



HVAC BLDC Blower Motor Assembly

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 standard establishes the component performance, design, test, manufacture and acceptance requirements for a fractional horsepower, electrically commutated, Brushless Direct Current (BLDC) Heating Ventilation Air Conditioning (HVAC) blower motor assembly (blower motor, blower controller, mounting method, and fan). The blower motor supplied to this specification shall meet all requirements defined herein unless specifically waived in writing by the GM Lead Engineer. Components that do not meet the requirements specified herein are subject to rejection. This document specifies minimum requirements; the motor supplier shall perform any additional testing or more stringent testing that the supplier feels is necessary to meet all requirements and ensure a high quality component.

1.2 Applicability. All GM HVAC brushless blower motors.

1.3 Remarks. This blower motor generates air flow for an automotive HVAC module.

1.4 Terminology. Figure 1 as follows explains the terminology of blower motor components in this specification.

- The term "controller" shall mean the blower motor circuit board, hereby included within the term "motor".
- The term "motor only" shall mean the motor without the flange/holder and without the fan.
- The term "motor assembly" shall mean the motor with the flange/holder but without the fan.
- The term "blower assembly" shall mean the motor with the flange/holder and the fan installed.
- The term "scroll" shall mean the plastic housing surrounding the blower assembly that directs airflow from the blower assembly.
- The term "HVAC" or "HVAC module" shall mean the full HVAC assembly including the blower assembly, scroll, heat exchangers, doors, etc.

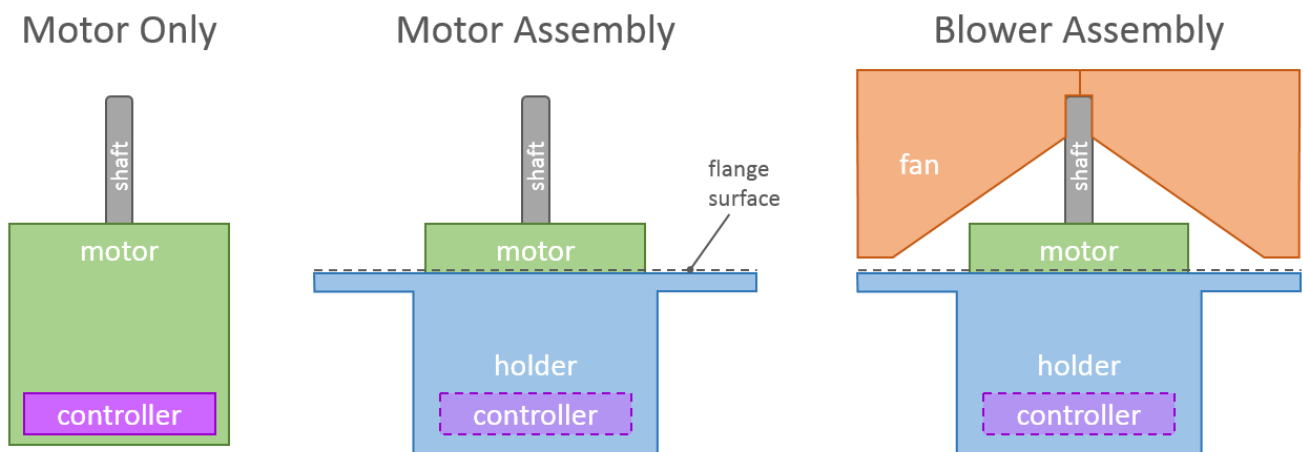


Figure 1: Blower Motor Terminology

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2 References

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

2.1 External Standards/Specifications.

FMVSS 302	SAE J1344	SAE J1351
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2.2 GM Standards/Specifications.

GMW3059	GMW3172	GMW14264	GMW15635
GMW3097	GMW3191	GMW14482	GMW15760
GMW3103	GMW3235	GMW14780	GMW16044
GMW3116	GMW8464	GMW15634	GMW17625

2.3 Additional References.

- CG2069 Brushed Blower Motor Analysis/Development/Validation Plan and Report (ADVP&R)
- CG4927 OBD-II Supplier Assessment Sheet
- General Motors (GM) OBD Smart Device Best Practices. The supplier shall work with the GM Design Responsible Engineer to comprehend this requirement.
- GM part number 13511335
- Statement of Requirements (SOR)
- Validation Cross Reference Index (VCRI)

3 Requirements

Note: The blower motor will meet or exceed all requirements stated in this standard. If a supplier has any concerns about meeting any of the requirements as stated herein, the supplier must note those concerns in all quotes or proposals to GM. All exceptions to the content of this standard must be clearly stated, in bold print, at the front of the quote or proposal, and must reference the exact section number of the exception. Design Failure Mode and Effects Analysis (DFMEA) will be baselined for sourced Program and any subsequent changes to the design Fit, Form, or Function will be appropriately communicated to the downstream customer(s).

