



150 Watt Modified Sine Wave DC-AC Power Inverter without Ground Fault Circuit Interrupter (GFCI)

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 Scope. This standard describes content, functional requirements, performance standards and component package for a 150 W Modified Sine Wave DC-AC Power Inverter.

This specification outlines the design, performance, appearance, and validation requirements for a 150 W Modified Sine Wave DC-AC Power Inverter. This assembly shall allow the user to power devices up to 150 W in 120 V_{AC} at 60 Hz or 225 V_{AC} at 50 Hz appliances. This assembly shall consist of the power inverter and attachment provisions. Unless otherwise specified, requirements described herein shall apply to the power inverter assembly using production intent connectors and hardware.

1.2 Mission/Theme. The GM Worldwide corporate common component 150 W Modified Sine Wave DC-AC Power Inverter is intended to provide the user with AC output power as a convenience feature. The assembly shall contain the ability to provide sufficient AC power for 150 W and lower devices. The power inverter will have an output of 125 V_{AC} at 60 Hz or 225 V_{AC} at 50 Hz depending on regional requirements.

This document provides specifications for the 150 W Modified Sine Wave DC-AC Power Inverter, in the areas of performance, reliability and customer perception.

1.3 Classification. The following is a specific classification of the assembly described in this document.

The 150 W Modified Sine Wave DC-AC Power Inverter will contain one each of the following:

- Inverter Module
- Attachment Provision

1.3.1 Limitations. This standard should not prevent the manufacturer from suggesting alternative approaches which would result in an improved or a more cost effective product. The manufacturer is encouraged to pursue such changes with the appropriate GM Design Release Engineer and Purchasing Agent.

It should be noted that the tests described herein generally produce stresses in excess of those found under normal customer usage. They are designed to provide an evaluation of product performance and durability in a time span considerably less than the expected life of the product. Furthermore, severe stresses are often applied to identify product design limits to ensure a significant margin of safety. Therefore, interpretation of these results must be made with care. Failure of any such test does not imply a likelihood of failure in the field.

2 References

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

2.1 External Standards/Specifications.

ISO 1431-1

2.2 GM Standards/Specifications.

GMW3059

GMW3172

GMW8739

GMW3097

GMW3191

GMW14082

GMW3116

GMW3232

GMW14334

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3 Requirements

The following sections describe in detail the specific functional, physical and electrical capabilities required to satisfy this specification

3.1 System/Subsystem/Component/Part Definition. The DC-AC Inverter, which is mounted in the interior compartment or trunk, shall be used to provide AC output power for AC appliances.

3.1.1 Appearance. The inverter appearance shall reflect quality design and shall not have scratches, cracks, nicks, sink marks, knit lines, blisters or other abnormalities reflecting poor workmanship.

3.1.2 Content. The required physical and functional content for the assembly is the described in the following paragraphs.

3.1.2.1 Physical Content. The inverter assembly packaging and dimensional requirements shall be specified in the packaging drawing and 3D math data.

3.1.2.1.1 Inverter Assembly. The inverter assembly contains the DC to AC power control electronics, integral connector(s) (for DC input, AC output and remote power switch) and heat dissipation packaging.

3.1.2.1.2 Inter-Connect. The inverter assembly shall have connectors integral to the respective package. The supplier and General Motors Corporation shall jointly agree upon a suitable connection system. Connection interfaces shall comply with GMW3191 and GMW3172. Pin-outs shall be specified on the released product drawing. Pin-outs cannot be changed without written authorization of GM Engineering.

3.1.2.2 Functional Content. The AC Inverter Assembly shall be used to operate the functions stated below.

3.1.2.2.1 Inverter Function Overview. The inverter assembly shall provide the following features:

3.1.2.2.1.1 AC Loads. The inverter shall be capable of continuously powering AC loads that require power within 150 W and providing necessary surge power, as described in paragraph 3.2.1.4 "Surge Power", to start such loads.

3.1.2.2.1.2 Output Signal Characteristics. The inverter shall output a modified sine wave AC output.

3.1.2.2.1.3 Remote Control. The inverter shall provide a safety feature to allow for an external activate signal (separate from DC input power) to allow start up and shut down from an input vehicle ignition status.

An AC control switch shall be considered to activate the inverter AC output power function. More details are described in paragraph 3.1.2.2.2 Electrical Mechanization.

