



Specification for Air-Side Positive Temperature Coefficient (PTC) Heater or Air-Side Electric Heater (AEH)

1 Introduction

Note: Nothing in this standard supercedes applicable laws and regulations.

Note: In the event of conflict between the English and domestic language, the English language shall take precedence.

1.1 Purpose. This document establishes the requirements for Air-Side Positive Temperature Coefficient (PTC) Heater, also known as the Air-Side Electric Heater (AEH) used in GM vehicles. All requirements in this standard apply to Air-Side PTC Heater design and interface. The specification defines the general requirements, test conditions and test methods for PTC heaters.

1.2 Applicability. The AEH is provided as a free-flow option for Global A and Global B (Local Interconnect Network (LIN) only) applications in gasoline and diesel engines.

In order to have enough heat quantity in the passenger compartment at low ambient temperatures an electrical auxiliary heater will be used. Its functionality is to support the heat exchanger at low coolant temperatures, by providing supplemental heat.

The system consists of semiconductor heating elements and an electronic control unit which provides a control signal to drive the heating elements, in order to ensure a uniform heat up of the AEH. The PTC elements are located downstream of the heater core in the Heating, Ventilation, Air Conditioning (HVAC) module. The Electronic Control Unit (ECU) and blower part are located near or in the HVAC housing directly. Cooling of the ECU is done by air flow.

1.3 Remarks.

1.3.1 The main functions of the product are:

- a. To heat the air flow with an electrical energy (current).
- b. To control the heater power according to the Input signal using the transfer function and provide a homogeneous heat-up of the whole heater for the premium AEH.
- c. To control the heater power according to the Input signal and provide an inhomogeneous heat up of the whole heater (1/3, 2/3, 3/3) for the switchable AEH.

Figure 1 represents the general overview of a vehicle electrical architecture and precise location of the PTC or AEH into it.

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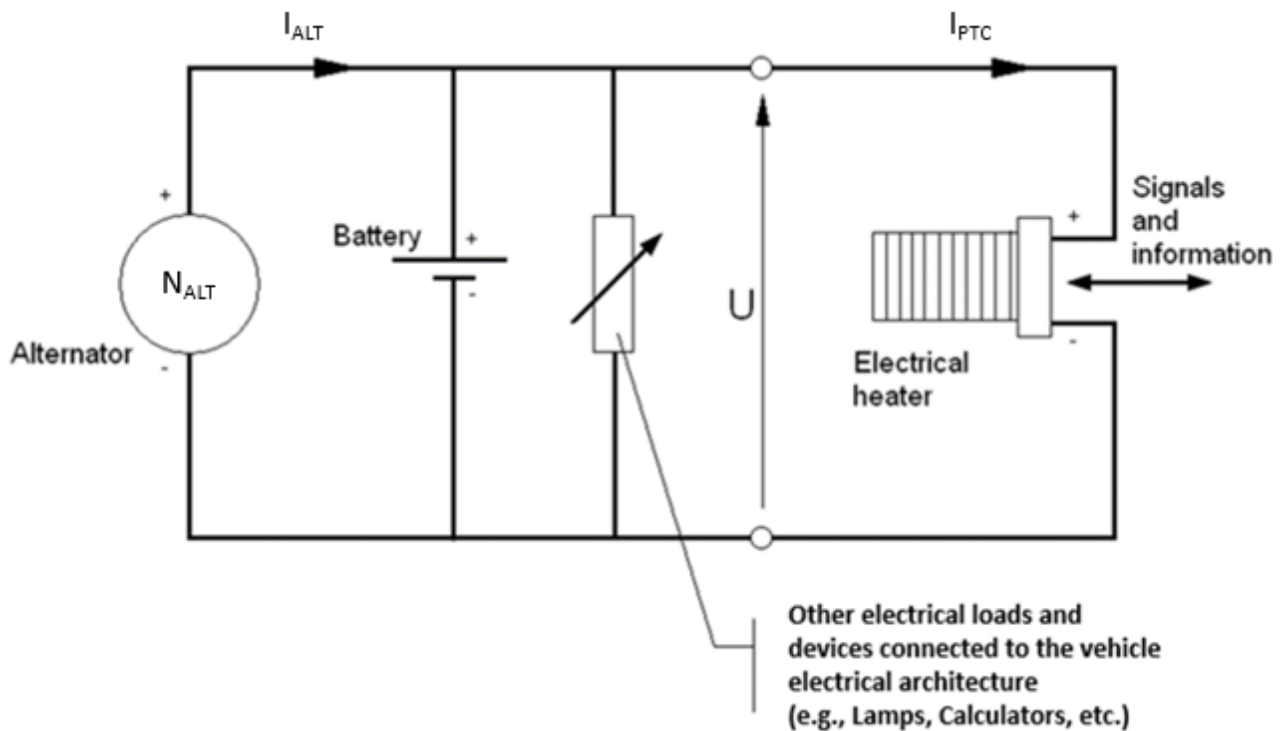
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Figure 1: Architecture and Location of the PTC Electrical Heater Example



B Voltage potential across PTC heater.
I_{PTC} Current through the PTC heater.
I_{ALT} Current through the alternator.
N_{ALT} Alternator speed.

