



Global-B 400 W / 100 V / 55 Hz DC/AC (JAPAN)

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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 describes a variant of the 400 W DC/AC inverter especially for Japanese application.

1.2 Applicability. The 400 W Modified Sine Wave DC/AC Power Inverter is intended to provide the user with AC output power as a convenience feature. This standard outlines the design, performance, appearance, and validation requirements for a 400 W Modified Sine Wave DC AC Power Inverter. The assembly shall contain the ability to provide sufficient AC power for 400 W and lower power devices. The power inverter will have an output of 100 V AC at 55 Hz as required in Japan.

This document provides specifications for the 400 W Modified Sine Wave DC/AC Power Inverter, in the areas of performance, reliability and customer perception.

1.3 Remarks. 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 shall 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	ISO 26262	SAE J2602-1	SAE J2602-2
SAE J2602-3			

2.2 GM Standards/Specifications.

GMW3059	GMW3091	GMW3091	GMW3097
GMW3103	GMW3116	GMW3172	GMW3191
GMW3232	GMW3286	GMW3431	GMW4710
GMW8287	GMW8288	GMW14011	GMW14082
GMW14089	GMW14241	GMW14334	GMW14573
GMW14573	GMW15010	GMW15049	GMW15841
GMW15862	GMW16331	GMW16449	GMW16552
GMW17219			

2.3 Additional References.

AEC-Q100 (Automotive Electronics Council)
 CG1763
 GVIEST_002 High Voltage Safety Requirements
 GB5105
 GB7100
 GM1829
 QS9000
 TLE-050046
 UL 840

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3 Requirements

The following paragraphs describe in detail the specific functional, physical and electrical capabilities required to satisfy this standard.

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. The subsystem integration must comply with TLE-050046.

3.1.1 Appearance. The DC/AC Inverter case shall have no sharp corners, edges or mechanical properties, which might cause physical injuries during servicing, maintenance and production. 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.

3.1.1.1 Color.

Plastic Housing: The DC/AC Converter case shall have a non-reflective black, gray, or silver exterior.

Aluminum Housing: The DC/AC Converter aluminum housing shall not be processed (painted etc.) in any way to have full cooling functionality and keep the aluminum looking.

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.

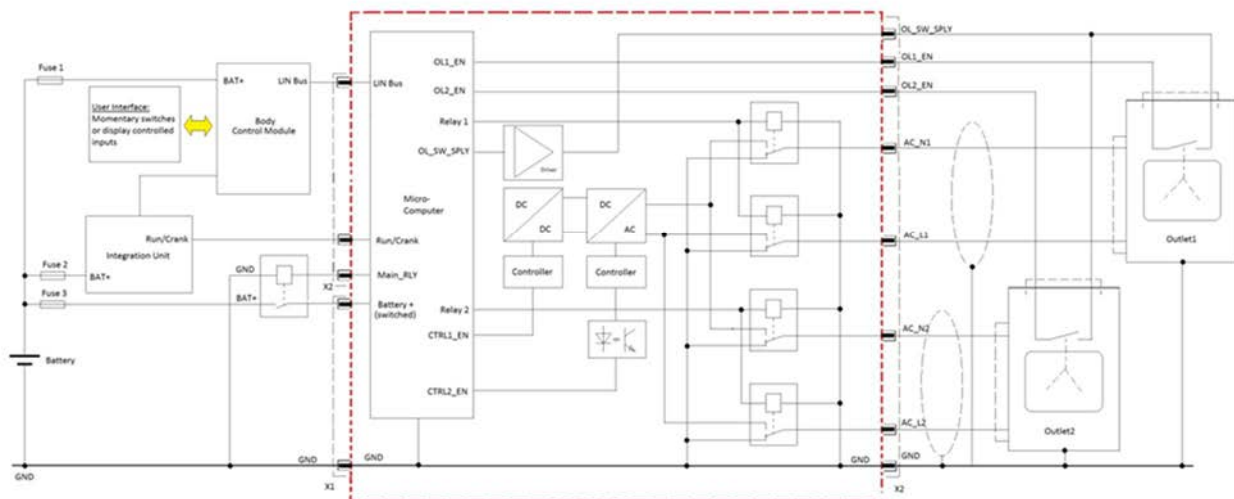
3.1.2.1.1 Inverter Assembly. The inverter assembly contains the DC to AC power control electronics, integral connector(s) (for DC input, AC output and remote power switch) and heat dissipation packaging.

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 "Connector Test and Validation Specification" and GMW3172 "General Specification for Electrical/Electronic Components". Pin-outs shall be specified on the released product drawing. Pin-outs cannot be changed without written authorization of GM Engineering.

3.1.2.1.3 DC/AC Mechanization.

Figure 1: DC/AC Assembly

DC/AC Assembly



3.1.2.2 Functional Content. The AC Inverter Assembly (see Figure 1) 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/conditions:

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3.1.2.2.1.1 The inverter shall be capable of continuously powering AC loads that require power within 400 W and providing necessary surge power, as described in the Surge Power section (see paragraph 4.2.3.2.3.1.1), to start such loads.

3.1.2.2.1.2 The inverter shall output a modified sine wave AC output.

3.1.2.2.1.3 The inverter shall provide a safety feature 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 the Electrical Mechanization section (see paragraph 3.1.2.1.3).

