JOHN DEERE CONFIDENTIAL

PD400 Inverter

CAN Specification

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Foreword

Read this manual carefully to learn how to operate your JDES inverter correctly.

Because of the variety of uses for the products described in this manual, those responsible for the application and use of this equipment must satisfy themselves that all necessary steps have been taken to ensure that each application and use meets all performance and safety requirements, including any applicable laws, regulations, codes, and standards. Illustrations, charts, sample programs, and layout examples shown in this guide are intended solely for purposes of example.

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1.1. Publication History

Table 1: Publication History

Doc ID	Rev.	Release Date	Author	Description of Release
N/A	-	10/12/2015	David Torgerson	– Initial Document
227357	1.01	5/1/2017	David Torgerson	– Adding AC Supply Command and Status Messages – Adding Voltage RMS 1 Status Message – Added/Fixed CAN Messages – Added State Transition Command – Updated Fault Section – Removed IEC 61800 – Updated Motor Control Unit State Definitions – Updated Diagnostics Function – Updated Derate Owner – Added note about flash/lamp statuses – Updated Fault Section
227357	1.02	07/17/2017	David Torgerson	– Updating AC Supply Command and Status Messages – Moving Fault list to annex – Moving Configurable Parameters to annex
227357	1.03	03/13/2018	David Torgerson	– Added coolant temperature reporting to existing Inverter Temperature 2 message – Added 3-phase short message – Added DC Link Power and Current Limiting messages – Added DC Link Power and Current Status messages – Fixing incorrect command bytes – Added Inverter Status 4 message
227357	1.04	02/01/2019	David Torgerson	– Added Command Configurable Messages – Added Status Configurable Messages

1.2. References

Table 2: Reference Documents

No.	Title/Description	Revision/Info
1	JDES PD400 User Manual	DOC-227358
2	SAE J1939 CAN Specification Standard	March 2009
3	JDES PD400 Installation Guide	DOC-220325

1.3. Definitions

Table 3: Definitions for Common Terms

Item	Definition
∞	Symbol indicating an infinite value. In this case, infinite implies the range of floating point numbers represented by a 32 bit single precision *float* value in IEEE 754 floating point representation. This gives an approximate usable range of $\pm1.18\text{x}10^{-38}$ to $\pm3.4\text{x}10^{38}$
BEMF	Back Electromotive Force (i.e., machine phase voltage generated by rotation of shaft without external voltage applied to wires)
Bi-Directional	Refers to the capability of the inverter to transfer power in both directions between the source (HVDC bus) and the motor load
EOL	End of Line
High-Voltage	Any voltage related to DC link and phase voltages
HVDC	High-voltage DC bus
IGBT	Insulated Gate Bipolar Transistor
IPM	Internal Permanent Magnet synchronous AC machine
JDES	John Deere Electronic Solutions
Low-Voltage	Consider 0 to 32 V DC as low-voltage, which falls into the Class A category as defined by SAE
LSB	Least Significant Byte
LSW	Least Significant Word
MSB	Most Significant Byte
MSW	Most Significant Word
NVM	Non Volatile Memory (typically EEPROM)
System	Refers to the overall application in which the inverter is being used

1.4. Introduction

This document is the standard CAN specification for the PD400 inverter. It is important that the user have a good understanding of this specification, as it is the only method available for controlling the inverter. This specification uses the J1939 CAN Specification for all message formatting, diagnostics, and operating parameter changes. This includes transmitting 0xFE on the CAN bus when data has an error and transmitting 0xFF when data is not available. It is important that the user is aware of these two conditions, as they need to be handled properly. Oftentimes, these values are associated with a fault that has occurred with the inverter.

1.5. Intended Audience

This manual is intended for use by the user of the product.

1.6. Purpose of This Manual

The purpose of this manual is to provide a structured resource for the user to reference when installing and operating the inverter.

1.7. The JDES Family

The JDES family is a series of Class B power inverters designed to provide advanced control for AC motor applications. They bi-directionally convert high-voltage DC power to three-phase AC power to drive a variety of machines, in a compact, rugged, environmentally sealed package. The inverters are built upon a common hardware platform accommodating a wide range of possible drive schemes with standard, JDES configurable firmware modules that determine specific family members.