2 References

Note: Only the latest approved standards are applicable unless otherwise specified.

2.1 External Standards/Specifications.

EU 2000/53/EC	ISO 8510-1/2	SAE J2602-1	USCAR2
FMVSS 302	ISO 6722	SAE J2602-2	USCAR12
IEC 61340	SAE J2602	SAE J2602-3	USCAR21

2.2 GM Standards/Specifications.

GMW3059	GMW3205	GMW15010	GMW15862
GMW3091	GMW3232	GMW15049	GMW16331
GMW3097	GMW3259	GMW15267	GMW16880
GMW3172	GMW14082 (LU)	GMW15626	GMW17388
GMW3191	GMW14573	GMW15760	

(LU) = This standard is limited to use only with Global A Electrical Architecture applications.

2.3 Additional References.

- AMP Specification 108-18597-1 and AMP Drawing 208-15592, code 1, (available from TE Connectivity AMP website; www.te.com/usa-en/home.html).
- Amphenol, Tyco, and Yazaki products available via TE Connectivity, www.te.com/usa-en/home.html.
- CG3796 Connector and Terminal Design Requirements. (ID)
- China Compulsory Compliance.

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- Component Technical Specification (CTS)
- Design Failure Mode and Effects Analysis (DFMEA).
- Design for Manufacturing/Assembly (DFMA).
- Design Guidelines and Knowledge Sets for Instrument Panel, Console, HVAC, Human Vehicle Interface, Squeak and Rattle, and other vehicle integration areas.
- Dimension Technical Specifications (DTS).
- Electromagnetic Compatibility (EMC) Component Test plan. The supplier shall work with GM Design Release Engineer (DRE) and EMC Subject Matter Expert to comprehend the EMC Test plan.
- GB5101
- GB5105
- GB7100
- GM Best Practices; HVACPTC-15, HVACPTC-16. The supplier shall work with the GM DRE to comprehend these requirements.
- GM LIN Questionnaire (provided in the Statement of Requirements (SOR) submission).
- GM Serial Data Test Results Template (part of SOR).
- GM Test Report Template (TRT)/Checklist (provide by GM Buyer).
- GM1829 Analysis/Development/Validation (ADV) Plan and Report Form.
- Human Factors Design Objectives.
- IHS Markit, <https://ihsmarkit.com/index.html>.
- Key Characteristic Designation System Process
- LIN conformance testing process.
- LIN Protocol Specification, version 2.0 or later, available at www.lin-subbus.org.
- Master Process Document (MPD).
- Node Configuration File (NCF).
- Owner's Manual.
- Process Failure Mode and Effects Analysis (PFMEA).
- Production Part Approval Process (PPAP).
- Service Manual.
- Serviceability Design Best Practices. The supplier shall work with the GM DRE to comprehend this requirement.
- SOR Appendices (including, but not limited to) C1, G2, and Q.
- Subsystem Technical Specification (SSTS).
- USCAR drawing EWCAP-001.

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3 Requirements

3.1 System/Subsystem/Component/Part Definition.

3.1.1 Appearance. Not applicable.

3.1.2 Content.

3.1.2.1 Physical Content. Not applicable.

3.1.2.2 Functional Content.

3.1.2.2.1 Premium Pulse Width Modulation (PWM)/LIN AEH. The ECU converts the input signal (provided by external control unit) into a "PWM-out" or into a "LIN percentage out" signal to drive each single heating circuit.

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3.1.2.2.2 Switchable AEH. The ECU converts the Input signal (provided by external control unit) into an output signal to drive the 1/3 or 2/3 or 3/3 heating circuit.

3.1.2.2.3 Control Algorithm.

3.1.2.2.3.1 Premium PWM AEH. The AEH can only run, if all of the following conditions are fulfilled:

- The KL15 is active, meaning the vehicle is in ignition-on condition.
- The PWM signal is > 14% and < 95% (control, e.g., HVAC-Silverbox needs to ensure that PWM commanded value is within this range).

3.1.2.2.3.2 Premium LIN AEH. The AEH shall be able to turn **ON**, without providing any heating, if all of the following conditions are fulfilled:

- The KL15 is active, meaning the vehicle in in ignition-on condition.
- The Ground (GND) is connected.
- The heater receives the "Air-Side Electric Heater Module Operation Enabled Command Front" equal to "Heater Operation Enabled (\$1)" from the LIN Master.