3.1.2.2.1.4 The inverter shall provide occupant shock protection via incorporation of galvanic isolation between the DC input and AC output portions of the power electronic circuit. Additionally, an isolation fault protect function shall disable AC output when AC current is diverted from the intended circuit via a fault path.

3.1.2.2.1.4.1 Isolation Resistance. The inverter assembly shall be a minimum isolation resistance to guarantee its immunity against loss of isolation. The inverter assembly shall meet requirements of Isolation Resistance according to GMW3172.

3.1.2.2.1.5 The inverter shall provide a LIN serial data interface. All electrical functions shall be monitored and controlled by the LIN-Master (BCM).

3.1.2.2.1.6 DC/AC High Voltage Output Stage Activation Conditions (DCAC Enable).

Hardwired standby condition: Run/Crank=high

Note: Both Outputs are affected by this command. Many other conditions can be defined in the Master software to enable/disable the DC/AC function. By using this command, the DC/AC inverter can either be switched on or completely disconnected from the main power supply voltage.

The LIN Master Command is an 8 bit representation: The master shall transmit the Command Frame \$08 (\$08) to the DC/AC and the DC/AC shall provide a functional respond on an additional request being send by the Master. Based on environmental routines, input from a human interface etc. the Master decides on the value being sent to the DC/AC.

Example:

No Load Shedding active (\$0) => DCAC Enable = true (Bit #0, \$1)

Load Shedding active (\$1) => DCAC Enable = false (Bit #0, \$0)

3.1.2.2.1.7 High Voltage Outlet 1 Supply Enable/Disable Conditions.

Hardwired request from outlet 1 to DCAC, microswitch = true (Consumer connected to outlet 1!)

Hardwired request from outlet 1 to DCAC, microswitch = false* (No consumer connected to outlet 1!)

Note: If the hardwired request is in condition false, outlet 1 will always be disabled. The functional feedback shall be sent to the master correspondingly.

The LIN Master Command is an 8 bit representation: The master shall transmit the Command Frame \$08 (\$08) to the DC/AC and the DC/AC shall provide a functional respond on an additional request being send by the Master. Based on environmental routines, input from a human interface etc. the Master decides on the value being sent to the DC/AC.

Output 1 Enable request = true (Bit#1, \$1)

Output 1 Enable request = false (Bit#1, \$0)

Note: Only Output 1 is affected by the value of Bit#1. Other conditions can be defined in the Master software to enable/disable the DC/AC Output 1.

3.1.2.2.1.8 High Voltage Outlet 2 Supply Enable/Disable Conditions.

Hardwired request from outlet 2 to DCAC, microswitch closed = true (Consumer connected to outlet 2!)

Hardwired request from outlet 2 to DCAC, microswitch open = false* (No consumer connected to outlet 2!)

*If the hardwired request is in condition false, outlet 2 will always be disabled. The functional feedback shall be sent to the master correspondingly.

The LIN Master Command is an 8 bit representation: The master shall transmit the Command Frame \$08 (\$08) to the DC/AC and the DC/AC shall provide a functional respond on an additional request being send by the

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Master. Based on environmental routines, input from a human interface etc. the Master decides on the value being sent to the DC/AC.

Output 2 Enable request = true (Bit#2, \$1)

Output 2 Enable request = false (Bit#2, \$0)

Note: Only Output 2 is affected by the value of Bit#2. Other conditions can be defined in the Master software to enable/disable the DC/AC Output 2.

3.1.2.2.1.9 Response Output 1 or Output 2 Enable Requested. The Master shall transmit the \$09 (\$49) frame to the DCAC and the DCAC shall provide the 2 Byte responses. The Outlet enable request response is located in Byte1 Bit 0 through 1. This message is based on a hardwired status request being provided by microswitches being assembled on the HV Outlets. This Output Enable Requested message shall not be used for error analysis. It shall be used for human interface facilities.

Hardwired Status on HV-Outlet 1:

- a) Device connected to AC Power 1 ▢ Microswitch 1 closed ▢ Output 1 request detected (Byte1, Bit#0, \$1)
- b) No Device connected to AC Power 1 ▢ Microswitch 1 open ▢ No Output 1 request detected (Byte1, Bit#0, \$0)

Hardwired Status on HV-Outlet 2:

- a) Device connected to AC Power 2 ▢ Microswitch 2 closed ▢ Output 2 request detected (Byte1, Bit#1, \$1)
- b) No Device connected to AC Power 2 ▢ Microswitch 2 open ▢ No Output 2 request detected (Byte1, Bit#1, \$0)

3.1.2.2.1.10 Response about Main Relay Status. The Master shall transmit the \$09 (\$49) frame to the DCAC and the DCAC shall provide the 2 Byte responses. The Main relay status is located in Byte1 by using a 2 bit message (see Table 1).

Note: The Main Relay shall connect the main power supply to the DC/AC. The feedback coming from the DCAC shall be used for diagnostics based on analysis being provided by the Master.

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Table 1: DC/AC Main Relay Status

DC/AC Enabled	Main relay open	Error Message (Y/N)
True	False	N
True	True	Y
False	False	Y
False	True	N
DC/AC Enabled	Main relay closed	Error Message (Y/N)
True	True	N
True	False	Y
False	True	Y
False	False	N
DC/AC Enabled	Main relay indeterminate	Error Message (Y/N)
True	True	Y
True	False	N
False	True	Y
False	False	N
DC/AC Enabled	Undefined and unused	Error Message (Y/N)
True	True	N
True	False	N
False	True	N
False	False	N

3.1.2.2.1.11 Response about Output Voltage Status. The Master shall transmit the \$09 (\$49) frame to the DCAC and the DCAC shall provide the 2 Byte responses. The output voltage status response is located in Byte1 using a two Bit message.