The JDES series inverters were designed for use in a variety of different applications. Some of these applications include industrial heavy-duty machinery, agricultural equipment, and utility vehicles. The inverters can also be used on an electrified vehicle as a gas engine assist to reduce peak loading and provide brake energy re-capture, helping to improve fuel economy.

This specification is valid for the PD400 inverter. Each family member has its own specifications related to output power, number of motors that can be driven, type of motors that can be driven, compatible position feedback sensors, etc. Please refer to the Installation Guide for your particular model inverter.

2. CAN Specification

This section of the document covers all of the specification except the operating parameters, which are covered in the next section.

2.1. General Information

On power-up, the inverter attempts to claim an address on the CAN bus. Once an address is successfully claimed, it begins broadcasting all J1939 formatted CAN status messages periodically at their defined broadcast rates. If no Critical or Fail Safe faults are active (which can be identified from the DM1 message and current inverter state), the inverter can be operated by sending J1939 formatted CAN Command Messages referenced below.

! Note	In order for the inverter to accept command messages from an ECU, the ECU shall be required to send the address claim message upon power-up. The inverter shall acknowledge the request, thus informing the ECU it is ready to receive messages. For more information, refer to the SAE J1939 Standard.

2.1.1. J1939 CAN Specification

This entire CAN specification is based on the J1939 protocol standard, published by the SAE (Society for Automotive Engineers). Throughout this specification, it is assumed that the user has a good understanding of the J1939 Standard. The reference to the actual dated documents in the standard that were used to develop this specification can be found in Table 2.

! Note	All information published in this document that is taken from the J1939 specification is for reference only. This includes all block diagrams, tables, and any specific references to the J1939 specification. Other than the definitions for the Proprietary A & B messages (which are defined by JDES), the J1939 specification takes precedence.

2.1.2. CAN Tools

2.1.2.1. Phoenix Utility 2

Since this specification uses the J1939 Standard, any tool that supports this standard may be used to access and control the inverter. However, John Deere Electronic Solutions has developed its own in-house engineering tool, called PU2, or Phoenix Utility 2. This tool has an interface that allows the user to access and control the inverter, monitor its status, view faults, and program new software. The tool accesses the inverter following the specification detailed here, but in a more user-friendly manner which can help accelerate prototype testing. PU2 can interface to a variety of different CAN devices, but it is important to check that your specific device is compatible before installing. JDES Product Support will support the installation and an overview of PU2 through an online meeting after the inverter is received by the user. This allows communication to the inverter to be verified before any actual testing begins.

2.1.2.2. CalPro

In addition, JDES has also developed another tool for programming called CalPro. This tool is typically used after the prototype phase of a project when multiple inverters need to be programmed. Please contact JDES for more information on each tool and when they will get used.

2.1.3. Definitions Used in Specification

The following table gives definitions for the various terms used throughout this specification, as they relate to inverter operation. Non-specific definitions can be found in Table 3.

Table 4: CAN Specific Inverter Related Definitions

Term	Definition
Critical Fault	A Critical Fault indicates a major problem with the inverter, electric machine, or system. When a Critical Fault occurs, the inverter will immediately move to a fault state, disabling the motor and allowing it to coast to a stop. Note that some critical faults may cause a three phase short to be applied as well. The user must intervene to reset the fault by commanding the inverter out of the fault state.
Fail Safe	Fail Safe is a state the inverter can transition to under specific faults conditions. This state requires the inverter to be power cycled in order to recover from the fault condition, unlike a critical fault which can be cleared without power cycling. Note that some Fail Safe faults may cause a three phase short to be applied.
DM	J1939 formatted CAN Diagnostic Message.
DM1	Diagnostic Message broadcast periodically by the inverter containing active DTCs.
DM2	Diagnostic Message broadcast on request by the inverter containing previously active DTCs.
DM3	Command to inverter to erase all previously active DTCs.
DM11	Command to inverter to erase all active DTCs.
DM13	Command to inverter to stop or start message broadcasting.
DM14	Memory Access Request (used for operating parameter access).
DM15	Memory Access Response (used for operating parameter access).
DM16	Binary Data Transfer (used for operating parameter access).
DTC	Diagnostic Trouble Code.
ECU	Electronic Control Unit.
Generating	This term is used to refer to the process of actively transferring power from the motor load, through the motor and inverter, to the HVDC bus.
Limits	A set of operating parameters that sets the Operating Area for the inverter and motor. If more than one limit is active at the same time, the limit with the lowest setting takes precedence over all others.
Motoring	This term is used to refer to the process of actively transferring power from the HVDC bus, through the inverter and motor, to the motor load.
NVM	Non-Volatile Memory (typically EEPROM).
Operating Area	Refers to the allowable inverter operating region (speed vs. torque) throughout the entire operating temperature range for the inverter.
PDU	Protocol Data Unit (used in the J1939 specification).
PGN	Parameter Group Number (used in the J1939 specification).
SAE	Society of Automotive Engineers, the group responsible for the J1939 specification.
SPN	Suspect Parameter Number (used in the J1939 specification).
Torque Limiting	Torque Limiting acts to dynamically reduce the available electric machine torque when a set of limits is exceeded. Some torque limits use a pair of setpoints, one setpoint at which torque limiting begins, and the other to indicate when the available torque is reduced to zero. **In all cases**, the torque percentage is a percentage of the total available torque at the current electric machine speed (i.e. relative torque). Torque Limiting is always active when the inverter is in Normal Operation.
Warning	A fault that allows the drive to continue running in its current state.