The LIN AEH shall provide heating, only when the previously listed conditions to turn the AEH **ON** have been fulfilled and when the LIN AEH receives the "Air-Side Electric Heater Percent Power Command Front" that is $\geq 1\%$ from the LIN Master.

The LIN AEH shall be able to receive the "Air-Side Electric Heater Percent Power Command Front" and the "Air-Side Electric Heater Module Operation Enable Command Front" from the LIN Master, as defined in 3.2.5.7.

3.1.2.2.3.3 Switchable AEH. The AEH can only run, if all of the following conditions are fulfilled:

- Input 1 or 2 at low level.
- Voltage Reference (V ref) is active.

3.1.2.2.4 PWM Slope for Premium AEH.

- To avoid sharp pulse loads and high inrush currents, the power of the PWM AEH is increased/decreased with a ramp rate of 15%/s and the power of LIN AEH is increased/decreased with a ramp rate of 10%/s.
- In case of failure recognition (e.g., under/over-voltage, over-temperature), the power is reduced to 0% with a ramp rate of 50%/s.

3.1.2.2.5 Transfer Function for Premium PWM AEH. Table 1 and Figure 2 define the transfer function for the premium PWM driven PTC heater.

Table 1: PWM AEH Transfer Function

Duty Cycle Signal	PTC Heater Performance
0% to < 14%	PTC OFF
14% to < 90%	PTC Provide Heating Function
90% to < 95%	PTC Guaranteed Maximum Heating Function
95% to 100%	PTC OFF
Control Signal Open Circuit	PTC OFF
Control Signal Battery Plus	PTC OFF
Control Signal Ground	PTC OFF
Frequency Range	150 Hz $\pm$ 10 Hz

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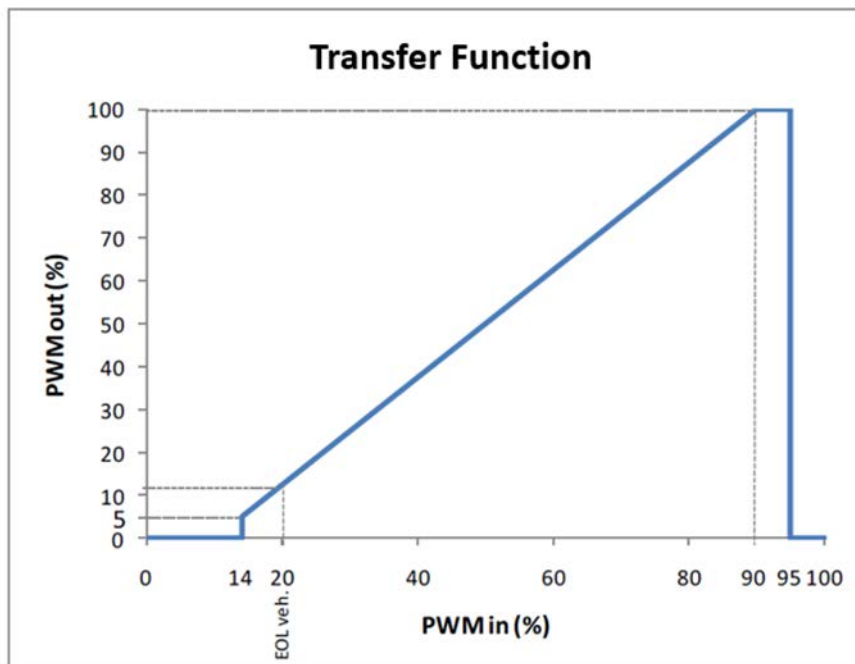
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Figure 2: PWM AEH Transfer Function



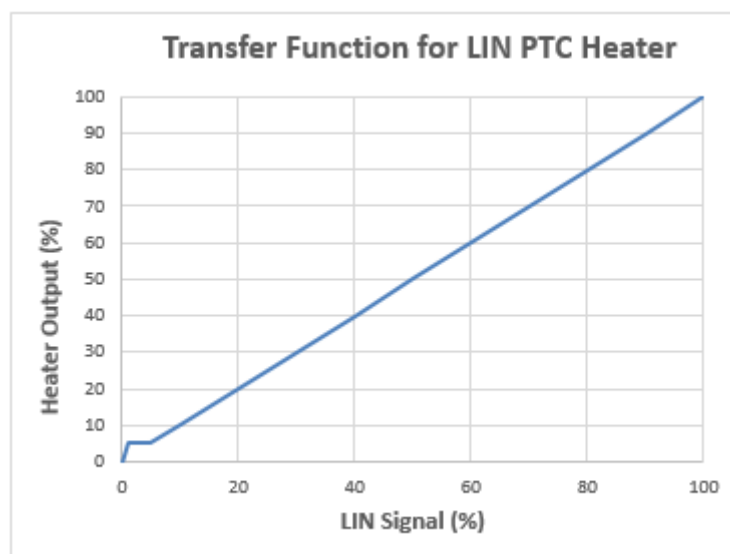
Note: Tolerance of Pulse Width Modulation input (PWMin): $\pm 2\%$.