The DC/AC shall monitor the power stage output voltage during operation. The feedback coming from the DCAC shall be used for diagnostics based on analysis being provided by the Master.

The output voltage level conditions are:

Indeterminate: This status is given, when the Power Output stage was disabled by the master or if the connection to the main power supply was broken. The DC/AC shall transmit the message identifier \$09 (\$49) 2 Byte response correspondingly.

Normal: The Normal status is given, when the Power Output stage voltage level keeps within the specified tolerance of $\pm 4\%$. The DC/AC shall transmit the message identifier \$09 (\$49) 2 Byte response correspondingly.

Output Voltage Low: The Output Voltage Low status shall be provided by the DCAC as soon as the output voltage is less than 90% of the nominal output voltage level. The DC/AC shall transmit the message identifier \$09 (\$49) 2 Byte response correspondingly.

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Output Voltage High: The Output Voltage High status shall be provided by the DCAC as soon as the output voltage is > 110% of the nominal output voltage level. The DC/AC shall transmit the message identifier \$09 (\$49) 2 Byte response correspondingly.

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 paragraph 4 "Validation". The code letter to check environment requirements according to GMW3172 is ZGCDBIP5K3.

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

Note: Further, detailed information is provided in paragraph 4 "Validation".

3.1.3.1.1.2 Vehicle Assembly. The DCAC converter shall be mounted in interior area or trunk.

Specific package requirements need to be detached from the best practice document related to the DC/AC.

3.1.3.1.1.2.1 Subsystem Part Integration. The DC/AC Inverter, which is mounted in the interior compartment or trunk, shall be used to provide AC output power for AC appliances. The subsystem integration must comply with TLE-050046.

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

3.1.3.1.1.2.3 Fasteners. The inverter assembly shall attach to the interior sheet metal using sufficient attachment points with fasteners. All fasteners shall be reusable and withstand a minimum of ten remove replace procedures. All fasteners requiring a backup shall use weld nuts or cage nuts.

3.1.3.1.1.2.4 Risk of Injury. The performance of repair tasks shall not subject the individual performing the task to risk of injury due to contact with hot components or sharp edges.

3.1.3.1.1.2.5 Labeling. Parts, components and modules, which are intended to provide machine readable bar-code information, shall comply with definition to GMW15862. The Parts Identification and Tracking Application Standard were defined within the Automatic Identification Data Capture work group (AIDC). Plastic parts shall be marked according to GMW3116. The DC/AC Converter shall be identified by a permanent identification, broadcast code or part number contained on the assembly itself (GMW4710). If the parts/components/assemblies change, the permanent ID shall also change. The label shall be located on the top surface of the DC/AC. The connector position shall be oriented down below the label footprint. The label color shall be white with all printed lettering in black ink. Label color is subject to GM Engineering approval, granted by the Lead DRE. The label shall be oriented providing its bottom line above the controller's front side (connector side). The label material shall meet GMW14573 "Global Performance Requirements for Labels".

3.1.3.1.1.2.6 Label Content.

The label shall contain the following content:

- the 8-digit GM production part number
- the production Broadcast Code
- GM Trademark
- FNA component name
- Origin of product
- Serial number
- Hardware/Software ID
- Bar Code

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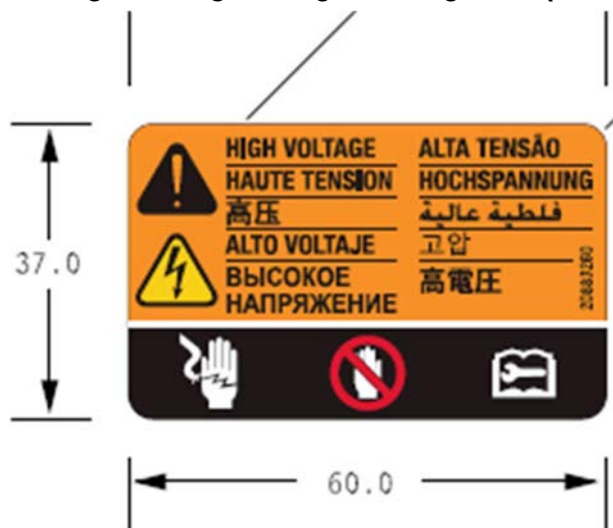
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3.1.3.1.1.2.7 High Voltage Warning Label. The Controller shall have a High Voltage Warning Label located in a GM approved location. GM part number 20883260 (latest revision) shall be used for the High Voltage Warning Label. The following figure illustrates artwork and dimensions in mm for the label. The label (see Figure 2) shall meet the performance requirements in GMW14573.

Figure 2: High Voltage Warning Label (Example)



3.1.3.1.1.3 Quality Requirements. The Controller shall conform to the following Quality Requirements specified in the subsections below.

3.1.3.1.1.3.1 Key Product Characteristics.

Continued Compliance:

- The Supplier shall perform a "Continued Compliance Test" using GMW8287 to develop a screen test, to ensure the quality and durability of the component for its production life. All testing shall be conducted at the manufacturing site unless agreed upon by GM Supplier Quality, Validation, and Release. The supplier shall ensure that the necessary equipment and sufficient resources be made available to cycle parts through the test.
- Testing shall be run after 1 month of production, 3 months, 6 months, and 9 months. After 12 months of production the test plan may be altered upon review of warranty between GM and the supplier.

