

Cabin Heating and Windshield Defrosting for Extended Range Electric, Pure Electric, & Plug-in Hybrid Vehicles

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ABSTRACT

Conventional HVAC systems adjust the position of a temperature door, to achieve a required air temperature discharged into the passenger compartment. Such systems are based upon the fact that a conventional (non-hybrid) vehicle's engine coolant temperature is controlled to a somewhat constant temperature, using an engine thermostat. Coolant flow rate through the cabin heater core varies as the engine speed changes.

EREVs (Extended Range Electric Vehicles) & PHEVs (Plug-In Hybrid Electric Vehicles) have two key vehicle requirements: maximize EV (Electric Vehicle) range and maximize fuel economy when the engine is operating. In EV mode, there is no engine heat rejection and battery pack energy is consumed in order to provide heat to the passenger compartment, for windshield defrost/defog and occupant comfort. Energy consumption for cabin heating must be optimized, if one is to optimize vehicle EV range.

A new heating system has been developed for providing cabin heating and windshield defrost for such new vehicle propulsion systems, which includes a HV (High-voltage) PTC (positive temperature coefficient) coolant heater, electric coolant pump, and coolant control valve.

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INTRODUCTION

A new heating system has been developed for providing cabin heating and windshield defrost for EREV, EV, & PHEV vehicle propulsion systems, which includes a HV PTC coolant heater, electric coolant pump, and coolant control valve.

BODY

The cabin heating and windshield defrosting system used in conventional vehicles uses engine coolant to provide heat to the cabin. For conventional vehicle propulsion systems, the engine is continuously running. The engine's coolant temperature is controlled to a somewhat constant temperature, using an engine thermostat. Coolant flow rate through the cabin heater core varies as the engine speed changes. Such cabin heating systems typically adjust the position of a temperature door to achieve the desired temperature of the air flowing into the passenger compartment.

Figure 1 shows a conventional cabin heating system, which consists of heater core, coolant hoses between the

engine and the heater core, and an air temperature door internal to the HVAC module.

New types of vehicle propulsion systems (EREVs and PHEVs) are being developed, which can operate for extended periods of time without any engine operation, and therefore no engine heat rejection is available for cabin heating or windshield defrosting.

Cabin HVAC power consumption is much higher for cabin heating and defrosting, compared to cabin cooling (Figure 2).

Two key vehicle requirements for both EREVs and PHEVs are: maximize EV range and maximize fuel economy when the engine is operating.

A new concept for providing cabin heat and windshield defrosting for EREVs and PHEVs has been developed which meets both of these vehicle requirements. This new concept consists of the following components (see Figure 3):

- High-voltage PTC coolant heater
- Electric coolant pump
- 3-way electric coolant valve

This new cabin heating system has (2) operating modes:



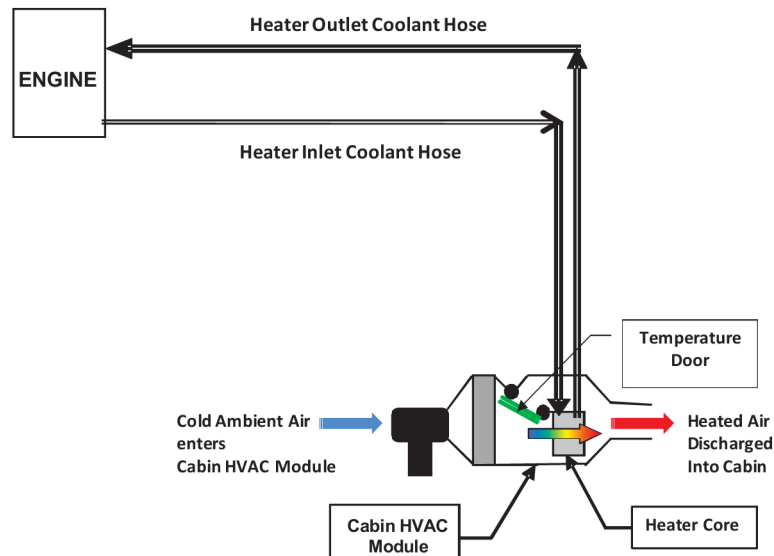


Figure 1. Conventional Cabin Heater System

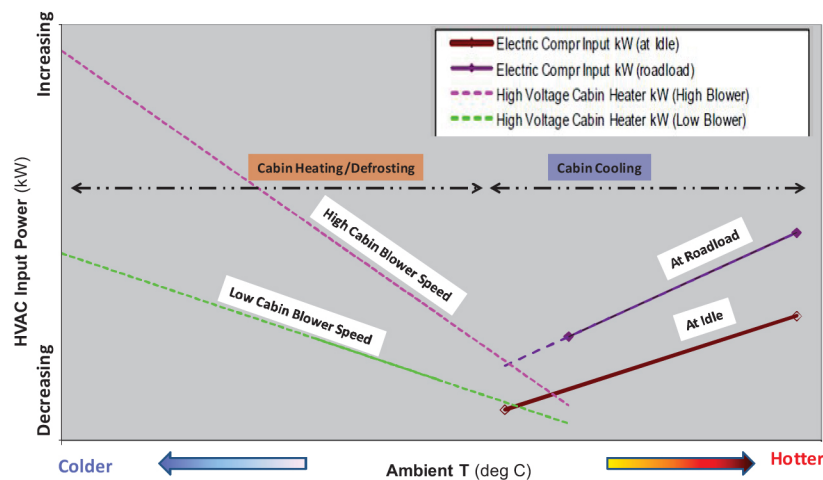


Figure 2. HVAC System Electrical Power vs. Ambient Air Temperature

- 'Bypass' Mode (Figure 4), where coolant flowing thru the cabin heating system is isolated from the engine
- 'Link' Mode (Figure 5) where coolant flowing thru the cabin heating system is shared with the engine

