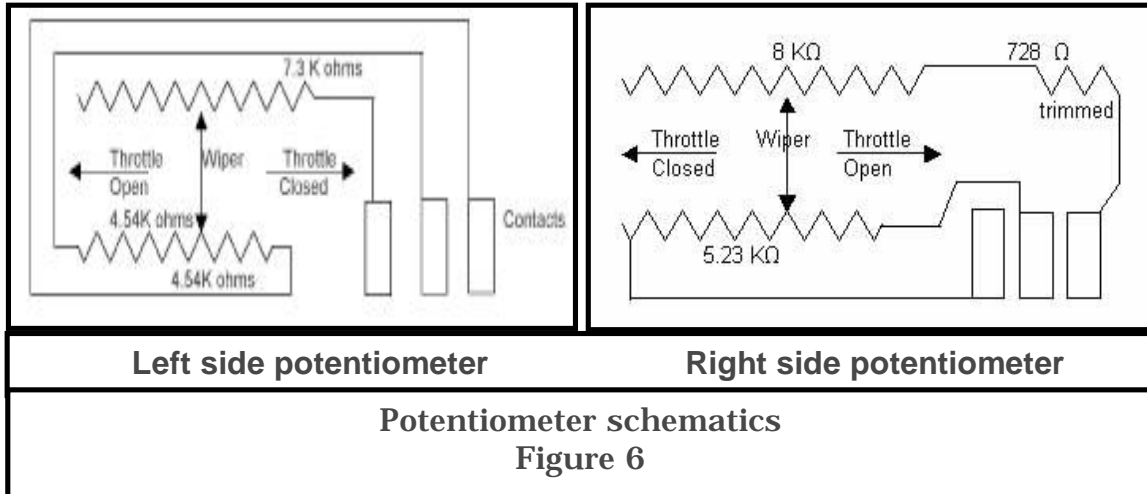


Figure 5

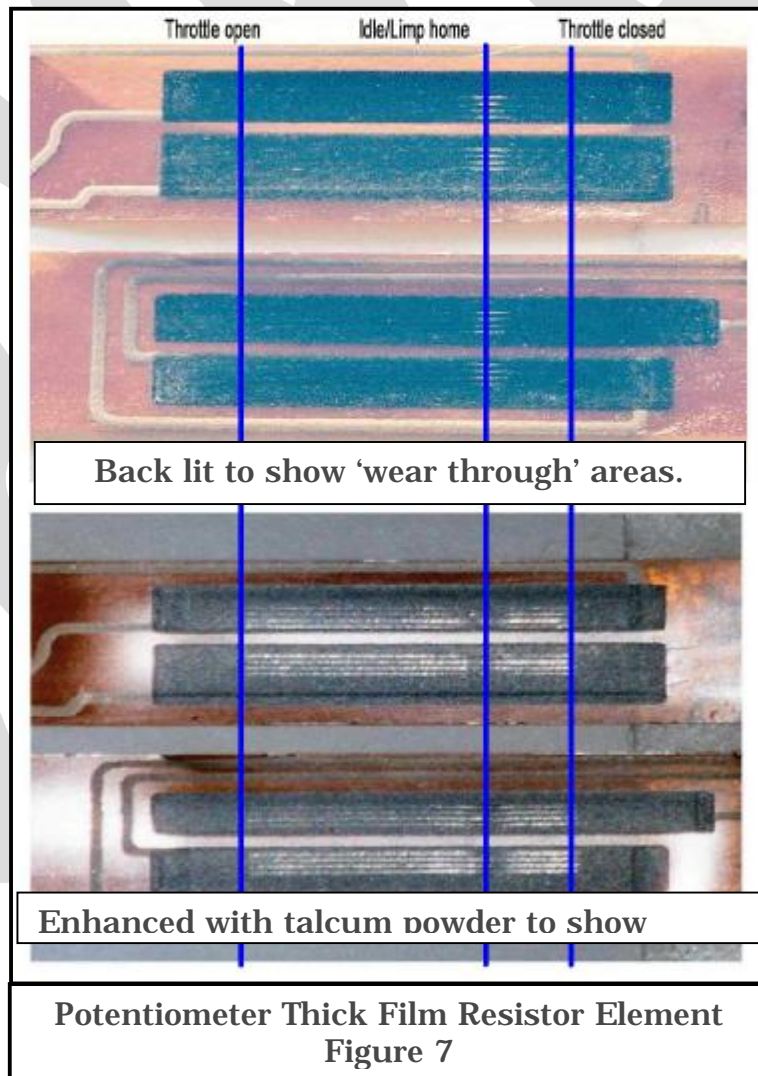
Volvo Enthusiasts eXposing Egregious Design



The theory for the two resistors can be found at <http://www.auto-solve.com/etc.htm>.

Voltage signals from the two potentiometers, with one increasing while the other decreases, allows the ETM to calculate a mean voltage output and provides for the butterfly position to be calculated with great accuracy. Since it is critical to know the throttle position accurately any degradation of the signals from the potentiometer would throw the ETM computer and its program into spasms.