Note: EOL = End of Line, PWMin = Pulse Width Modulation input, PWMout = Pulse Width Modulation output, Veh. = Vehicle.

3.1.2.2.6 Transfer Function for Premium LIN AEH. Figure 3 shows the transfer function for the premium LIN driven AEH.

- Power output = 0% for a demand power input of 0%.
- Power output = 5% for a demand power input from 1% to 5%.
- Power output is equal to demand power input from 5% to 100%.

Figure 3: Transfer Function for LIN PTC Heater



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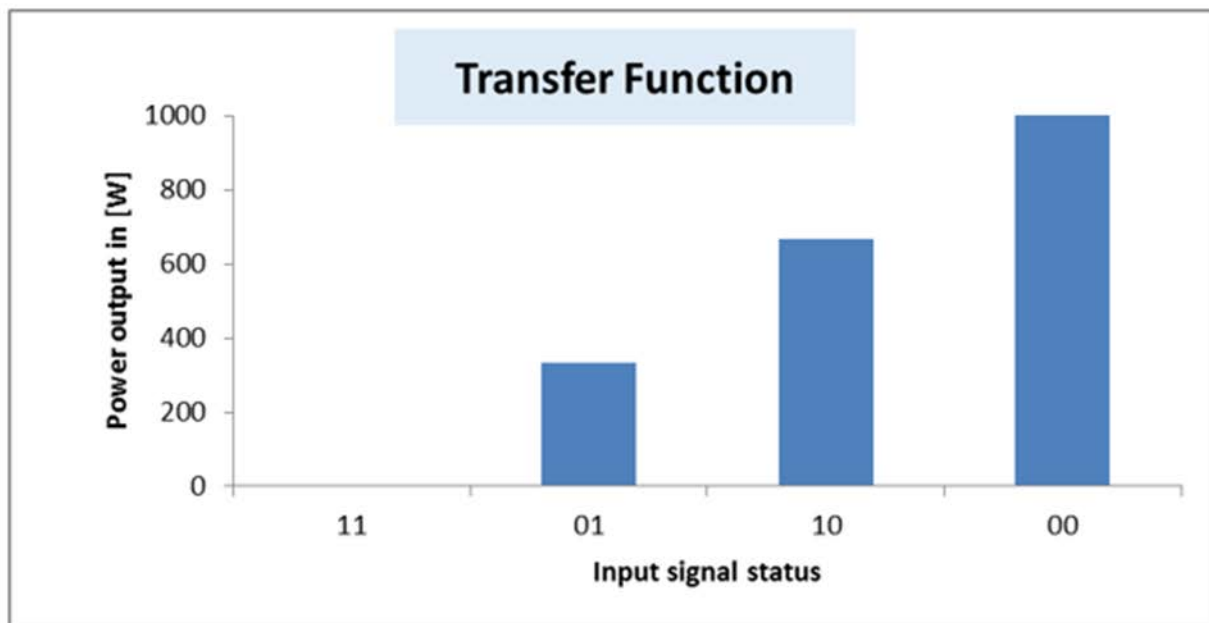
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3.1.2.2.7 Transfer Function for Switchable AEH. Table 2 and Figure 4 show the transfer function for the switchable PTC heater.

Table 2: Transfer Function for Switchable AEH

Input Signal	PTC Heater Performance
Input Level High	PTC OFF
Input 1 or 2 Level Low	PTC Provide Heating Function
Input 1 and 2 Low Level	PTC Guaranteed Maximum Heating Function
Control Signal Open Circuit	PTC OFF
Control Signal Battery Plus	PTC OFF

Figure 4: Transfer Function for Switchable AEH



3.1.3 Ambient Environment.

- The AEH shall be operational in temperature range of (-40 to 85) °C.

3.1.4 Interfaces.

3.1.4.1 Mounting.

- The AEH is mounted at the interface between the vehicle interior and HVAC module. The heat sink is inside of the HVAC module and therefore in the main air flow.
- Insufficient air cooling will lead to reduced operating range and activate the over-temperature shut down.
- Placement of AEH in the HVAC:
 - The heatsink must be located in the main airflow for cooling.
 - Overall length in airflow:
 - Long version: 200 mm minimum.
 - Short version: 180 mm minimum.