Functional Content:

- The DC/AC inverter shall provide microprocessor and peripheral health/integrity data to the BCM according to SAE J2602-1
- The inverter shall output a modified sine wave AC output.
- 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.
- The inverter shall provide occupant shock protection via incorporation of galvanic isolation between the DC input and AC output portions of the power electronic circuit. Additionally, an isolation fault protect function shall disable AC output when AC current is diverted from the intended circuit via a fault path.
- The inverter shall provide a LIN Serial Data Interface. This interface is capable of a bi-directional communication. Please refer to the SAE J2602 specification for adequate device implementation.
- The Inverter shall read in serial data information coming from the BCM, which is necessary to decide on when the DC/AC shall be disabled or not. This function includes the consideration of a Load Shed function. The BCM (Master) decides upon this function.
- The Inverter shall check internal and environmental input and out signals to be able to provide functional and health information to the BCM via LIN.

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The signals need to include:

- Input Voltage Level
- Output Voltage level 1 and 2
- Electrical Load status in %
- Hardware failures
- Controller error
- A/D converter error
- Boost Error
- Main Relay status
- Overload and or short circuit
- Input Voltage high
- Input Voltage Low
- Residual Current detected
- Lost Communication
- High Temperature

A detailed LIN communication between the BCM and the DC/AC is shown in paragraph 3.1.2.2.1.5. The inverter shall provide a LIN serial data interface. All electrical functions shall be monitored and controlled by the LIN-Master (BCM).

3.1.3.1.1.4 Integrated Circuit Quality. The Controller Design shall meet the following Integrated Circuit Quality Requirements.

3.1.3.1.1.4.1 Electronic Components Requirements. The Controller Design shall only use Integrated Circuits (ICs) that meet AEC-Q100 requirements unless an exception is granted per GM's Electronics Supply Chain Risk Management Team.

The Controller Supplier shall provide IC Level Qualification documentation per AEC-Q100 Appendix 4A and or 4B:

4A: AEC-Q100 "Qualification Test Plan"

4B: AEC-Q100 "Generic Data on all integrated circuits"

3.1.3.1.1.4.2 BOM Requirements. The Controller Supplier shall provide a BOM utilizing the "RFQ_Tier 1 Supplier Semiconductor Template rev.a.xlsx" template for all electrical components.

The Controller Supplier shall provide all documentation above at each Hardware Design Review, Hardware Release, Design Validation, and Production Validation.

3.1.3.1.1.4.3 Six Sigma for Test Requirements. The Controller shall provide Integrated Circuits (ICs) and Discrete Semiconductors that have had Six Sigma guard banding activities applied to all analog tests at every test operation in the manufacturing of the components (IC's & Discrete). These Six Sigma activities need to take in account the variation from tester to tester and load board to load board via R&C (Repeatability & Correlation) studies. The range of acceptable Process Capability Indices (Cpks) for these guard banded test limits are Cpk min. = 2.0 and Cpk max. = 6.0. For special cases such as low level leakages the acceptable Cpk max. = 15. For exception to this requirement contact GM's Electronics Supply Chain Risk Management Team.

A GM engineering group that oversees changes related to CTRs's and Change Notices (CN's) or Part Change notices (PCN's).

3.1.3.1.1.4.4 Design Requirements. The controller design shall meet the following requirements:

- All unused integrated circuit pins shall be connected as recommended by the manufacturer of the integrated circuit.
- Integrated circuit inputs tied to ground shall include sufficient resistance in the path to ground to protect the input from negative transients unless specifically required otherwise by the integrated circuit manufacturer.

3.1.3.1.1.5 Lifetime and Durability Requirements. The inverter shall be reliable such that $\leq 0.5\%$ of the production volume exhibits true failures (as determined by root cause analysis) throughout the useful life of the inverter.

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The useful life of the inverter is 11 years or 200 000 miles, whichever comes first. This includes 7 500 h of ignition "on" time during 40 000 ignition cycles. The total engine run duration is 6 700 h during 36 000 engine run occurrences.

These results shall be achieved by considering the following recommendations:

- A. Minimize number of component interconnections
- B. Minimize/dissipate component self-heating
- C. Consider aging effects on components
- D. Consider physical & functional stack-up tolerances
- E. Consider safety margins, component derating
- F. Select components with proven application /performance history
- G. Design structural support to minimize object harmonic mass deflection
- H. Design robust interconnections to withstand cyclic fatigue failure
- I. No single-sided PCB without plated through-hole interconnects
- J. Minimize/eliminate use of screw fasteners
- K. Limit/eliminate hazardous materials in design
- L. Design for Reliability, failure prevention and failure detection

3.1.4 Interfaces.

3.1.4.1 Electrical Interface.

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

3.1.4.1.2 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.