3.1.2.2.1.4 Input Voltage Range. The inverter shall incorporate the following user and device protections via electronic control that interrupts AC output power under the following circumstances:

- a) Over load of inverter output via short circuit or from AC appliance;
- b) Over voltage of DC input beyond 18.0 V_{DC}
- c) Over voltage of DC input beyond 16.0 V_{DC}
- d) Under voltage of DC input below 11.0 V_{DC}.

The restart shall be possible only upon fault removal.

For faults described in items a, and b the restart can be manual, cycling of Activate Signal by AC control switch described in paragraph 3.1.2.2.2 "Electrical Mechanization".

For fault described in item c, and d restart type is always automatic regardless of Fault duration.

Table 1: The Restart Types of Low Input and High Input Voltage Interrupt

DC Input Voltage	Time	Restart Type
< 9 V _{DC}	≥ 1s	Automatic
< 10 V _{DC}	≥ 3 s	Automatic
< 11 V _{DC}	≥ 4 s	Automatic
> 16 V _{DC}	≥ 0.1 s	Automatic
> 18 V _{DC}	momentarily	Manual

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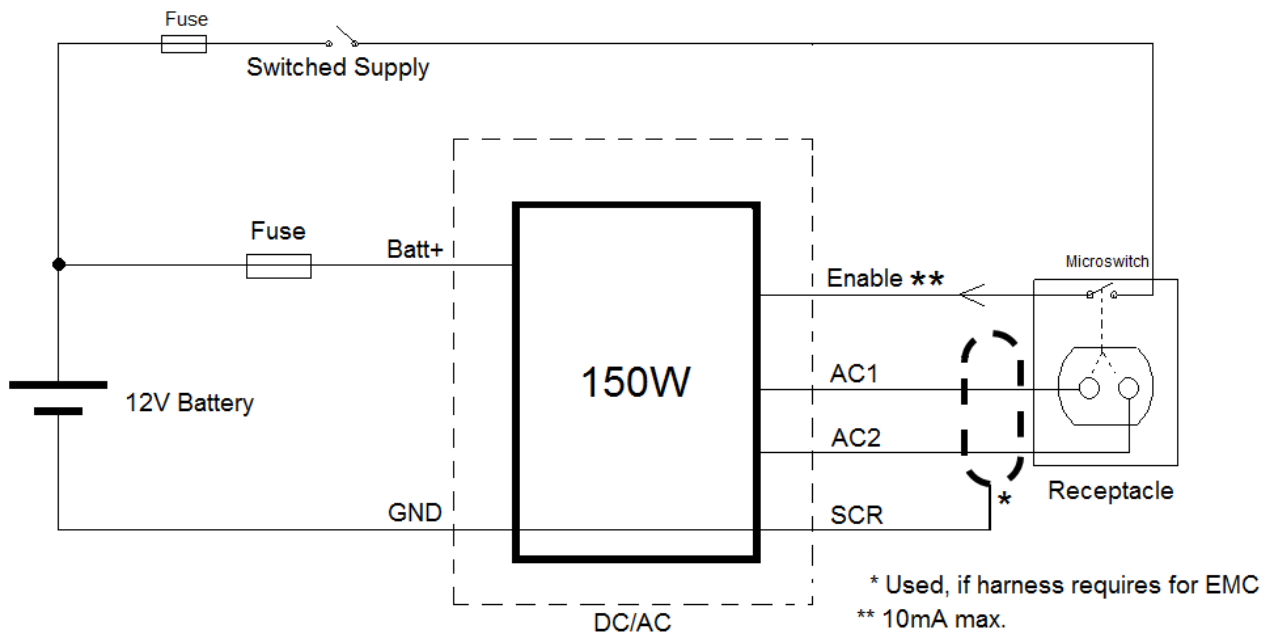


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3.1.2.2.2 Electrical Mechanization.. The electrical mechanization for the Inverter and AC Receptacle Assembly is shown in Figure 1. Wiring harness team has to define when AC line shielding is needed.