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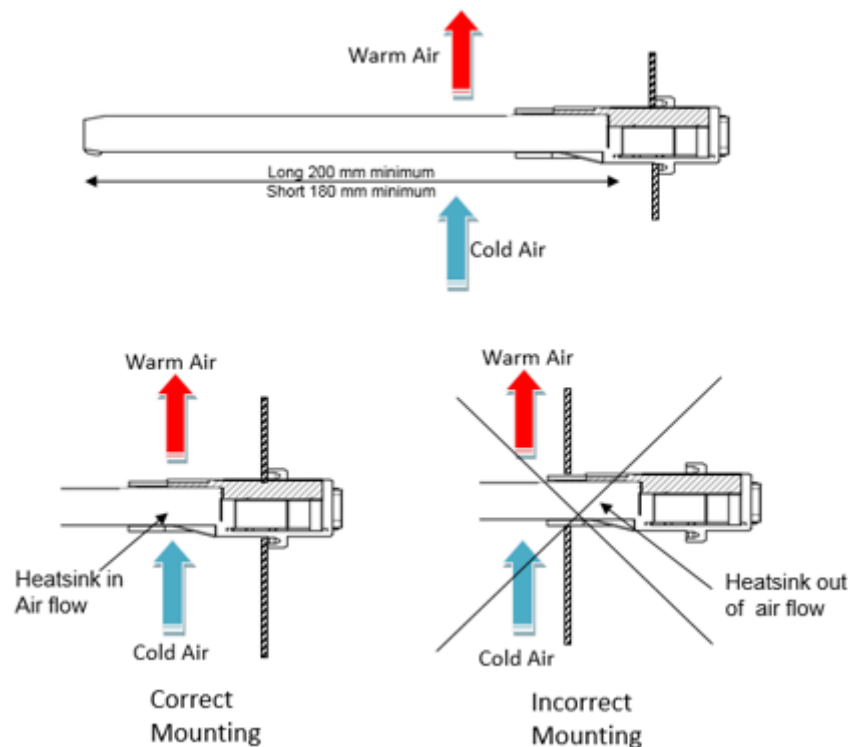
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3. A restriction of airflow on the heatsink must be first submitted and evaluated by GM Component Engineering.
4. Figure 5 shows a typical installation/mounting of the PTC heater in the HVAC module.

Figure 5: Mounting of PTC Heater in the HVAC



3.1.4.2 HVAC Interface Requirement.

3.1.4.2.1 HVAC Front Interface.

- a. Fixing in end position using two (2) fixing eyes diameter 5.5 mm, as shown in Figure 6.
- b. Tongue and groove design according to GM Three-Dimensional (3D) and Two-Dimensional (2D) drawing as shown in Figure 7.

3.1.4.2.2 HVAC Rear Interface.

- a. Rib design of rear case in HVAC to be matched with PTC heater to have an interference between HVAC module and PTC heater as shown in Figures 8, 9 and 10.
 1. Two (2) ribs are located on the PTC heater top side as shown in Figure 9.
 2. One (1) rib is located on the HVAC module to support the bottom side of PTC heater as shown in Figure 10. This rib must be located in the middle of the rear case. The distance from the side of the case to the rib must be $61.9 \text{ mm} \pm 0.1 \text{ mm}$, as shown in Figure 10.

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Figure 6: Fixing Eye Positions for Front HVAC Interface

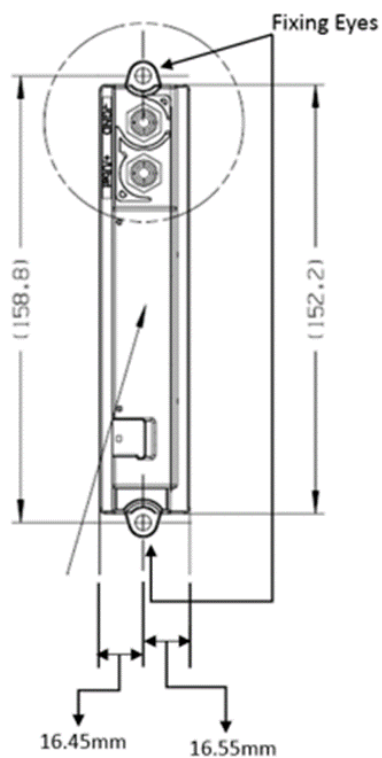
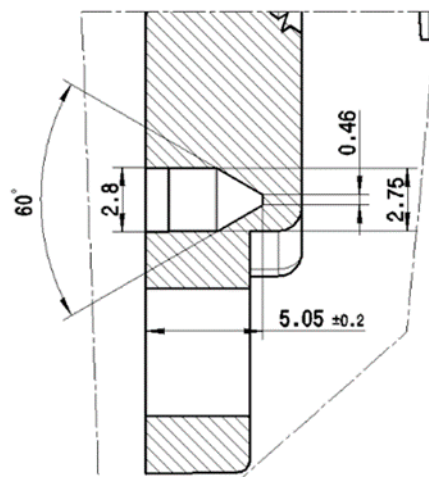