3.1 Physical Requirements.

3.1.1 Color. All external surfaces visible after installation into the HVAC module (except part number label and screws) shall be black, unless approved by the GM blower motor Bill of Material Functional Owner (BFO).

3.1.2 Materials.

3.1.2.1 Materials must comply with GMW3059 – GM Material Requirements, GMW15634, and GMW15635.

3.1.2.2 Supplier is responsible for designing recyclable and recoverable parts using GMW3116.

3.1.2.3 Materials used in motor(s) shall meet specifications per GMW3235 - B - T1 – 2 mg maximum.

3.1.2.4 Motor assembly must be lead-free.

3.1.2.5 Motor assembly must not use rare earth materials unless specifically disclosed to and approved by GM.

3.1.3 Label Requirements. Basic label requirements shall include part number, serial number, manufacture date, and country of origin via a one-dimensional barcode, two-dimensional barcode, or QR code. GM recommends to use a QR code including the part number, serial number, and the motor speed and current measured by the End of Line (EOL) tester.

3.1.3.1 Traceability. Motors and blower assemblies shall have traceability back to EOL testing based on the serial number, and be retained for a period of ten (10) years.

3.1.4 Marking of Plastic Parts. Plastic parts shall be marked per SAE J1344 to designate the type of material from which the part was fabricated. Where applicable, cavity number shall be marked.

3.1.5 Finish. Unless specifically defined on the engineering drawings, external surfaces of parts shall conform to good commercial practice (reasonably free of gates, flash, ridges, roughness, tool marks, and mold and tool lubricants and other contaminants).

3.1.6 Cleanliness. All parts and surfaces shall be free from dirt, oil, grease, scale, and other foreign materials that may detrimentally impact appearance, performance, durability, or assembly.

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3.1.7 Safe Handling. The blower assembly and its component parts must be free from flash, burrs or other surface conditions, which could prohibit safe handling of the product. Dropped components or assemblies shall be scrapped and not reworked.

3.1.8 Safe Fan Assembly. The fan press force and inclination angle must be measured and be within the supplier's specification when the fan is press fit to the motor shaft, to avoid bearing damage. If a press force is detected above the limit, the blower assembly must be scrapped on the line and not reworked. Minimum press force must also be detected to ensure the shaft was engaged during fan assembly to absorb the press force, rather than the motor's bearings.

3.2 Mechanical Requirements.

3.2.1 Mass. The mass of the blower assembly (including fan) shall be ≤ 1.20 kg.

3.2.2 Shaft/Fan Direction of Rotation. A marking should exist on the motor assembly to denote the clockwise or counterclockwise rotation.

3.2.3 Mounting to Scroll. The blower assembly shall be mounted into the HVAC module via a plastic holder. The interface options defined in Table 1 shall be used, which utilize a 3-point screw attachment with tongue and groove, unless a deviation is granted by the GM BFO.

Table 1: Common Holder Definition

Size	Open Area Diameter	Motor Rotation	3 Dimensional Data	2 Dimensional Drawing
Medium	157 mm	CCW	OPW81234/001.0006	D2XX, Diagram 157 Interface Groove
		CW	OPW81235/001.0002	D2XX, Diagram 157 Interface Tongue

CW Clockwise
CCW Counterclockwise

3.2.4 Motor Holder. The blower motor holder (not including the cooling tube, if applicable) design must:

- Prevent condensate inside the scroll inlet from dripping, penetrating, and/or otherwise coming in contact with the motor or its internal components. A wall of at least 10 mm should exist on the flange surface to avoid water from directly entering the motor.
- The holder must contain design elements (dams, shields, labyrinth, etc.) to keep condensate from contacting critical motor components. At least 10 mL of water should be able to enter the motor through the cooling channel and not contact the bearings, shaft, rotor, or other metallic parts.
- The holder must consider water paths that could directly drip water onto the blower's connector or wire harness. An example water path is water on the flange surface that enters the tongue and groove and drips out over the connector; such a water path should be prevented by including an umbrella feature over the connector so that water drips away from the connector and harness.
- The motor holder design may contain an air outlet (hole) to allow the shaft to be supported during fan assembly, but it is recommended to be covered by a sticker, label, or plastic cover to stop dust/debris/water/fingers from entering the hole, and also block some airborne noise from exiting the motor.