Figure 1: 12 VDC to 120/230 VAC Inverter and AC Receptacle Assembly Mechanization



3.1.3 Ambient Environment. This paragraph defines the environmental conditions that the vehicle may experience during its intended life within its target market. Unless otherwise specified, the inverter assembly shall meet the performance requirements specified herein and operate without physical damage or functional degradation when exposed to the following ambient and operating environmental conditions. The validation of these requirements is defined in Section 4 Validation. The code letter to check environment requirements according to GMW3172 is ZGCABIP5K2.

3.1.3.1 Temperature. The inverter assembly shall adhere to the following thermal environmental conditions.

3.1.3.1.1 Operating Temperature Range. The environmental temperature of operation is defined as the temperature range at which the inverter assembly functions are intended. Normal operating temperature shall be designated at +23 °C. The requirements are as follows:

3.1.3.1.1.1 Inverter Assembly. Components (electrical and mechanical) shall function as described herein while exposed to a temperature range of (-40 to +85) °C.

3.1.3.1.1.2 Rated Power. Inverter shall be capable of delivering rated AC Power over a temperature range of (-40 to +65) °C as defined in paragraph 3.2.1.3 "Continuous Output Power".

3.1.3.1.2 Storage Temperature Range. The assembly shall operate without damage or performance degradation when subjected to a storage temperature of (-40 to +95) °C.

3.1.3.2 Humidity. The inverter assembly shall meet the requirements of Humid Heat Cyclic (HHC) and Humid Heat Constant (HHCO) from GMW3172 with a 75 W resistive load or 90 W charger.

3.1.3.3 Frost. The inverter assembly shall meet the requirements of GMW3172 with 75 W resistive load or 90 W charger.

3.1.3.4 Vibration with Thermal Cycling. The inverter assembly shall be immune to vibration that occurs in the vehicle meeting requirements of GMW3172.

3.1.3.5 Thermal Shock. The inverter assembly shall resist cracking and crazing of encapsulated compounds, opening of case seams or changes in electrical or mechanical characteristics due to component displacement or rupture, upon completion of Thermal Shock Air-to-Air and Power Temperature Cycle according to GMW3172.

3.1.3.6 Chemical Loads. The inverter assembly shall withstand exposure to the following fluids:

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3.1.3.6.1 Coffee or Soft Drinks. Tests according to "Sugar Water Function" defined in GMW3172.

3.1.3.6.2 Cleaning Agents for Interior. Tests according to Chemical Resistance to Fluids from GMW14334 using fluids classified with the code A.

3.1.3.7 Free Fall. The inverter assembly shall meet the requirements of GMW3172 while providing an upwards orientation of the connector.

3.1.3.8 Mechanical Shock. The inverter assembly shall meet the requirements of Mechanical Shock – Pothole and Mechanical Shock – Collision from GMW3172.

3.1.3.9 Corrosion/Material Stability. There shall be no visible corrosion or degradation of functional requirements when the inverter assembly is subjected to the Fretting Corrosion Degradation and Salt Mist per GMW3172.

3.1.3.10 Dust Exposure. The inverter assembly shall meet the requirements of GMW3172.

3.1.3.11 Water Exposure. The inverter assembly shall meet the requirements of GMW3172.

3.1.3.12 Flammability Requirements. The materials used in the inverter assembly shall comply with GMW3232 Test Method for Determining the Flammability of Interior Trim Materials.

3.1.3.13 Ozone. If rubber components are utilized in design, the inverter assembly shall withstand exposure to ozone when tested according to ISO 1431-1 Method A. If no rubber components are utilized in design, ozone test shall not be required.

3.1.3.14 Mechanical Fatigue. The inverter assembly shall meet the requirements of mechanical fatigue according to GMW3172. As reference, see Leg 1 of Figure 7 of this standard.

3.1.3.15 Thermal and Climatic Fatigue. The inverter assembly shall meet the requirements of thermal fatigue according to GMW3172. As reference, see Leg 2 of Figure 7 of this standard.

3.1.4 Interfaces.

3.1.4.1 Electrical Interface.

3.1.4.1.1 Harness Requirements. The inverter assembly shall interface with the vehicle electrical system through a DC and AC wiring harness per GMW14082.

3.1.4.1.2 Ground Path Requirements. The inverter assembly shall be immune to ground path inductance and meet requirements of Ground Path Inductance Sensitivity from GMW3172.

3.1.4.2 Mechanical Interface. The inverter assembly shall attach to the interior sheet metal using sufficient attachment points with fasteners.

