Chevrolet Volt Cooling/Heating Systems Explained

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The Chevy Volt is equipped with four fully independent cooling systems or "loops". The power electronics cooling system loop is dedicated to cooling the battery chargerand the power inverter module. The batterycooling system cools (or in some cases heats) the 360V high voltage battery. The enginecooling system and heater loop is specific to cooling the gasoline engine and when required, provides heat for the passenger compartment. The electric drive unit cooling system is designed to cool the two motor generator units and electronics within the 4ET50E drive unit transaxle, and provides lubrication for the various gears, bearings, and bushings.

All four systems each utilize their own separate radiator (or rad-partition) for heat exchange, and are sandwiched together and mounted in the traditional location at the front of the enginecompartment. These radiators (and internally routed coolants) are primarily cooled by undercar airflow directed by an air-dam, through the radiators. Airflow is augmented by a pair of variable speed, electrically powered (12V) cooling fans controlled by the Engine Control Module (ECM). Within all but the electric drive-unit cooling system, a precise mixture of "premixed" Dexcool® coolant is used as a heat transport medium. The electric drive cooling and lubrication system utilizes Dexron VI®.

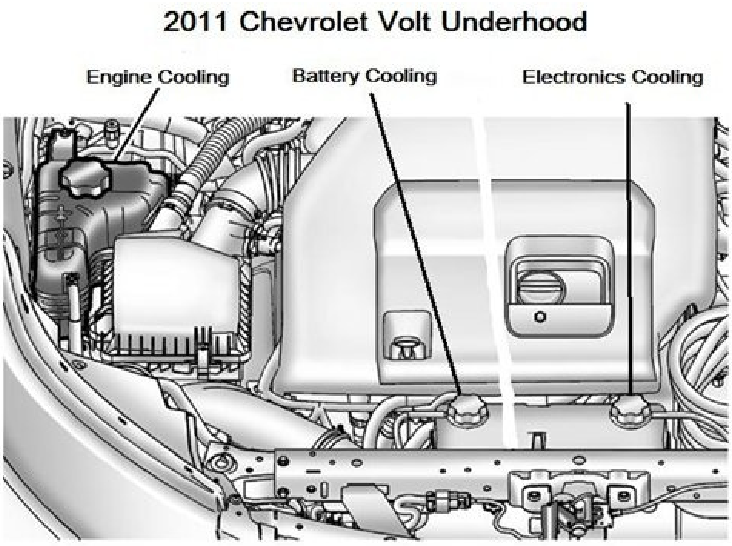
Warning Due to potential issues with high-voltage safety,
the Chevy Volt's engine cooling, heater,
power electronics and battery cooling systems should only be serviced by a qualified factory-trained Volt technician.

Warning Steam and scalding liquids from a hot cooling system can blow out and burn you badly. They are under pressure, and if you turn the surge tank pressure cap — even a little — they can come out at high speed. Never turn the cap when the cooling system, including the surge tank pressure cap, is hot. Wait for the cooling system and surge tank pressure cap to cool if you ever have to turn the pressure cap.

Warning You can be burned if you spill coolanton hot engine
parts. Coolant contains ethylene glycol and it will burn if the engine parts are hot enough. Do not spill coolant on a hot engine.

Warning The electric cooling fans under the hood can start up even when the engine is not running and can cause injury. Keep hands, clothing, and tools away from any underhood electric fan.
WOT Says: "When topping up or replacing coolants, always use pre-mixed

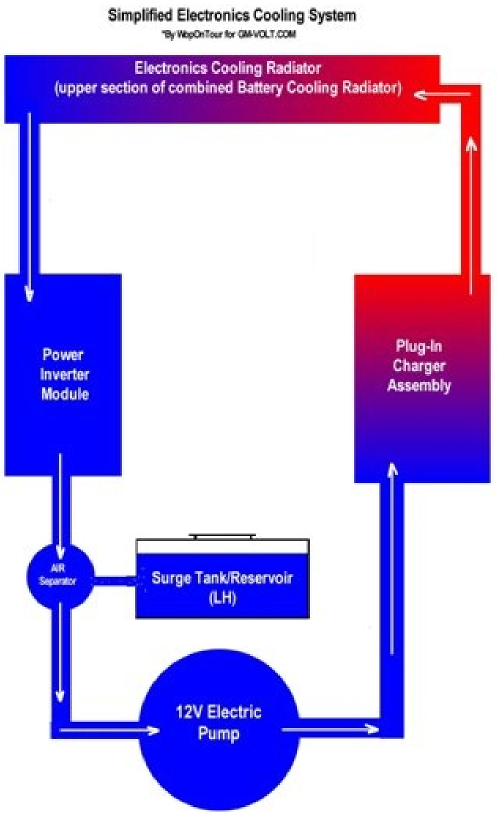
Dexcool® coolant and NEVER add regular green anti-freeze or tap water to ANY of the Volt's cooling systems. This premix coolant (available at your GM dealer) is essentially a 50:50 mixture of GMDexcool® (or other GM6277M compliant coolant) and filtered low-silicate, deionized water. The use of deionized water in hybrids, EREVs, and EVs is a necessity to ensure high-voltage isolation and to prevent the internal corrosion of cooling system components."