3.2.5 Fan-to-Shaft Interface. Motor shaft shall be round, and shall have a diameter between 8.003 mm and 8.009 mm, unless a deviation is granted by the GM blower motor BFO.

3.2.6 Blower Motor Fan. The blower motor fan must have a closed hub design with no openings and/or holes, and must not have a flat surface which could collect water/ice; at least a 3 degree slope must be used to drain water.

3.2.7 Blower Assembly Unbalance. All blower assemblies shall have a maximum unbalance specification of the total rotating assembly per Table 2 and shall be 100% measured during production.

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Table 2: Blower Motor and Fan Rotating Assembly Unbalance Requirement

Rotating Assembly	Per Plane Unbalance	Force/Static Unbalance	Couple/Dynamic Unbalance	Maximum Distance Between Planes
Blower Assembly	6 g-mm	4 g-mm	6 * (Fan Height) g-mm ²	75 mm

Notes:

The couple shall be calculated by multiplying the fan height in mm by 6 g-mm. For example, the maximum allowable couple for a 75 mm tall fan shall be 450 g-mm². A 60 mm tall fan shall be 360 g-mm².

The per plane, couple, and static unbalance of the HVAC blower motor and fan assembly must be measured on production intent balancing equipment with the blower motor powered at maximum vehicle operating speed (typically 13.0 Volt Direct Current (VDC) and 90% Pulse Width Modulation (PWM) duty cycle).

The balance machine shall fixture the blower assembly by the mounting tabs, to gain the best representation of vibration transferred to the HVAC module.

Any required balance correction should be made as close to the end planes of the fan as possible. Adding mass or material removal is allowable.

During development testing, the supplier shall avoid applying reflective tape to the fan, which can affect the balance level. It is recommended instead to apply a reflective paint pen mark before balance correction.

The blower fan base shall be defined as Correction Plane 1 and the blower fan top as Correction Plane 2. The defined Balance Reference Plane shall be at a point half way between the correction planes.

3.2.7.1 Balance Capability. The capability of meeting this requirement must be demonstrated using a statistical model, such as a Variation Simulation Model (VSM), accounting for variation of all components, processes, and dimensions influencing balance.

3.2.8 Motor Rotor Unbalance. Rotor unbalance shall be 100% controlled during production to support meeting the blower assembly requirements.

3.2.9 Motor Cooling. A blower motor cooling scheme which eliminates water entry into the motor is required. The cooling channel/tube opening should be located to achieve sufficient cool air and minimize water pick-up. The cooling channel/tube opening must not reside in a high condensate formation or flow area such as the floor of the HVAC scroll.

3.2.10 Connector Requirements. The blower motor shall use a connector housing that mates with Yazaki part number 7289-7139-30 (GM part number 13511335), per the dimensions and tolerances provided by Yazaki. This connector is the GM global standard for blower controllers, meets GMW3191, and utilizes a Connector Position Assurance (CPA). The recommended pin-out is shown in the following Figure 2 example, but any discrepancies are superceded by the application specific Interface Control Document (ICD).

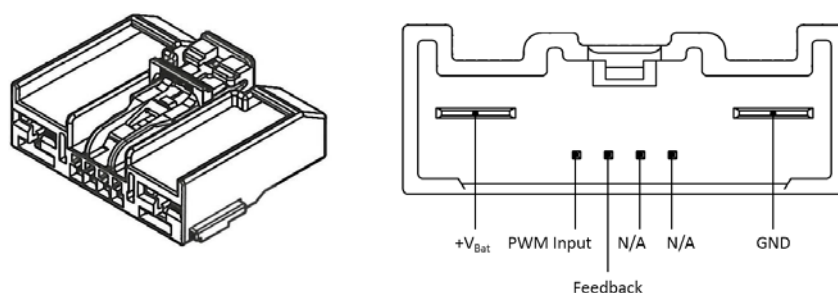


Figure 2: Connector Pin-Out Example

3.2.11 Bearing System. The blower motor shall use two (2) ball bearings. The motor supplier should measure vibration 100% during production to check for known failures, especially bearing damage. The requirements must be set specific to the supplier's motor.