3.1.4.3 Connector Interface. Connection systems of inverter assembly shall meet the requirements of GMW3191 and Connector Installation Abuse – Side Force and Foot Force from GMW3172.

3.1.5 Usage Definition.

3.1.5.1 Target Life – Usage. GM has estimated the following profile for customer usage of the inverter assembly in Table 2.

Table 2: Usage

Function	Calendar	Mileage	Cycles
Inverter Assembly	10 Years	240 000 km (150 000 miles)	300 000

3.1.5.2 Duty Cycle. For purposes of durability tests (Thermal Fatigue and Mechanical Fatigue), the inverter assembly duty cycle is defined in Table 3.

Table 3: Duty Cycle

Inverter Assembly	With DC voltage applied to DC Input, apply DC voltage to Activate Signal input as specified and connect a 150 W resistive load at AC Output. Dwell for 100 s. Remove voltage from Activate Signal input to deactivate inverter for 20 s before reactivating.
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3.2 Product Characteristics. The required physical characteristics for the inverter assembly are specified in the following paragraphs.

3.2.1 Performance Requirements. The critical electrical performance characteristics of the inverter circuits are summarized below. Unless otherwise specified, test voltages shall be maintained $\pm 0.1 V_{DC}$.

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3.2.1.1 Operating/Test Voltage. The inverter shall function as specified in this document without interruption within the operating voltage range of (11 to 16) V_{DC}. The operating voltage level shall be measured at the inverter connector to consider impact of the voltage drop on the wire harness. The electrical loads code letter specified in paragraph 3.1.3 "Ambient Environment" is Z, therefore $U_{min} = 11 \text{ V}_{DC}$ and $U_{max} = 16 \text{ V}_{DC}$.

Also, the inverter shall be immune of generator output ripple voltage and supply voltage pulses meeting the requirements of Sinusoidal Superimposed Voltage and Pulse Superimposed Voltage from GMW3172.

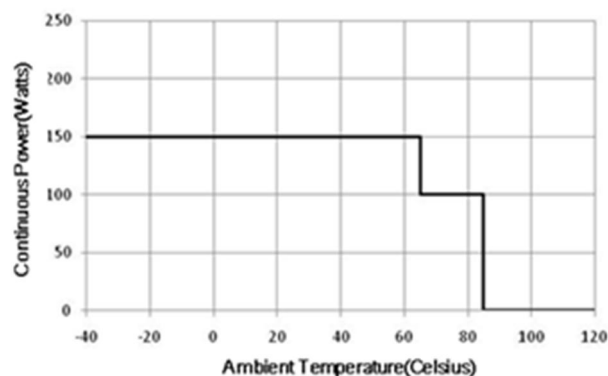
3.2.1.2 Output Voltage. The inverter voltage output shall meet the following criteria:

- | | |
|--|--|
| a. Wave Shape: | Modified Sine Wave |
| b. Frequency: | (60 ± 7) % for 120 V _{AC}
(50 ± 7) % for 225 V _{AC} |
| c. Total Harmonic Distortion: | 45 % maximum |
| d. Efficiency (maximum power at +25 °C): | 82 % minimum |
| e. Voltage Range: | 120 V _{AC} ± 10 %
220 V _{AC} ± 10 % |

Note: Throughout operating range input voltage, temperature and output load.

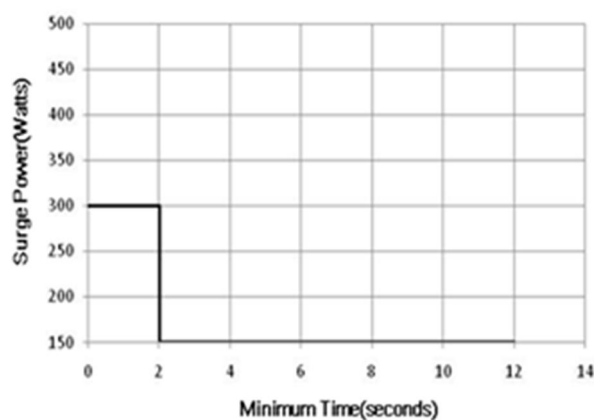
3.2.1.3 Continuous Output Power. The inverter shall be capable of generating minimum continuous power at various ambient temperatures per the following output derating curve, as shown in Figure 2. The inverter shall shut down the AC output when ambient temperature is out of range as described in Figure 2. Output power shall return to normal operation according to paragraph 3.2.1.13 "User Restart After Shutdown".