The Power Electronics Coolant Loop

The power electronics coolant loop is designed to ensure the main underhood electronics do not overheat during use. The Power Inverter Module(PIM) utilizes high power Insulated Gate Bipolar Transistors (IGBTs) in order to convert DC current from the high-voltage battery into 3-phase AC motor drive signals for the motorgenerator units. These same devices also convert AC to DC for charging operations during regenerative braking. The normal operation of the IGBTs creates a significant amount of heat.

The plug-in battery charger also rectifies 120-240 volt household alternating current (ac) from the grid into the direct current (dc) necessary to fully charge the high voltage battery.



It is essential that the heat developed by these devices while operating the Volt or when plugged in be dissipated in order to prevent damage to the components. The Chevrolet Volt uses a high flow 12-volt electric pump to create and control the coolant flow which passes through (in order); the plug-in battery charger assembly, the radiator, the power inverter module (PIM), and the and then back to the pump. The power electronics cooling system radiator is the upper half section of a dual radiator assembly that is common with the high voltage battery cooling system.

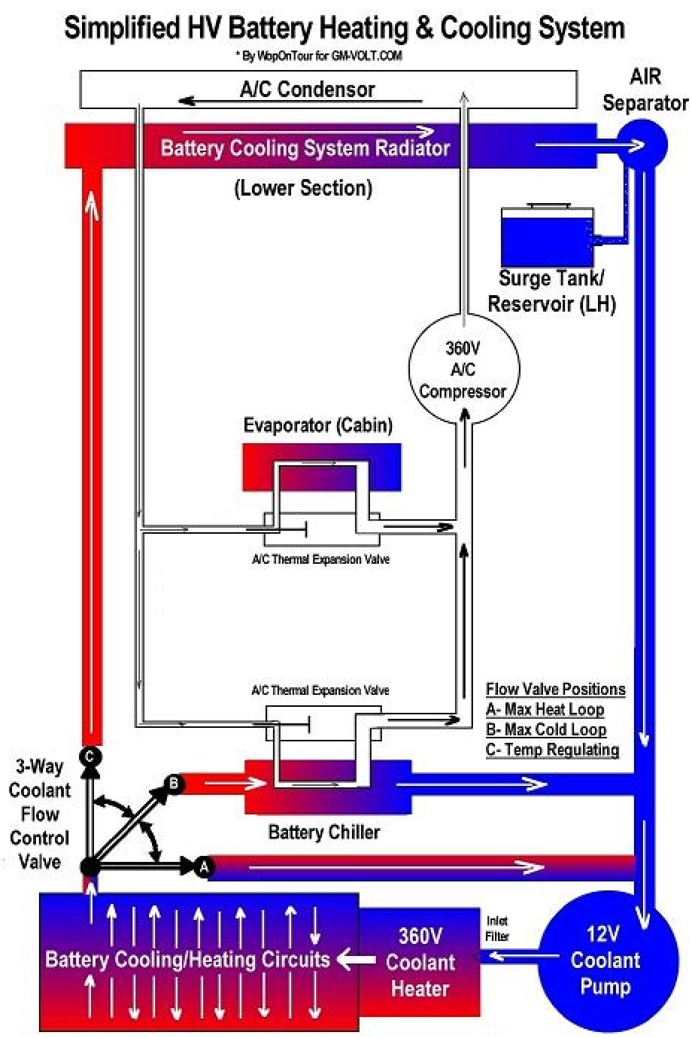
The power electronics cooling system also uses an air separator device to prevent air-bubbles from affecting cooling performance and utilizes a surge tank that acts as a coolant reservoir, and facilitates the routine addition of coolant via a pressure cap. (See *Warnings*)

The Hybrid Powertrain Control Module 2, controls the coolant pump as well as radiator fanspeeds based on a temperature sensorsmounted in the radiator. To operate the fans the HPCM2 communicates a FAN SPEED COMMAND to the Engine Control Module (ECM) via the GMLAN (DWCAN) network. The electronics coolant pump will be activated whenever the Volt is “ON” and during 120-240VAC “plug-in” charging.