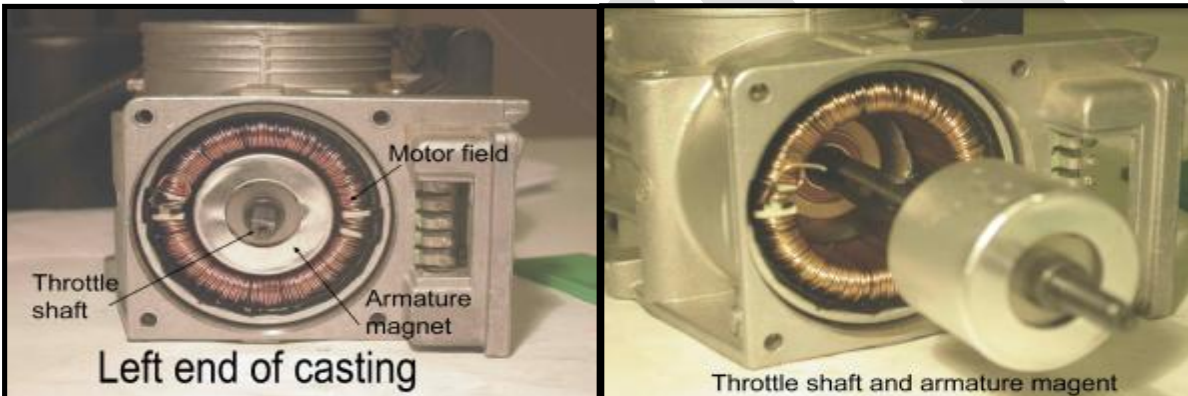
Figure 7 are photos, at about 2X magnification, of the thick film resistor. The top is backlit to show the absence of the resistance material. Dusting with powder



enhances the visibility of the wear grooves in the lower view.

Left End cap

At this end is the drive motor (also referred to as a servomotor) for moving the throttle shaft shown in Figure 8. When the throttle plate is removed the throttle shaft can be removed. The armature is a strong circular magnet 1.25" in diameter by 1" long. The field winding is a toroid with copper wound around a cylinder 1.5" inside diameter, 2" outside diameter and 1" long.



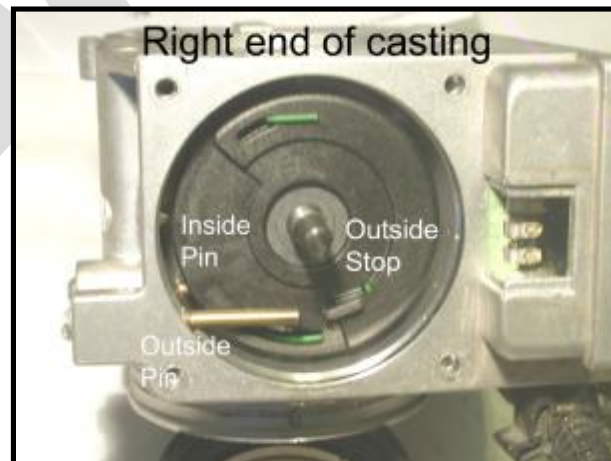
Throttle Position Drive Motor
Figure 8

The armature magnet is polarized N/S, perpendicular to the shaft. Thus by controlling the current in the toroid the field is shifted so that the throttle shaft follows. Essentially it is a DC (direct current) motor but instead of the magnet continually chasing the rotating magnetic field around a circle, it follows the magnetic field as it moves back and forth through 86°.

Right end of the casting:

At the right end of the ETM, keyed to the throttle shaft by the 'D' flat, is a 2" diameter disk. There are two adjustable, but locked and sealed pins, one on each side of the disk. The inside pin (the one behind the disk) aligns with a stop that adjusts the no power position of the throttle. Under no power conditions the edge of the throttle plate is about 0.040" inch open. This stop is spring loaded so the throttle plate can be driven fully closed against this spring by the servomotor.

The outside stop (the one on



Idle and limp home stops
Figure 9

the near side of the plate) is about $\frac{1}{4}$ " away from its outside pin. When the disk is pushed against the outside pin a thin crescent of light can be seen around the periphery of the throttle plate. The clearance is about 0.001 inch as measured with paper shims of varying thickness. When moving the disk against this pin there is a significant spring resistance from the backside stop. This acts as a solid stop when compared to the throttle closing spring, effectively holding the throttle open under no power condition.

Normal idle is less than 20 mph; which means the throttle servomotor is bi-directional and can drive the throttle more open for higher speed but also more closed for idle and creep.

Summary

Other than the selection and design of the throttle feedback potentiometers the construction is excellent. The casting is smooth and free of voids. All internal surfaces were clean with no traces of carbon or oil contamination. The internal machined surfaces are mirror bright. The throttle bore had only a slight bit of carbon type buildup.

The circuit boards and construction are very appropriate for the application. Visual examination shows no signs of thermal damage.

The throttle plate position stops were of a reinforced thermoset plastic. They were free of any damage and their movement was smooth with no binding.

The movement of the throttle shaft was smooth and when against the full closed position there was no sign of binding or sticking that would require throttle bore cleaning