'Bypass' Mode may be used during the following vehicle conditions:

- During EV (Charge-depletion) condition (when the engine is not being operated)
- During Charge-sustaining mode:
- While the engine is initially warming up
- When the engine has been cycled off and the engine's coolant temperature is too cool for cabin heating

During 'Bypass' Mode, electrical power consumption of the High Voltage PTC coolant heater is adjusted to reach the

required discharge air temperature requested by the customer, while keeping the HVAC module temperature door in the full hot position. By keeping the HVAC module temperature door in the full hot position, only enough electrical energy is consumed in order to meet the customer heating demanded, maximizing energy efficiency.

'Link' Mode may be used when engine's coolant temperature is sufficiently warmed up. As the engine coolant temperature continues to increase, the electrical power consumption of the High Voltage PTC coolant heater is decreased.

Key Advantages of this new cabin heating concept include:

1. Minimizes HVAC electrical power when the vehicle is not operating in EV mode, by utilizing Engine waste heat.
2. Allows re-use of non-hybrid/conventional vehicle content, such as automatic climate control software

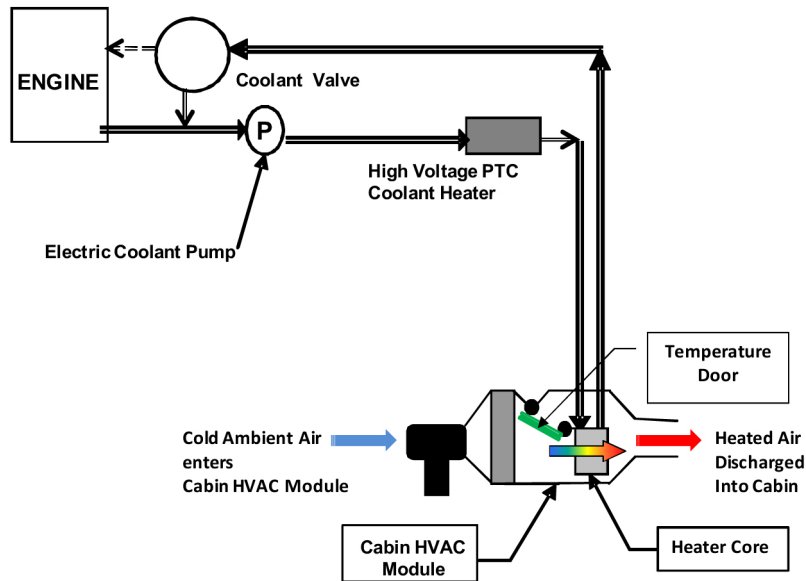


Figure 3. VOLT Cabin Heater System

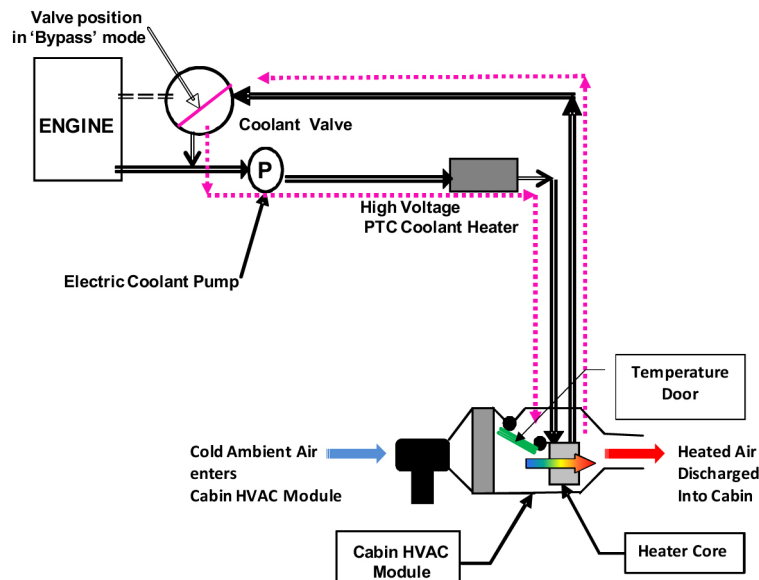


Figure 4. VOLT Cabin Heater System ('Bypass' Mode)

(temperature door control) and carryover HVAC module design/tooling from non-hybrid/EV vehicle programs.

3. Allows re-use of a single High Voltage PTC coolant heater design across multiple vehicle types (EREV, PHEV, EV) and across multiple vehicle architectural platforms (both within a given OEM, as well as across different OEMs), increasing economies of scale for the High Voltage Coolant Heater.

4. Allows High Voltage heating components to be located outside the passenger compartment (avoiding additional technical challenges)

5. Reduces Electric Compressor power consumption in hot ambients by utilizing 'Bypass' mode and preventing hot engine coolant from flowing through the cabin heater core (i.e. eliminate 'heater core scrub').

Depending upon the specific vehicle cabin heating and windshield defrost performance levels required (due to either vehicle size or simply the level of performance specified) this new cabin heating concept may at some low ambient air temperatures require the engine to operate, to provide some amount of engine waste heat in order to meet all performance requirements (Figure 6). By utilizing the High Voltage PTC Coolant Heater along with the engine waste heat, engine