The High Voltage Battery Cooling / Heating System
The Volt’s T-shaped Lithium Ion battery (~360V) is mounted underneath the car and runs down the center tunnel and beneath the rear seating positions.

A pair of quick-coupler fittings create the coolant IN/OUT connections to the high voltage battery housing. Inside the battery housing there are thermal passages that permit coolant to flow in-between the Lithium Ion battery cells. These passages permit the cells to be cooled or heated depending on operational requirements. The coolant inlet to the battery housing includes a debris filter, and a variable high voltage heating element that operates directly off the 360V Lithium Ion battery, and able to accurately heat the coolant when the batterycells are too cold.

As mentioned previously, the battery cooling system shares a radiator assembly (and twin 12-volt variable speed cooling fans) with the power electronics cooling system. The lower section of this dual radiator is used for battery system cooling. The battery cooling system has its own 12-volt coolant pump, a refrigerant to coolantheat exchanger (aka chiller) and a 3-way coolantflow control valve to route coolant through the radiator, the chiller, or bypass. There is also an AIR separator and surge tank that is integrated with the electronics reservoir/tank (a single housing but with 2 separate tanks).



The Hybrid Powertrain Control Module 2 and other networked modules monitor ambient conditions, the battery IN/OUT coolanttemperatures, various Li-Ion cell temperature probes, as well as refrigerant temperatures and pressures to establish battery heating or cooling requirements.

The HPCM2 will then selectively turn the coolantpump ON or OFF, positions the coolant flow control valve, and depending on whether cooling or heating is required, request either the electric A/C compressor to operate (cooling), or turn ON the high voltage battery heater(heating) . The battery cooling/ heating system can be activated when the vehicle is “ON” and if necessary during charging operations.

As shown in the diagram, when battery HEATING is required the 3-way coolant flow control valvewill be in position “A” and permits fast heating of the Lithium Ion cells to quickly permit them to attain a desirable operating temperature in cold weather.

Position “B” will be commanded whenever the Li-Ion battery cells are too hot. By operating the electric air-conditioning compressor, R-134A refrigerant will be throttled by the thermal expansion valve/s and permit super-cooling of the battery coolant as it passes through the chiller unit.

During more temperature stable operating conditions, the flow control valve will typically be commanded to position “C” circulating the flow of battery coolant out to the battery cooling radiator and back to the pump. This route permits temperature stability by controlling cell temperatures through pump control.

The Engine Cooling System and Heater Loop
The engine cooling system (and heater loop) uses the engine radiator, two 12V variable speed radiator fans, an electric coolant heater pump(12V), a coolant flow bypass valve, a high voltage (360V) coolant heater, and a cabin mounted heater core.

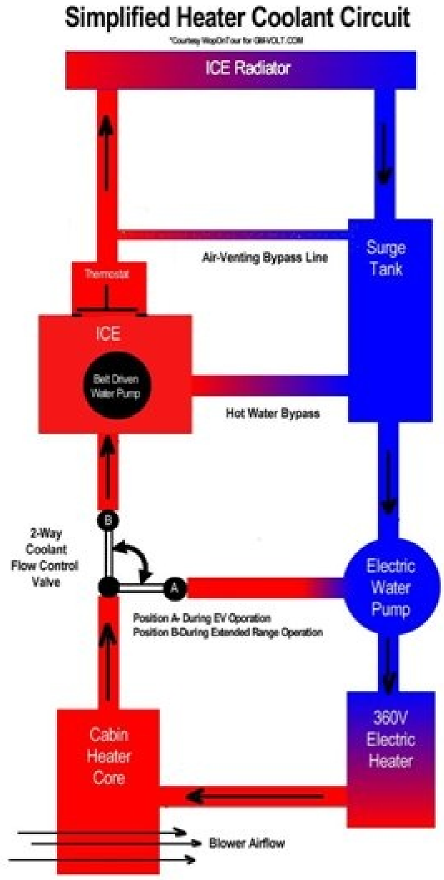
The engine coolant flow bypass valve is a controlled by the Hybrid Powertrain Control Module (HPCM2) to assist in regulating passenger compartment comfort based on the availability of engine heat from the 1.4L range-extender engine. The coolant bypass valveseparates the engine and the cabin heatercoolant loops to prevent heat generated by the high voltage coolant heater for the passenger compartment from dissipating into the enginecoolant loop.

The coolant flow bypass valve has two positions. When the engine is OFF (as during electric only EV operation) the valve is commanded to be in engine bypass mode (Shown as Position “A” in the attached diagram). This permits the electric pump to circulate coolant through the 360V heater then through the heater core in a short, efficient loop. For maximum electrical efficiency, feedback from temperature sensors in the passenger compartment and heater coolant loop are used to determine the necessary amount of electric current applied to the high voltage (360V) heating element which is an integral part of the Coolant Heater Control Module (CHCM).