3.1.4.4 DC/AC Converter Interfaces. See Figure 3.

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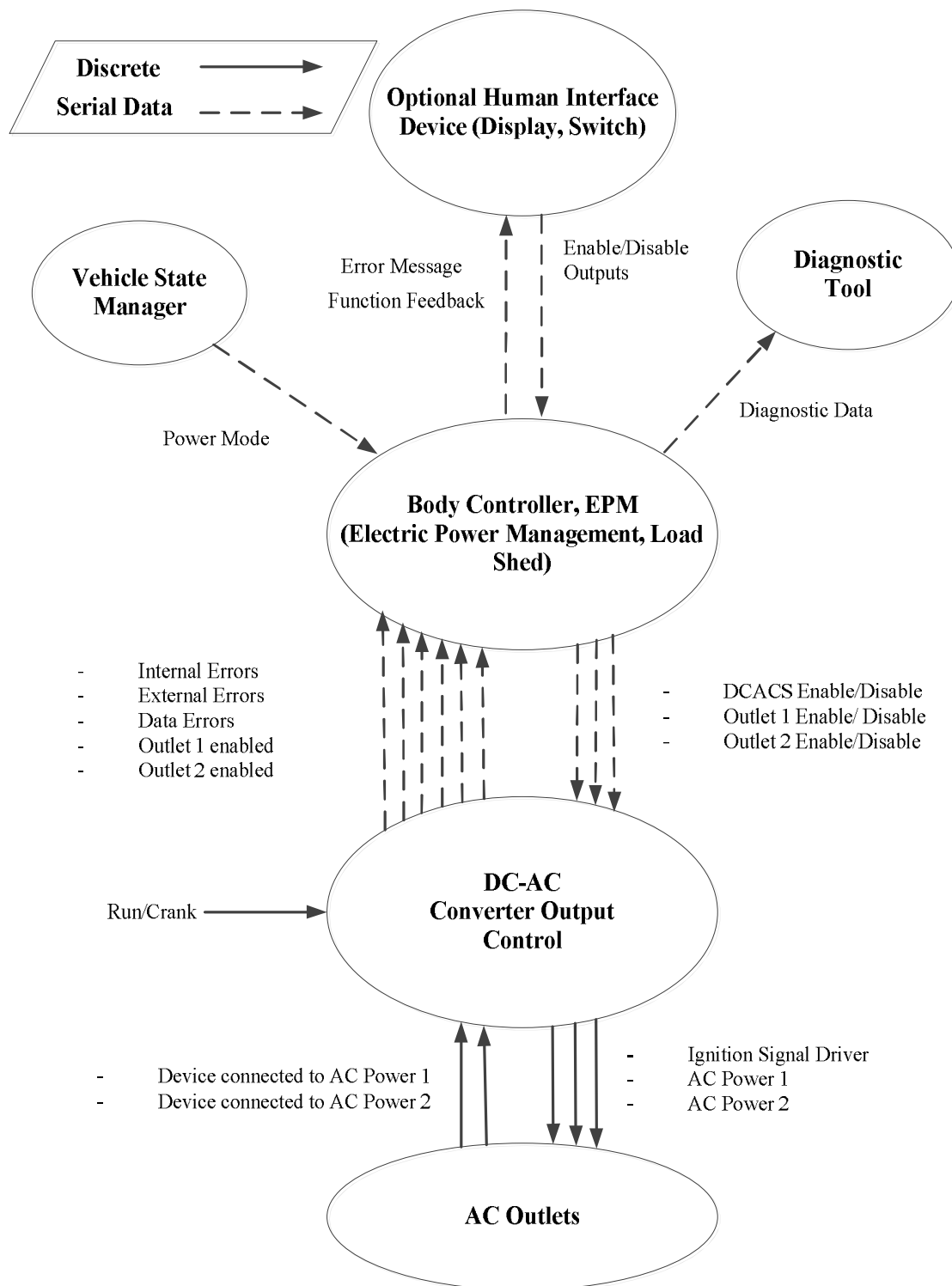
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Figure 3: Interfaces

**3.1.4.5 DC/AC Activation (wake up process), Standby Operation.**

Condition: Run/Crank = high (hardwired)