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3.3 Environmental Requirements.

3.3.1 Environmental and Durability. The blower motor shall meet all requirements of GMW3172. Any deviation to GMW3172 shall be approved by the GM BFO.

3.3.2 Operating Temperature Range. The blower motor operating temperature range shall be -40 °C to +85 °C with full performance, and is allowed up to a 50% reduction in speed above +65 °C.

3.3.3 Storage Temperature Range. The blower motor storage temperature range shall be -40 °C to +105 °C.

3.3.4 Odor. Materials shall have an odor scale rating of three (3) or less when tested per SAE J1351 and GMW14780.

3.3.5 Fogging. Materials shall meet specifications per GMW3235 - B - T1 - 2 mg maximum.

3.3.6 Federal Motor Vehicle Safety Standard (FMVSS) 302. All components shall comply with FMVSS 302 where applicable.

3.4 Electrical Requirements.

3.4.1 Operating Voltage. The typical GM vehicle provides a constant battery voltage to the blower motor through a fuse, but typically not through a relay. The BLDC blower motor shall operate in a vehicle voltage range of 9.0 Volt Direct Current (VDC) to 16.0 VDC.

3.4.2 Blower Motor Load Point. The HVAC supplier shall use the HVAC restriction from GMW17625 to determine the worst case blower motor load point at 13.0 VDC, which should be documented on the blower motor drawing(s), and will be used in this specification hereby termed "load point". The load point shall consist of a voltage at the motor terminals, PWM input %, motor speed, and motor current. The load point should anticipate a 1 minute warm up at the rated load. The speed tolerance on the drawing must be at most ± 100 rpm. The current draw tolerance on the drawing must be at most ± 1 A. Nominal motor efficiency at the specified load point shall be $\geq 75\%$. The load point must be verified 100% during production at the rated load.

3.4.2.1 Blower Ramp Up Speed. The BLDC shall reach the blower motor load point in a sufficient time to satisfy the customer. From 0% duty, the BLDC shall ramp up and reach 95% of the load point speed within 5 s when the load point duty cycle is applied. For example, if the load point speed is 4000 rpm, the motor must reach 3800rpm within 5 s, and continue to converge to 4000 rpm.

3.4.3 Electrical Design Disclosure. The blower motor electrical operating points and their respective conditions must be supplied to and reviewed with GM BFO. The supplier shall send the following information to the GM BFO when Design Validation (DV) and Process Validation (PV) test reports are submitted:

- Plot - Blower Motor Operating Curve [Speed (rpm), Torque (N·m), Efficiency (%)].
- Nominal Operating Point - unless otherwise specified, 13.0 VDC, or specify if deviation.
- Motor Stall Condition - [Current (A) and Torque (N·m)].
- Maximum Motor Velocity under No-Load Condition (rpm).
- Surge Current Peak - Peak Current (A), Time to Peak (ms) @ -40 °C, 25 °C, and 85 °C.
- Capacitance (μ F).

3.4.4 Interfaces. Supplier to provide all applicable interfaces to complete application specific Interface Control Document (ICD), at a minimum the maximum power, connector pinout, and all electrical circuits.

3.4.4.1 Speed Control. The BLDC rotational speed shall be controlled by the HVAC ECU via Pulse Width Modulated (PWM). This is typically sent as a low active 35 Hz $\pm 5\%$ PWM signal. The generic diagram of electrical interface is shown in Figure 3, but is superseded by the application specific ICD.