2.1.4. ED CAN

The inverter always uses the ED (Electric Drive) CAN bus. All features described in the following sections are enabled for the ED CAN Bus unless otherwise noted.

2.1.5. HS CAN

The HS (High Speed) CAN bus is typically used to send and receive the Feed Forward command/status message and for engineering purposes. If the Feed Forward command and status message is not required for the application, HS CAN is not needed.

2.1.6. Baud Rate

The standard baud rate is 500 kbps for ED CAN and 1 Mbps for HS CAN. The baud rate can be reconfigured to 250 kbps on ED CAN by programming the inverter. Contact JDES if any other baud rate is required.

2.1.7. Fault Handling

All active faults and warnings are broadcast by the inverter using the DM1 Diagnostic message (see section 2.4).

2.1.8. Inverter Configuration Parameters

The inverter has a large variety of configurability such as slew rates, source addresses, torque curves, fault thresholds, and various derating parameters. These parameters are modified by reprogramming the inverter. JDES will work with the end user to adjust the parameters for each application. JDES will provide default values initially which will provide a starting point.

2.1.9. J1939 Name Detail

Each inverter is assigned a permanent J1939 formatted name that is unique for that specific device. The name is important in that it helps resolve address claim contention issues. The formatting of the name is part of the J1939 Standard, with certain data field values predefined by the standard. The name is contained in a 64 bit data field, and encodes the information shown in Table 5. The J1939 Standard gives more complete definitions for possible entries in each field. In this case, an ECU represents a single CAN channel in the inverter. If the second CAN bus is active, it uses the exact same name as the first CAN bus (it is assumed that the two CAN buses will not be connected together).

Table 5: J1939 Name Details

Field Name	Description	Bit Length	Usage	Defined By
Arbitrary Address Capable	Set if ECU is arbitrary address capable, clear otherwise. This bit is always set in the inverter.	1	Same as field name	JDES
Industry Group	Code associated to specific industry. Some possible entries are: – 0 = Global, applies to all – 1 = On-Highway Equipment – 2 = Agricultural & Forestry Equip. Group – 3 = Construction Equipment	3	Same as field name	J1939 Standard
Vehicle System Instance	Identifies a specific vehicle system instance on the network. Inverter default is 0.	4	Same as field name	JDES
Vehicle System	Type of vehicle or system that the inverter is installed in. For the inverter, this is usually set to 0 (Non-specific System).	7	Same as field name	J1939 Standard
Reserved	Reserved by SAE for future use. Always 0 in the inverter.	1	Same as field name	J1939 Standard
Function	Function that the inverter is responsible for in the system. Some possible entries are: – 0 = Engine – 1 = APU – 2 = Electric Propulsion Control – 3 = Transmission – 4 = Battery Pack Monitor For the inverter, Electric Propulsion Control is usually the default value used.	8	Same as field name	J1939 Standard
Function Instance	Identifies a specific function instance on the network. Inverter default is 0.	5	Same as field name	JDES
ECU Instance	For multiple ECUs with the same function, this helps provide unique identification for each inverter. Inverter default is 0.	3	Same as field name	JDES
Manufacturer Code	Code assigned specifically to device manufacturer by SAE. The code assigned to JDES is 166.	11	Same as field name	J1939 Standard
Identity Number	Number assigned by JDES to guarantee a unique J1939 Name for each device. Each inverter controller is assigned a unique number.	21	Unit Serial Number	JDES

Typically the values in all of the fields are identical from one inverter to the next, except for the Identity Number. The only requirement is that the name is unique when used with other J1939 compatible devices, and this is done through the Identity Number and the Manufacturer Code. At this time it is not possible for the user to modify any of these fields without requesting customized application code from JDES.