3.1.4.5.1 DC/AC State Diagram. See Figure 4.**GM Confidential**

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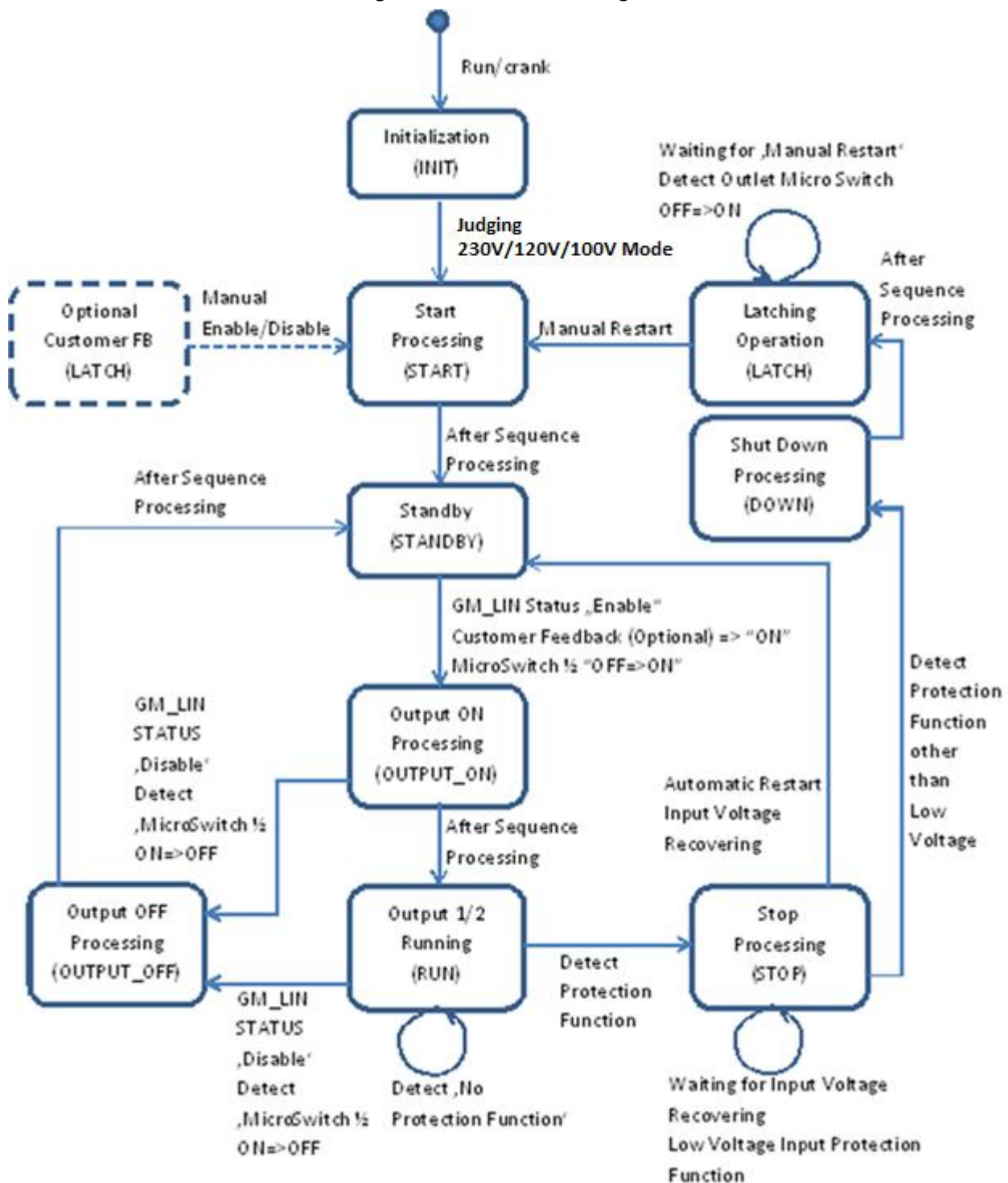
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Figure 4: DC/AC State Diagram



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Processing on each state

State	Processing
INIT	Judge 100 V/120 V/230 V mode
START	Main relay ON ^{Note 3}
STANDBY	(Status Check)
OUTPUT_ON	DC/DC ON (Primary side of DC/AC Inverter)
OUTPUT_OFF	DC/DC OFF (Primary side of DC/AC Inverter)
RUN ^{Note 4}	Output relay 1/2 ON/OFF
STOP ^{Note 2}	1) Output Relay 1/2 OFF 2) DC/DC OFF (Primary Side of DC/AC Inverter) ^{Note 1} Wait for input-voltage-recovering in case of Low voltage protection activated (Automatic Restart)
DOWN	Main Relay OFF
LATCH	Wait for Manual Restart ^{Note 5}

Note 1: Unless otherwise specified, state transition takes ≈ 1 ms.

Note 2: Carry out Sequences in order as described. Timing adjustment possible.

Note 3: 100 ms waiting time for state transition.

Note 4: Drive the relay, which is correspondent to the plugged-in Outlet.

Note 5: Turning the DC/AC OFF/ON via plug IN/OUT can be considered as user operation.

3.1.4.6 General Controller Requirements. This Controller shall meet the needs of multiple vehicle applications with diverse Input/Output (I/O) content requirements. The specific pin current and voltage information is located in Tables 3 to 8. These tables contain the I/O Definition Matrix specifies the signal I/O content required for all applications. The tables are separated into a number of sub-tables based upon the functional type of I/O signal. The exceptions are the Power/Ground and Serial Data signals which have no functional requirements. Each table includes columns that specify signal requirements per the following definitions.

3.1.4.6.1 Signal Name. This column defines the name of each signal for which the Controller shall provide some I/O interface; this name will be referred to exactly as shown in later sections of these requirements.

3.1.4.6.1.1 Signal Name Abbreviation. This column defines the only abbreviation, which shall be used for the signal if a documentation tool (e.g., drafting or circuit design software) cannot accept the longer Signal Name defined above; note, all Controller documentation shall use only the full Signal Name or Signal Name Abbreviation above within an individual document.

3.1.4.6.2 Remote I/O ESD Testing. This column classifies the signal to define the maximum dis-charge levels for the ESD, Remote Inputs/Outputs test in GMW3097; the coded values are as follows: NA – remote I/O test not applicable (handling ESD test still applies), 1 – test up to ± 15 kV level, 2 – test up to ± 25 kV level.

3.1.4.6.3 Connector Design X. These columns define which Controller connector (and possibly pin number) shall be used to externally transmit/receive the signal; pin number (or letter) shall be separated from connector with a “-” (dash).

3.1.4.6.4 DC/AC Electrical Interface Signal Requirements. This column specifies the type of electrical interface to use for each signal. The electrical interface name may be prefixed by an exclamation point (!). This indicates, that the interface should be depopulated in the Controller (i.e., a “protect for” design). Note the same signal name may include multiple row entries with different electrical interfaces listed. If all include the protect for prefix (!), then the Controller-design shall be optimized to minimize the space and components required to implement only one of the interfaces unless specified otherwise in the Build Variants-section. any validation requirements are specified in the Validation section (see paragraph 4).