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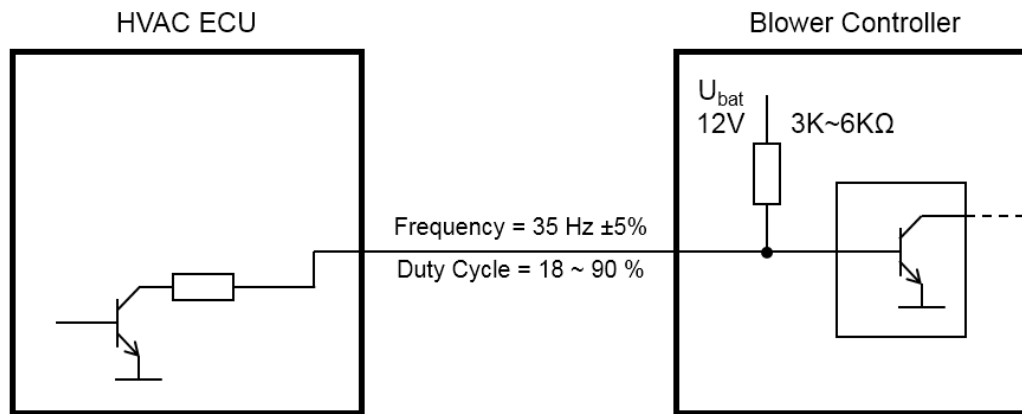


Figure 3: Generic Diagram of Electrical Interface

3.4.4.2 Transfer Function. The speed control function of the BLDC motor shall have a positive slope transfer function input (PWM input, percentage on X-axis and Speed, revolutions per minute (rpm) on Y-axis) with indeterminate ranges defined at both the minimum and maximum PWM input duty cycle ranges. See Figure 4. The blower motor speed control needs to follow without delay for blower speed up and down the blower control request from the HVAC ECU. The maximum tolerance of this curve shall be ± 100 rpm at a given PWM %.

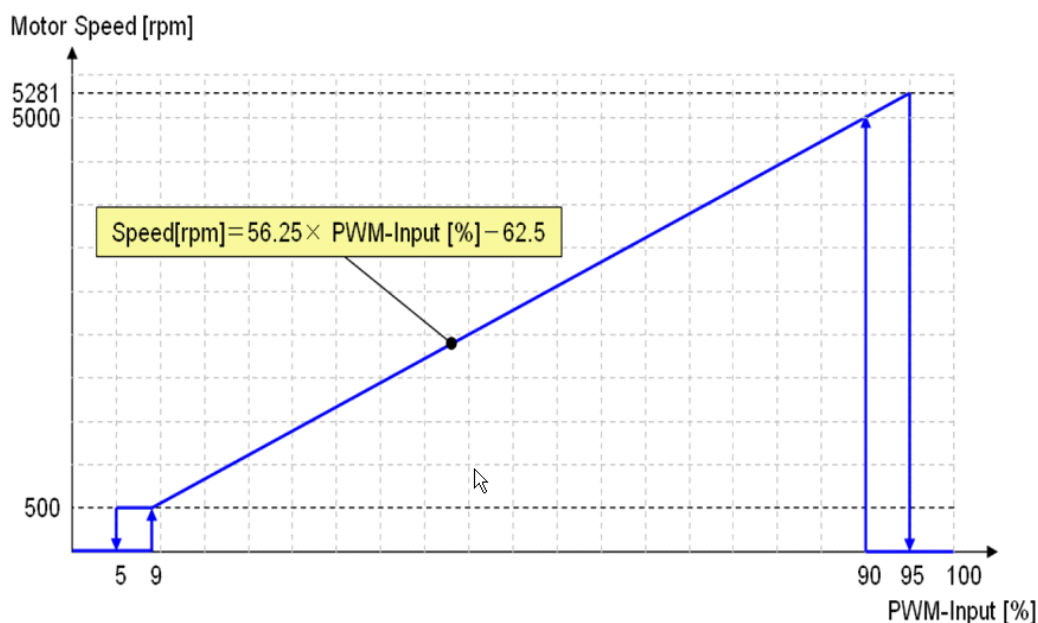


Figure 4: Transfer Function Definition

3.4.4.3 Diagnostic Output Requirements. The BLDC shall send diagnostic speed feedback to the HVAC ECU per the following requirements.

3.4.4.3.1 Onboard Diagnostics (OBD)-II Smart Device Supplier Assessment. The supplier shall complete CG4927, OBD-II Smart Device Supplier Assessment, and have approval by the GM OBD-II team 15 weeks prior to DV Design Freeze. The assessment shall be used by General Motors BFO/DRE and OBD team to evaluate the Smart Device design for compliance with General Motors (GM) OBD Smart Device Best Practices and OBD regulations (the supplier shall work with the GM Design Responsible Engineer to comprehend this requirement). The assessment requires a comprehensive review of all potential Smart Device failure modes (software and

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hardware) to insure component failures are justified and visible to the host controller. The GM OBD and Controls teams shall insure appropriate actions are taken by the host controller based on the assessment.