2.1.10. Multiple Inverters on Same CAN Bus

Since the inverter is configured for arbitrary address claim, each inverter on the bus will attempt to claim its preferred address, and if that address is not available, will attempt to claim the next address in its table (see Table 5). If it reaches the end of its table without claiming an address, it will go bus quiet and quit responding to CAN requests and transmitting messages. If multiple inverter controllers are on the same bus, it is not possible to know which inverter will claim which address in its table, unless the user knows the exact J1939 Name for each inverter (this determines priority in claiming addresses — see the J1939 Standard). Even if the name is known for each inverter, there may be other devices on the bus attempting to claim the same address, and they may get priority. If you wish to connect multiple inverter controllers to the same CAN bus, you will, at a minimum, have to change the Source Address for one of the controllers to something other than the default value.

2.1.11. Reading Inverter Info

Since the user may read out specific inverter information using a J1939-compatible CAN tool (see section 2.1.2 for JDES provided tools). The following information is available when performing inverter info read:

- Source address of inverter.
- TLA (three letter acronym assigned by JDES).
- J1939 Name, which includes the following information:
    - ID or serial number of the inverter
    - ECU instance
    - Function
    - Function instance
    - Industry group
    - Manufacturing group
    - Vehicle system
    - Vehicle system instance
    - Self Config address capable
- Vehicle ID[1]
- Calibration identification[2]
- Calibration verification number[3]

[1] Optional information.
[2] Optional information.
[3] Optional information.

2.1.12. J1939 Standard PGN Support

In addition to the information mentioned above, the following standard J1939 PGN's are supported:

2.1.12.1. Software ID PGN – 65242 (0xFEDA)

The inverter Software ID contains software part number and revision number information.

2.1.12.2. ECU ID PGN - 64965 (0xFDC5)

The inverter ECU ID contains hardware part number, serial number, and configuration information.

2.1.12.3. Component ID PGN - 65259 (0xFEEB)

The inverter Component ID contains information regarding how the inverter is configured for the current application.

2.2. CAN Message Formatting

Command and Status messages are the primary method of controlling the inverter and determining its operating characteristics. Command messages are sent by a vehicle controller or CAN tool directly to a specific inverter address to command inverter operation. Status messages are broadcast periodically on the CAN bus by the inverter and are available to be read by any other device on the bus.

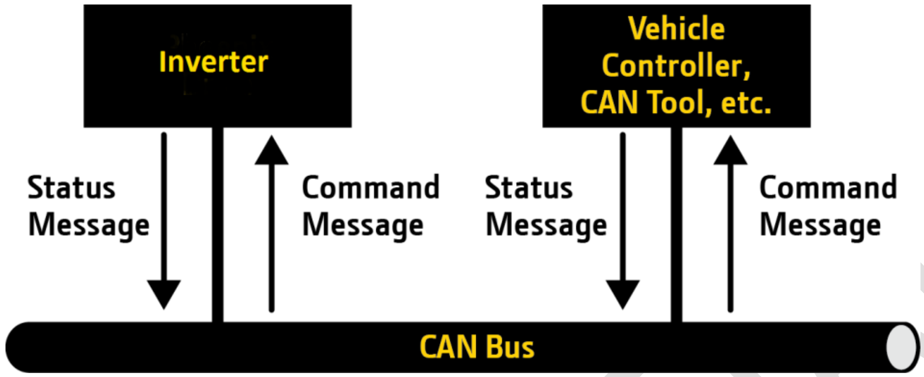

Figure 1: Command and Status Message Flow Diagram

2.2.1. Field Definition

All CAN Command and Status messages sent or received by the inverter are constructed of a 29 bit ID field, a 64 bit data field, plus other fields. The 64 bit data field used has the following format: [4]

Byte	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Bit	0 – 7	8 – 15	16 – 23	24 – 31	32 – 39	40 – 47	48 – 55	56 – 63
Usage	Command Byte 1	Command Byte 2	Message Specific Data					

[4] The number of Command Bytes varies. Refer to each individual message to determine the number of Command Bytes.