Figure 7: Tongue and Groove Design



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Figure 8: Rear HVAC Interface

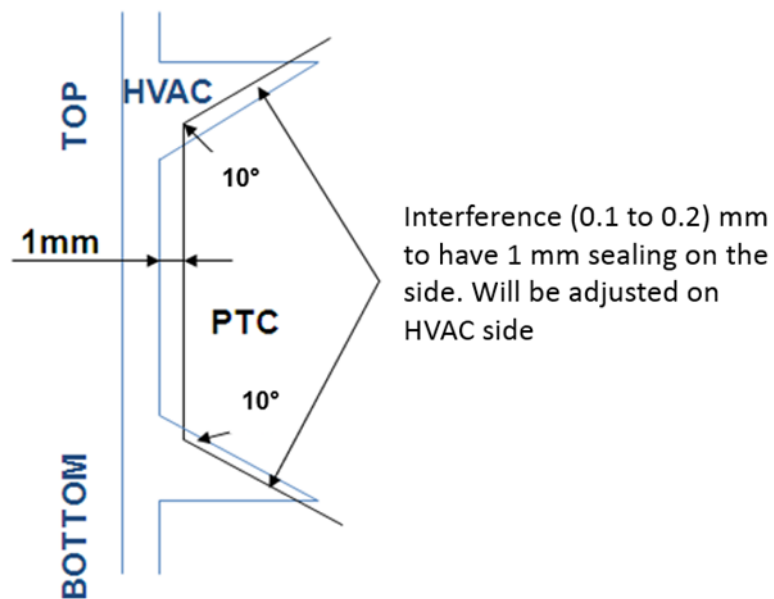
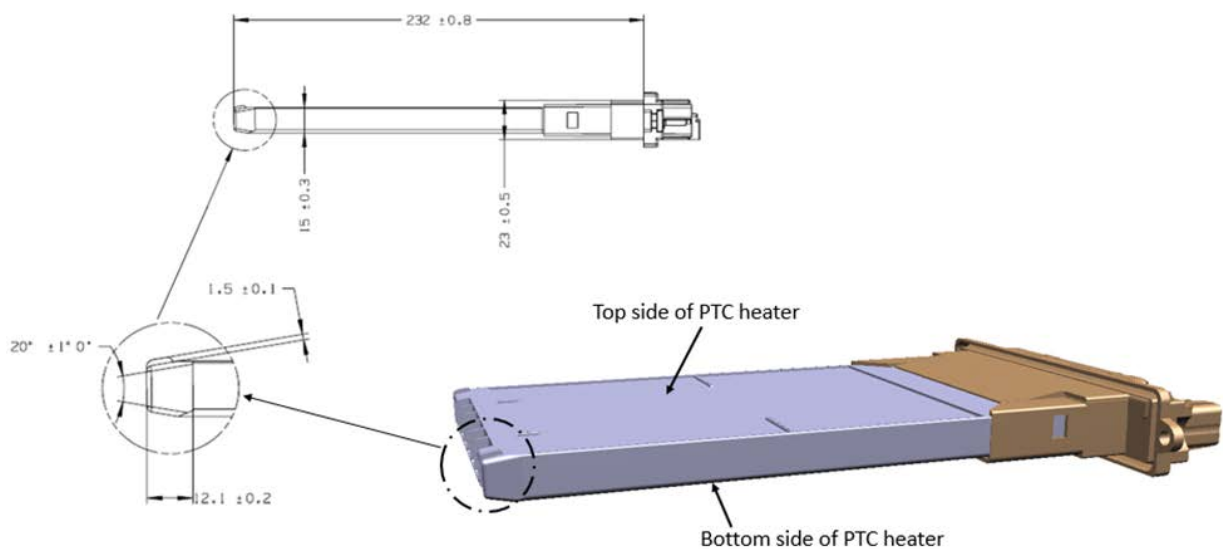