3.4.4.3.2 Microprocessor. The controller shall use a programmable microprocessor, rather than a fixed ASIC. The microprocessor may not be field re-flashable.

3.4.4.3.3 Output Circuit. The diagnostic feedback circuit shall meet the following:

- Field-Effect Transistor (FET) designs: Circuit resistance $\leq 543 \Omega$
- BJT designs: Circuit resistance $\leq 236 \Omega$

3.4.4.3.4 Output Signal. The diagnostic feedback signal shall be a PWM signal at varying frequencies per the following requirements:

- PWM at 50% $\pm$ 4% duty cycle, low active.
- Speed [rpm] = (Frequency [Hz] – 50) * 30; per Figure 5.
- The frequency output shall be accurate to within the equivalent of ± 100 rpm of actual motor speed.
- The motor speed shall be constantly output with ≤ 2 s of measurement and/or filtering.
- The output shall remain accurate during limp modes (over temperature/current), and protection modes where the motor speed is 0 rpm (locked rotor, over/under voltage).

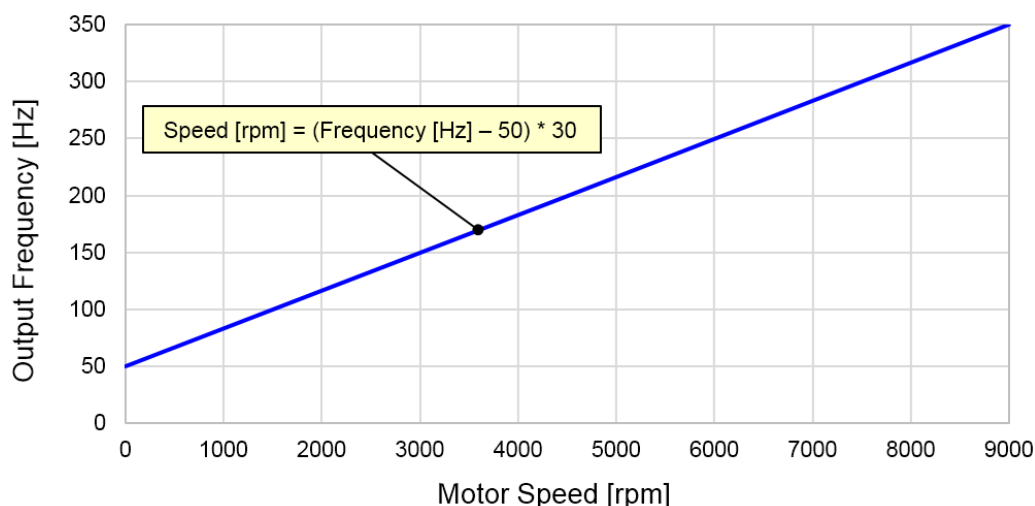


Figure 5: Diagnostic Output Definition

3.4.5 Protection Features. The BLDC shall provide the following protection features. The supplier shall submit the logic diagrams for each protection feature to the GM BFO prior to the start of component DV testing.

3.4.5.1 Under/Over-Voltage Protection. The BLDC shall provide under/over-voltage protection, including hysteresis, which remains outside of the operating voltage range.

3.4.5.2 Over-Current Protection. The BLDC shall provide over-current protection. In the vehicle application, the BLDC shall operate below the required current limit value. Activation of over-current protection caused through an overload condition shall result in the BLDC operation being limited (clamped) at or below the current limit value. This will result in a constant operating point until the cause for the over-current is eliminated or the thermal protection is activated.

3.4.5.3 Thermal Protection. The BLDC shall provide over-temperature protection. Activation of thermal protection is allowed dependent on the ambient temperature ranges as follows:

- **From -40 °C to 65 °C:** Thermal protection shall not occur under normal operating conditions. This includes operating at the maximum blower motor load point, at all voltage ranges.
- **From 65 °C to 85 °C:** Thermal limp mode is allowed to reduce the motor output to as low as 50% of the blower motor load point output power. GM recommends to linearly reduce motor speed to the lowest limp

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