After the engine starts up (in extended range mode for instance) additional engine heat will soon become available to assist the fan driven cabin heater in warming the passenger compartment. At that point flow control valve is commanded to the “linked” position (Shown as position “B” in the attached diagram) and the two coolant loops are then connected. This parallel connection permits the sharing of coolantbetween the engine and heater core, and subsequently the 360V heating element (CHCM) power level will be reduced and/or cycled OFF/ON as the engine turns on/off during extended range (charge-sustaining) operation in order to maintain cabin comfort utilizing the most efficient heat source.

Whenever the 1.4 liter range extender ICE is ON, coolant through the engine is managed by a conventional belt-driven water pump. A belt driven pump was selected to ensure positive cooling flow whenever ICE is ON, that is automatically varied proportionately with enginespeed. The thermostat regulates the normal engine operating temperatures in a conventional fashion, but can be heated electrically to speed opening and regulate flow. Thus the thermostat creates an appropriate flow restriction for the engine cooling loop that promotes a positive coolant flow and helps to limit air cavitation. When the engine is first started and the thermostat remains closed, a hot water bypass line permits heated coolant flow to the electric pump and heater core. Once the thermostat opens, flow will be permitted through the radiatorwhich will maximize cooling yet still allow flow through the heater core loop for passenger compartment heating.

See the simplified diagram below as a reference for the Engine Cooling System and Heater Loop.



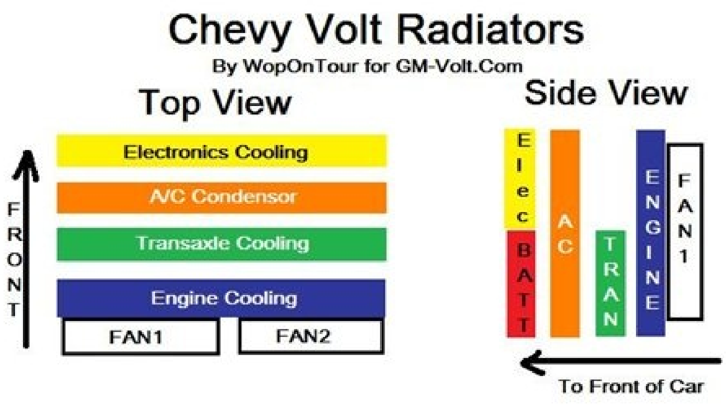
Electric Drive Unit Cooling and Lubrication System
The electric drive unit cooling and lubrication system is designed to maintain the internal temperature of the 4ET50 transaxle used in the Volt. This unique electric drive unit contains a pair of motor generator units that are used to propel the Volt using electric power as well as generate electricity to maintain the high voltage battery state-of-charge. Because of the high power levels of these motor generator units (MGU-A is 58 kilowatts and MGU-B has a peak of 116 kilowatts) there is considerable heat generation during operation.

The 4ET50 drive unit utilizes a system of pressurized automatic transmission fluid(Dexron VI®) that is used to :

– create fluid pressure to apply 3 multi-disc clutches and input damper clutch
– lubricate all gears, bearings and bushings
– cool the motor generator units (MGA & MGB) and other components

The necessary pressure is primarily created by a 3-phase A.C. electrical motor/ pump assembly within the transaxle. There is also a more conventional mechanically driven gear pump to ensure transmission fluid pressures and flow are always present when the internal combustion engine is running.

An external transaxle cooler outlet fitting directs fluid under pressure into a high pressure line and to the transmission fluid heat exchanger (radiator/ cooler) mounted between the enginecooling radiator and air-conditioning condenser. Transmission fluid circulates through the coolertubes as airflow across the radiator withdraws heat from the fluid. An outlet fitting from the transmission cooler/radiator then directs the cooled Dexron fluid back into the transaxle via the return line. There is a transmission coolerfluid bypass device at the IN/OUT fitting of the cooler so that in the event of a restricted cooler(due to debris or extremely cold temperatures) the bypass valve would open and redirect the fluid back to the transaxle return fitting.



The thermal management systems used by the Chevrolet Volt are an important aspect of its efficient use of various heat energies.
Balancing and utilizing numerous heat sources and dissipation opportunities for useful purpose in order to minimize heat energy loss is a complicated task that the Volt manages admirably. Future iterations of the Voltec powertrain are certain to take even more advantage of the potential thermal resources and maximize efficient use-reuse of energy for maximum efficiency.

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