Figure 9: Rib Design for Rear HVAC Interface



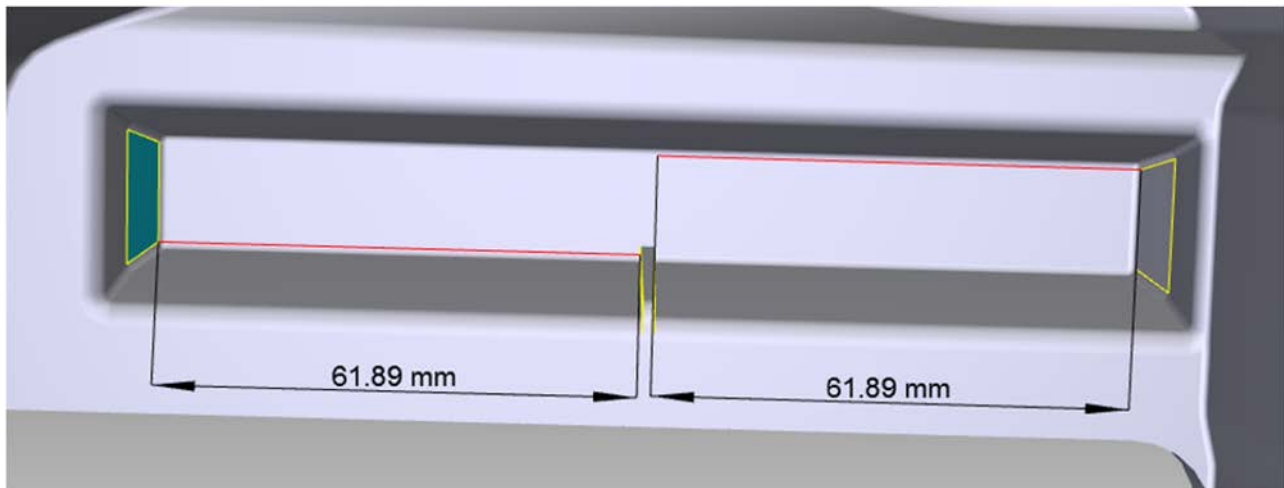
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Figure 10: Rib Location on HVAC, Supporting Bottom Side of PTC Heater



3.1.4.3 Connector Requirements. The connectors shall be designed and validated per USCAR12 (Revision 3) and GMW3191.

3.1.4.3.1 Power Connector on the 1.0 KW Premium PWM AEH-Side (Male):

- KL31/KL30: Amphenol 3.6 mm quick connector part number 13595022.

Note: At least the KL30 (Permanent + Battery) power connection must be fully covered and isolated. This system requirement must be done in HVAC module or cockpit assembly after assembly of the power wire harness.

3.1.4.3.2 Power Connector on the 1.0 KW Premium LIN AEH-Side (Male):

- KL31/KL30: Amphenol 3.6 mm quick connector part number 13595022.

Note: At least the KL30 (Permanent + Battery) power connection must be fully covered and isolated. This system requirement must be done in HVAC module or cockpit assembly after assembly of the power wire harness.

3.1.4.3.3 Power Connector on the 1.0 KW Switchable AEH-Side (Male):

- KL31/KL30: Amphenol 3.6 mm quick connector part number 13595022.

Note: At least the KL30 (Permanent + Battery) power connection must be fully covered and isolated. This system requirement must be done in HVAC module or cockpit assembly after assembly of the power wire harness.

Note: All 1.0 KW PTC heaters sourced for new programs shall have the Amphenol 3.6 mm quick connector.

3.1.4.3.4 Power Connector on the 1.5 KW premium LIN/PWM AEH-Side (Male):

- KL31/KL30: Yazaki 2P 9.5 connector part number 7288-8751-30, with 16 mm silver coated terminals.

Note: At least the KL30 (Permanent + Battery) power connection must be fully covered and isolated. This system requirement must be done in HVAC module or cockpit assembly after assembly of the power wire harness.

3.1.4.3.5 Signal Mating Connector-Housing on the Wiring Harness (Female):

- Tyco C 13510940 (connector housing).
- Per AMP Specification 108-18597-1 and AMP Drawing 208-15592, code 1.

3.2.4.3.6 Signal Connector on the Premium PWM AEH-Side (Male):

- 4-PIN connector TE Connectivity part number C 208 15592 Coding A. Table 3 shows the PIN configuration of the signal connector for the PWM AEH.

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Table 3: PIN Configuration for Signal Connector on PWM AEH

PIN	Name	Type	Terminal
1	PWM	Signal	Male terminal
2	KL15	Signal	Male terminal
3	Not applicable	Not applicable	Not connected, no terminal fitted
4	Not applicable	Not applicable	Not connected, no terminal fitted

3.1.4.3.7 Signal Connector on the Premium LIN AEH-Side (Male):

- 4-PIN connector Tyco part number C 208 15592 Coding A. Table 4 shows the PIN configuration of the signal connector for the LIN AEH.

Table 4: PIN Configuration for Signal Connector on LIN AEH

PIN	Name	Type	Terminal
1	Not applicable	Not applicable	Not connected, no terminal fitted
2	KL15	Signal	Male terminal
3	LIN	Signal	Male terminal
4	GND	Signal	Male terminal

3.1.4.3.8 Signal Connector on the Switchable AEH-Side (Male):

- 4-Pin connector Tyco part number C 208 15592 Coding A. Table 5 shows the PIN configuration of the signal connector for the Switchable AEH.