Figure 2: Minimum Inverter Power vs. Ambient Temperature



3.2.1.4 Surge Power. The inverter shall be capable of generating surge power as shown in Figure 3.

Figure 3: Surge Power Generation (in W)



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3.2.1.5 Jump Start. The inverter shall withstand voltage of $26 V_{DC}$ for 1 minute with no performance degradation. Output power shall return to normal operation according to paragraph 3.2.1.13 User "Restart After Shutdown".

3.2.1.6 Low Battery Voltage Shutdown. The low battery voltage shutdown shall occur for input voltage $< 11.0 V_{DC}$. For detailed low voltage behavior, refer to paragraph 3.1.2.2.1.4.

The inverter shall return to normal operation automatically (no cycling of Activate Signal is needed) within 1.5 s maximum after DC input voltage rises to $11.0 V_{DC}$ and higher.

The inverter shall meet requirements of Power Supply Interruptions and Battery Voltage Dropout from GMW3172.

3.2.1.7 Crank Pulse Capability. The inverter shall meet the requirements of Crank Pulse Capability and Durability from GMW3172.

3.2.1.8 Over Voltage Shutdown. The over voltage shutdown shall occur for input voltage $> 16.0 V_{DC}$. The inverter shall return to normal operation automatically (no cycling of Activate Signal is needed) after DC input voltage comes to $16.0 V_{DC}$ and lower. Once input voltage rises $> 18.0 V_{DC}$, the inverter shall return to normal operation manually (cycling of Activate Signal is needed) The inverter shall return to normal operation according to paragraph 3.2.1.13 "User Restart After Shutdown".

3.2.1.9 Reverse Voltage Protection. The inverter shall withstand reverse voltage of $-13.5 V_{DC}$ for 2 minutes with no performance degradation.

Output power shall return to normal operation according to paragraph 3.2.1.13 "User Restart After Shutdown".

3.2.1.10 Over Current Protection. During the overcurrent event the Inverter shall restart automatically 5 to 10 times within one ignition cycle. If over load still present after the final try, the inverter shall shut down and restart according to paragraph 3.2.1.13.

The Inverter shall be robust against any variants of inrush current and overload events without subsequently degradations in function. The inverter shall return to normal operation automatically (no cycling of Activate Signal is needed) after over load is removed.

The inverter shall meet requirements of Over Load – All Circuits and Fuse Protected Circuits Tests from GMW3172.

3.2.1.11 AC Output Short Circuit Protection. The inverter shall shut down AC output in 1 s maximum upon application short between AC phases. Output power shall return to normal operation according to paragraph 3.2.1.13 "User Restart After Shutdown".

The inverter shall meet requirements of Intermittent and Continuous Short Circuit to Battery and to Ground Tests and Ground Interconnect Short to Battery Test from GMW3172. Deviations from GMW3172 concerning manual restart requirements are component specific and need to be considered as described in this document.

3.2.1.12 Occupant Shock Protection. The DC-AC shall provide an isolation between the High voltage generation unit and the 12 V system to avoid electrical shocks being caused by a single failure event. The isolation shall be checked against high voltage tests up to 400 V. The minimum isolation shall provide an impedance of $Z \geq 20 M\Omega$.

3.2.1.13 User Restart After Shutdown. After the removal of AC output shutdown condition(s) and/or DC input shutdown condition(s) described herein, the inverter shall restart and produce output voltage, according to paragraph 3.2.1.2, within the maximum power up time, described in paragraph 3.2.1.14, after cycling of the Activate Signal (removal and reapplication of the activate signal input) by AC control switch, described in paragraph 3.1.2.2.2 "Electrical Mechanization".

3.2.1.14 Power Up Time. The inverter AC output power shall meet the requirements, described in paragraph 3.2.1.2 "Output Voltage", within 1.5 s maximum from AC enable switch activation.

The inverter shall meet requirements of State Change Waveform Characterization from GMW3172, for the state changes described in Table 4, within 1.5 s maximum from AC control switch activation.

Table 4: State Changes

Enable Signal Condition	FROM State	TO State
ON	OFF	ON
OFF	ON	OFF

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