2.2.2. Message Definition Tables

In the following sections each CAN Command and Status message is defined in several tables. The tables define how the 64 bit data field is formatted for each message. Each column in the tables provides a specific piece of information about each of the data items within the message. Here is how the columns are used:

- **Data Item:** Variable encoded into message data field.
- **Start Bit:** First bit number used where data item starts within the message data field. The bit range is from 0 to 63, and the bit order is shown in section 2.2.1.
- **Len:** Bit length of the data item.
- **Gain:** Conversion constant (see section 2.2.3).
- **Offset:** Conversion constant (see section 2.2.3).
- **Units:** Engineering units of data item.
- **Default:** Default value of data item. For Command messages, this is the value that the inverter assumes for the data item until it receives a Command message from the vehicle controller or CAN tool. For Status messages, this value is not applicable since the inverter will always report the actual value of the variable. Command bytes are also defined using default values that cannot be changed.
- **Min:** Minimum allowed value for the data item before it is converted to CAN encoded data (see section 2.2.3.3).
- **Max:** Maximum allowed value for the data item before it is converted to CAN encoded data (see section 2.2.3.3).

2.2.3. Data Conversion

All data sent or received in a CAN message must be scaled and converted into a proper CAN data format. Floating point is the native data type for most data contained in the message, however, all data is converted to unsigned 8-bit or 16-bit data prior to being sent in a CAN message.

2.2.3.1. Native to CAN Data Conversion

This conversion must be done before the data variable is transmitted on the CAN bus to the inverter. This conversion is actually done inside the inverter prior to transmitting the data in a status message. When an external controller transmits a CAN Command message to the inverter, it must perform this conversion as well, assuming that its native type is floating point. Even if its native type is not floating point, then end result must be the same so that the variable can be decoded properly by the inverter. In the following equation, the $DATA_{NATIVE}$, Offset, and Resolution variables are all floating point. The final value for $DATA_{CAN}$ is always an unsigned 8 or 16 bit integer. The actual values for Offset and Resolution, and the bit length of $DATA_{CAN}$ (8 or 16), can be found for each variable in the message definition tables, which are in sections 2.3.4 and 2.3.5.

$$DATA_{CAN} = \left(\frac{DATA_{NATIVE} + Offset}{Resolution}\right)$$

In all cases the $DATA_{CAN}$ result is transmitted as part of the data field in a CAN message, either by the inverter (as a Status message), or by the external controller (as a Command message). When $DATA_{CAN}$ is 16 bits, its Least Significant Byte (LSB) is transmitted before its Most Significant Byte (MSB). To keep from losing significant data resolution, make sure to perform the above conversion using the data variable's native type first, and then convert the result to an unsigned integer as the final step.

2.2.3.2. CAN Data to Native Conversion

Each CAN message received by either the external controller or the inverter have specific data fields containing variables that need to be converted into a native format and scaled before they can be used. All variables in a CAN message are formatted as either 8 or 16 bit unsigned integers. The actual bit lengths for each variable are found in the message definition tables, in sections 2.3.4 and 2.3.5. When a variable is formatted as a 16 bit unsigned integer, it will be constructed using two CAN data bytes, with the first byte forming the Least Significant Byte (LSB), and the second byte received forming the Most Significant Byte (MSB) of the word. The following equation is used to convert these variables into their native type with the proper scaling in engineering units. Assuming that $DATA_{NATIVE}$ is floating point (as it is inside the inverter), $DATA_{CAN}$ must first be converted to floating point before it is used in the equation. Note that Offset and Resolution are floating point, and their actual values for each specific variable can also be found in the message definition tables.

$$DATA_{Native} = (DATA_{CAN} \bullet Resolution) - Offset$$

2.2.3.3. CAN Data Min and Max Values

Each data value in a CAN message has defined minimum and maximum values. These values are considered the limits of the CAN data itself, and do not represent the actual limits of the inverter. These limits help define the scaling and precision of the data within the message.

2.3. CAN Command Messages Details

2.3.1. CAN Command Messages

Command messages are typically sent by a vehicle controller or tool to the inverter to command some sort of action. Multiple command messages are defined for the inverter, however, not all of them may not be needed for all applications.