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3.1.4.6.5 Functional Interface Requirements. This column specifies the particular functional interface to be used for each signal. These will be defined within the general functional type identified by the sub-table. The value "Custom" indicates a functional interface unique to that signal or group of signals, look for a custom interface function as a specific subsection of the functional type of the signal; alternatively, the corresponding section number of the functional interface may be directly entered into this column.

3.1.4.6.6 Lo V Limit. This column defines to what minimum voltage level the I/O function and electrical interface associated with the signal shall be fully functional. The coded values are as follows:

C – minimum Cranking Voltage

F – minimum Critical Function Voltage

S – minimum Auto-Start Cranking Voltage

N – minimum Normal Voltage.

The voltage range specification-details are defined in paragraph 4.2.3.2.2 and Table 12.

3.1.4.6.7 Hi V Limit. This column defines to what maximum voltage level the I/O function and electrical interface associated with the signal shall be fully functional; the coded values are as follows:

N – maximum Normal Voltage

H – maximum Generator Over Voltage

J – maximum Jump Start Voltage. The voltage range specifications are defined in paragraph 4.2.3.2.2 for further details.

3.1.4.6.8 Number (#) of Retries. This column specifies the maximum number of Output fault retries per Operating Cycle. The coded values are as follows:

U = unlimited

L = limited

or a specific value less than that specified by code L (see paragraph 3.2.8 "I/O Electrical Interfaces" for more specific requirements).

3.1.4.6.9 Wake Type. This column specifies any Controller wakeup functions that shall be implemented for specific signals; the coded values are comprised of up to three characters. See paragraph 3.2.1.17.12 "Controller Wakeup And Shutdown Requirements" for more specific requirements on the wakeup types.

- a. The first two characters are in reference to, whether the I/O is used as wakeup in CAN Frame Detect and Sleep Controller Power Mode state, and are as follows:
 - DR – digital rising edge
 - DF – digital falling edge
 - DB – digital rising/falling (both) edges
 - AR – analog rising level
 - AF – analog falling level
 - AC – analog changing level
 - Blank – no wakeup required
- b. The third character is in reference to, whether the I/O is used as wakeup in CAN Frame Detect, Sleep and Deep Sleep Controller Power Mode state, and whether the I/O has configurable Wake Types, where configurable means whether the Wake Type shall be active or inactive. See paragraph 3.2.1.17.12 "Controller Wakeup And Shutdown Requirements" for more specific requirements on the wakeup types. The third character is as follows:
 - S – if the Controller shall use the specific signal for wakeup in CAN Frame Detect, Sleep and Deep Sleep Controller Power Mode State
 - C – if the Controller shall have a configurable wakeup in CAN Frame Detect and Sleep Controller Power Mode State only
 - D – if the Controller shall use the specific signal for wakeup in CAN Frame Detect, Sleep and Deep Sleep Controller Power Mode State and shall have a configurable wakeup
 - Blank – wakeup in CAN Frame Detect and Sleep Controller Power Mode states only

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3.1.4.6.10 Wake Threshold. This column specifies a threshold for the analog wakeup types (if required for the signal, see above). For AR or AF-types it is the absolute threshold beyond which the wakeup shall occur; for AC type it is the amount of change in the analog value that shall trigger a wakeup; if blank, no threshold is required. Furthermore, specific requirements on the wakeup types are shown in this document.

3.1.4.6.11 Voltage Source. This column specifies the voltage source, that shall be used for a given signal/electrical interface. For inputs, it specifies the voltage supply to use for pull-ups; for high-side outputs, it specifies the power source for the high-side driver circuit. For low-side outputs, it specifies the power source for the low-side driver circuit (e.g., gate drive pull-up) and also that will be applied to the load connected to the signal (external to the Controller). The coded values are as follows: B thru Bn – Battery (or Battery #1) to Battery #n inputs. P thru Pn – Powertrain Relay to Powertrain Relay #n inputs. C thru Cn – run/Crank to run/Crank #n inputs. 9 V thru 9 Vn – the 9 V to 9 Vn specific sensor supply. 9 Vx – one of the 9 V sensor supplies. 5 V thru 5 Vn – the 5 V to 5 Vn specific sensor supply. 5 Vx – one of the 5 V sensor supplies. 5 Vint thru 5Vintn – the 5 V to 5 Vn specific internal supplies. 5 Vintx – one of the 5 V internal supplies. The Signal Name Abbreviation for any high-side driven signal may be used to indicate a pull-up via the (switched) supply provided by the driver.

3.1.4.6.12 Ground Source. This column specifies the ground source that shall be used for a given signal/electrical interface; the coded values are as follows: G thru Gn – Power ground to Power ground #n; R thru Rn – signal Return to signal Return #n.

3.1.4.6.13 Coherency. This column specifies inputs that shall be sampled together, outputs that shall be changed together or specifies inputs that need to be sampled based on the change in value of an output voltage or another trigger. The first character specifies the coherent group (A-Z), the second character specifies the maximum skew between the samples, Sample Coherent Window, or between the output or trigger change and the input sample or output change, and the third character specifies the maximum delay from the output or trigger change to the start of the coherent window, Max Delay from Trigger. A two character entry indicates the window for the group starts when the first signal is sampled or the first output is changed. A blank entry indicates the input is not coherent with any other signal.