Table 5: PIN Configuration for Signal Connector on Switchable AEH

PIN	Name	Type	Terminal
1	Stage 1	Signal	Male terminal
2	Stage 2 and 3	Signal	Male terminal
3	Not applicable	Not applicable	Not connected, no terminal fitted
4	V ref	Signal	Male terminal

3.1.4.4 Connector System Requirements. The application of the connector system is subjected to the conditions defined by the USCAR12 (Revision 3).

Note: Special focus must be paid to following conditions:

- Fixation of the harness on the HVAC-module or vehicle to avoid failures caused by vibrations.
- Minimum allowed radius for bending wires.
- Number of connector insertion repetitions.
- Environmental condition for the connector system.
- Temperature/current limits of the connector system.

3.1.4.4.1 Connector Terminal Coating Requirements.

- All connectors must be Silver plated per USCAR drawing EWCAP-001 specifications. Any deviation to this requirement must be approved by GM.

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3.1.4.4.2 Integrated Pigtail Requirements.

- Pigtails must comply with GMW15626 and SOR Appendix C1.
- Crimped connection must meet USCAR21 for crimp specification and pull force.
- Pigtail wires must have strain relief mechanism as it exits the PTC heater.
- Pigtail wires must have a "D" level anti abrasion protection, as defined in SOR Appendix C1, at a minimum.
- Pigtail must comply with ISO 6722.

3.1.4.5 Power Connection Requirements for M6 Connector.

Note: This is **not the preferred** solution and the information here is provided only from a lessons learned/reference purpose.

Installation requirements for installing pigtail to the PTC heater using M6 nut:

- When installing the pigtail to the PTC heater using M6 nut, the nut must be tightened to the appropriate torque listed on the PTC heater drawing, by using an electronic torque ranch that has displacement, torque and angle control. A record of the applied torque must be kept. Nut must be installed on the stud using a single screwing operation. Loctite must be applied to prevent any loosening of the nut/harness assembly.
- If there is an anti-rotation feature on the nut/flange then care must be taken to make sure that the nut seats properly, i.e., without interfering with the anti-rotation feature of the flange before applying torque to tighten the nut.

3.1.5 Usage Definition. Not applicable.

3.2 Product Characteristics.**3.2.1 Performance Requirements.**

3.2.1.1 Performance Premium AEH. The AEH shall meet the operating conditions shown in Table 6.

Table 6: Operating Condition for the Premium AEH

Parameter	Values	Test Conditions		
		Q _{air} (kg/h)	T _{air} (°C)	T _{out} (°C)
P _{cont} @ U _n	1000 W ± 10%	300 ± 5	0	-
U _n	13 V ± 0.1 V	-	-	-
U _{min-H}	9 V	-	-	-
U _{max-H}	16 V	-	-	-
I _{PTC continuous} @ U _n	77 A ± 10%	300 ± 5	0	-
I _{max worst case}	95 A	-	-	-
ΔP	45 Pa ± 10%	300 ± 5	23 ± 5	-
T _{PTC}	163 °C	-	-	-
T _{cont}	≤ 90 °C	0	-	-
T _{SF}	≤ 155 °C	0	-	-
T _{FIX}	≤ 100 °C	0	-	-
M	410 g (Target)	-	-	-

Note: @ = at, ΔP = Pressure Drop.

3.2.1.1.1 The premium AEH shall incorporate the following functions:

- Battery voltage measurement and under/overvoltage heating limitation.

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- Heating regulation via PWM output to integrated heating elements.
- Input signal (PWM or LIN).
- Maximum current limitation.
- Open load protection.
- Reverse voltage protection.
- Short circuit protection.
- Supports direct battery connection.
- Temperature limitation.

3.2.1.2 Performance Switchable AEH. The AEH shall meet the operating conditions shown in Table 7.

Table 7: Operating Condition for the Switchable AEH

Parameter	Values	Test Conditions		
		Q_{air} (kg/h)	T_{air} (°C)	T_{out} (°C)
$P_{cont} @ U_n$	1000 W $\pm$ 10%	300 $\pm$ 5	0	-
U_n	13 V $\pm$ 0.1 V	-	-	-
U_{min}	6 V	-	-	-
U_{max}	27 V	-	-	-
$I_{PTC \text{ continuous}} @ U_n$	77 A $\pm$ 10%	300 $\pm$ 5	0	-
$I_{max \text{ worst case}}$	105 A	-	-	-
ΔP	45 Pa $\pm$ 10%	300 $\pm$ 5	23 $\pm$ 5	-
T_{PTC}	163 °C	-	-	-
T_{cont}	$\leq$ 90 °C	0	-	-
T_{SF}	$\leq$ 155 °C	0	-	-
T_{FIX}	$\leq$ 100 °C	0	-	-
M	410 g (Target)	-	-	-

3.2.1.3 Performance of 1.5 KW Premium AEH. The 1.5 KW AEH shall meet the operating conditions shown in Table 8.

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