The inverter must receive at least one of the command messages defined below in order to continue operating. If the time between the successive command messages exceeds the configurable CAN Timeout a fault occurs and the inverter transitions to a fault state.

2.3.1.1. Inverter Command Message 1 (Relative Torque Mode)

This message is received by the inverter. This message allows commanding of the inverter in Relative Torque mode. The actual NM value is based off of a user defined reference torque multiplied by the torque percent command.

Table 6: Inverter Command Message 1 (Relative Torque Mode)

Byte	0	1	2	3	4	5	6	7	
Bit	0 – 7	8 – 15	16 – 23	24 – 31	32 – 39	40 - 47	48 – 55	56 – 58	59 – 63
Usage	0xF4	0x18	Torque Percent Command		0xFF	0xFF	State Transition Command	0x0	0x1F

Format	Priority	PGN	PDU Format	PDU Specific	Source Address
Proprietary A	2	0xEF00	0xEF	Inverter Source Address	Vehicle Controller Source Address

Data Item	Start Bit	Len	Gain	Offset	Units	Default	Min	Max
Command Byte 1	0	8	-	-	-	244 (0xF4)	-	-
Command Byte 2	8	8	-	-	-	24 (0x18)	-	-
Torque Percent Command	16	16	0.00390625	125	%	0	-125	125.99
Unused	32	8	-	-	-	0xFF	-	-
Unused	40	8	-	-	-	0xFF	-	-
State Transition Command – 0 – 99 = Defined in OSM Diagram in User Manual and section 2.3.3 – 100-255 = Diagnostic Functions defined in section 2.3.5	48	8	-	-	-	-	-	-
Reserved	56	3	-	-	-	0x0	-	-
Unused	59	5	-	-	-	0x1F	-	-

2.3.1.2. Inverter Command Message 2 (Speed Mode)

This message is received by the inverter. This message allows commanding of the inverter in Speed mode.

Table 7: Inverter Command Message 2 (Speed Mode)

Byte	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	
Bit	0 – 7	8 – 15	16 – 23	24 – 31	32 – 39	40 – 47	48 – 55	56 – 58	59 - 63
Usage	0xF4	0x1B	Speed Command		0xFF	0xFF	State Transition Command	0x0	0x1F

Format	**Priority**	**PGN**	**PDU Format**	**PDU Specific**	**Source Address**
Proprietary A	2	0xEF00	0xEF	Inverter Source Address	Vehicle Controller Source Address

Data Item	**Start Bit**	**Len**	**Gain**	**Offset**	**Units**	**Default**	**Min**	**Max**
Command Byte 1	0	8	-	-	-	244 (0xF4)	-	-
Command Byte 2	8	8	-	-	-	27 (0x1B)	-	-
Speed Command	16	16	0.5	16000	RPM	0	-16000.0	16127.5
Unused	32	8	-	-	-	0xFF	-	-
Unused	40	8	-	-	-	0xFF	-	-
State Transition – 0 – 99 = Defined in OSM Diagram in User Manual and section 2.3.3 – 100-255 = Diagnostic Functions defined in section 2.3.5	48	8	-	-	-	-	-	-
Reserved	56	3	-	-	-	0x0	-	-
Unused	59	5	-	-	-	0x1F	-	-

2.3.1.3. Inverter Command Message 3 (Voltage Mode)

This message is received by the inverter. This message allows commanding of the inverter in Voltage mode.

Table 8: Inverter Command Message 3 (Voltage Mode)

Byte	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	
Bit	0 – 7	8 – 15	16 - 23	24 – 31	32 – 39	40 – 47	48 – 55	56 – 58	59 – 63
Usage	0xF4	0x1C	Volts Command		Motoring Torque Limit		State Transition Command	0x0	0x1F

Format	**Priority**	**PGN**	**PDU Format**	**PDU Specific**	**Source Address**
Proprietary A	2	0xEF00	0xEF	Inverter Source Address	Vehicle Controller Source Address

Data Item	**Start Bit**	**Len**	**Gain**	**Offset**	**Units**	**Default**	**Min**	**Max**
Command Byte 1	0	8	-	-	-	244 (0xF4)	-	-
Command Byte 2	8	8	-	-	-	28 (0x1C)	-	-
Volts Command	16	16	0.03125	0	V	0	0	2007.97
Motoring Torque Limit	32	16	0.00390625	125	%	0	-125	125.99
State Transition Command – 0 – 99 = Defined in OSM Diagram in User Manual and section 2.3.3 – 100-255 = Diagnostic Functions defined in section 2.3.5	48	8	-	-	-	-	-	-
Reserved	56	3	-	-	-	0x0	-	-
Unused	59	5	-	-	-	0x1F	-	-

2.3.1.4. Inverter Command Message 7 (Absolute Torque Mode)

This message is received by the inverter. This message allows commanding of the inverter in Absolute Torque mode.