3.1.4.6.14 CPU Usage. A GM-specific processor list (CPU) on which the software portions of the function shall be implemented shall be provided by GM-Engineering during the sourcing.

3.1.4.6.15 ASIL Rating. The first character defines the required ASIL Rating (from ISO26262) for this pin. The choices are as follows:

- A - ASIL A
- B - ASIL B
- C - ASIL C
- D - ASIL D
- Q - Quality Managed
- N - No ASIL rating

The second character is the Detection Index that identifies the required Fault Detection Time.

3.1.4.6.16 Controller I/O Definition Matrixes and Signal Names. See Tables 3 to 8.

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Table 3: Power and Ground Inputs

Signal Names											
Power And Ground Inputs	Signal Abbrev	Remote I/O ESD Testing	Connector Design 1	Connector Design 2	Electrical Interface	Lo V Limit	Hi V Limit	Wake Type	Wake Threshold	Source Reference Code ^{Note 1}	ASIL Rating
Power Ground	PWRGND	2	J1		PGND11					G	Q
Run/Crank	IGN	2	J2		EISWVB04					C	Q
DC/AC Main Relay Contact (switched B+)	SWVBAT	2	J1		EISWVB11					SWVBAT	Q

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Table 4: Other Supply and Return Outputs

Signal Names: Other Supply And Return Outputs	Signal Abbrev	Remote I/O ESD Testing	Connector Design 1	Connector Design 2	Electrical Interface	Lo V Limit	Hi V Limit	# of Retries	Voltage Source	Ground Source	Source Reference Code Note	ASIL Rating
120 VAC Phase A (Output 1)	AC_L1a	2	J2		HVAC01	N	N	L	SWVBAT			Q
120 VAC Phase B (Return 1)	AC_L1b	2	J2		HVAC01	N	N	L	SWVBAT			Q
120 VAC Phase A (Output 2)	AC_L2a	2	J2		HVAC01	N	N	L	SWVBAT			Q
120 VAC Phase B (Return 2)	AC_L2b	2	J2		HVAC01	N	N	L	SWVBAT			Q
230 VAC Phase A (Output 1)	AC_L1a	2		J2	HVAC02	N	N	L	SWVBAT			Q
230 VAC Phase B (Return 1)	AC_L1b	2		J2	HVAC02	N	N	L	SWVBAT			Q
230 VAC Phase A (Output 2)	AC_L2a	2		J2	HVAC02	N	N	L	SWVBAT			Q
230 VAC Phase B (Return 2)	AC_L2b	2		J2	HVAC02	N	N	L	SWVBAT			Q

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Signal Names:												
Other Supply And Return Outputs	Signal Abbrev	Remote I/O ESD Testing	Connector Design 1	Connector Design 2	Electrical Interface	Lo V Limit	Hi V Limit	# of Retries	Voltage Source	Ground Source	Source Reference Code Note	ASIL Rating
100 V _{AC} Phase A (Output 1)	AC_L1a	2	J2		HVAC03	N	N	L	SWVBAT			Q
100 V _{AC} Phase B (Return 1)	AC_L1b	2	J2		HVAC03	N	N	L	SWVBAT			Q
100 V _{AC} Phase A (Output 2)	AC_L2a	2	J2		HVAC03	N	N	L	SWVBAT			Q
100 V _{AC} Phase B (Return 2)	AC_L2b	2	J2		HVAC03	N	N	L	SWVBAT			Q

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Table 5: Special Returns

Signal Names: Special Returns	Signal Abbrev	Remote I/O ESD Testing	Connector Design 1	Connector Design 2	Electrical Interface	Lo V Limit	Hi V Limit	Ground Source	Source Reference Code Note	ASIL Rating
HV Drain wire (Screen)	SCRGND	2	J2	J2	HvShld01					Q

Table 6: Serial Data

Signal Names: Serial Data	Signal Abbrev	Remote I/O ESD Testing	Connector Design 1	Connector Design 2	Electrical Interface	Comm Strategy Interface	S/W Implement Interface	Lo V Limit	Hi V Limit	Wake Type	Voltage Source	Ground Source	CPU Usage
LIN Bus A	LIN_A	2	J2		GB7100	GB5105	N/A	N	N				

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Table 7: Discrete Inputs

Signal Names Discrete Inputs	Signal Abbrev	Remote I/O ESD Testing	Connector Design 1	Connector Design 2	Electrical Interface	Functional Interface	Lo V Limit	Hi V Limit	Wake Type	Wake Threshold	Voltage Source	Ground Source	Coherency	DSP Index	CPU Usage	ASIL Rating
DC To AC Inverter Control (Outlet Enable Input 1)	OL1_EN	2	J2		SIH2	DscrIn	N	N			C					Q
DC To AC Inverter Control (Outlet Enable Input 2)	OL2_EN	2	J2		SIH2	DscrIn	N	N			C					Q

Table 8: Discrete Outputs

Signal Names Discrete Outputs	Signal Abbrev	Remote I/O ESD Testing	Connector Design 1	Connector Design 2	Electrical Interface	Functional Interface	Lo V Limit	Hi V Limit	# of Retries	Voltage Source	Ground Source	Coherency	DSP Index	CPU Usage	ASIL Rating
DC/AC Inverter Relay Control	ACRLY	2	J2		HSIL1	DscrOut1	N	N	L	C					Q
DC/AC Ignition Signal Driver	IGNSIGDR	2	J2		HSLEDO1	DscrOut1	N	N	L	C					Q

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