Table 9: Inverter Command Message 7 (Absolute Torque Mode)

Byte	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	
Bit	0 – 7	8 – 15	16 – 23	24 – 31	32 – 39	40 - 47	48 – 55	56 – 58	58 -62
Usage	0xFB	0x01	Torque Command NM		0xFF	0xFF	State Transition Command	0x0	0x1F

Format	**Priority**	**PGN**	**PDU Format**	**PDU Specific**	**Source Address**
Proprietary A	2	0xEF00	0xEF	Inverter Source Address	Vehicle Controller Source Address

Data Item	**Start Bit**	**Len**	**Gain**	**Offset**	**Units**	**Default**	**Min**	**Max**
Command Byte 1	0	8	-	-	-	251 (0xFB)	-	-
Command Byte 2	8	8	-	-	-	1 (0x01)	-	-
Torque Command NM	16	16	0.1	3200	NM	0	-3200	3255.5
Unused	32	8	-	-	-	0xFF	-	-
Unused	40	8	-	-	-	0xFF	-	-
State Transition Command – 0 – 99 = Defined in OSM Diagram in User Manual and section 2.3.3 – 100-255 = Diagnostic Functions defined in section 2.3.5	48	8	-	-	-	-	-	-
Reserved	56	3	-	-	-	0x0	-	-
Unused	48	5	-	-	-	0x1F	-	-

2.3.1.5. Brake Resistor Command

This message is received by the inverter. This message allows commanding of the brake resistor if the inverter is equipped with the additional brake chopper module. This message does not need to be transmitted periodically.

Table 10: Brake Resistor Command

Byte	0	1	2	3	4	5	6	7
Bit	0 – 7	8 – 15	16 - 23	24 – 31	32 – 39	40 – 47	48 – 55	56 – 63
Usage	0x7E	Brake Resistor On Volts		Brake Resistor Off Volts		Brake Resistor Duty	Brake Resistor Mode	0xFF

Format	Priority	PGN	PDU Format	PDU Specific	Source Address
Proprietary B	3	0xFFFE	0xFF	0xFE	Vehicle Controller Source Address

Data Item	Start Bit	Len	Gain	Offset	Units	Default	Min	Max
Command Byte 1	0	8	-	-	-	126 (0x7E)	-	-
Brake Resistor On Volts	8	16	0.03125	0	V	0	0	2007.96875
Brake Resistor Off Volts	24	16	0.03125	0	V	0	0	2007.96875
Brake Resistor Duty	40	8	0.5	0	%	0	0	125
Brake Resistor Mode – 0 = Hysteretic only – 3 = Hysteretic and PWM->Use Commanded Duty Cycle	48	8	-	-	-	-	-	-
Unused	56	8	-	-	-	0xFF	-	-

2.3.1.6. **Torque Limiting Command**

This message is received by the inverter. This message allows commanding of the inverter torque limits. This message does not need to be transmitted periodically.

Table 11: Torque Limiting Command

Byte	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Bit	0 – 7	8 – 15	16 - 23	24 – 31	32 – 39	40 – 47	48 – 55	56 – 63
Usage	0xFB	0x00	Motoring Torque Limit	Generating Torque Limit	Secondary Voltage Limiting Setpoint		Secondary Speed Limiting Setpoint	

Format	**Priority**	**PGN**	**PDU Format**	**PDU Specific**	**Source Address**
Proprietary A	2	0xEF00	0xEF	Inverter Source Address	Vehicle Controller Source Address

Data Item	**Start Bit**	**Len**	**Gain**	**Offset**	**Units**	**Default**	**Min**	**Max**
Command Byte 1	0	8	-	-	-	251 (0xFB)	-	-
Command Byte 2	8	8	-	-	-	0 (0x00)	-	-
Motoring Torque Limit	16	8	0.5	0	%	0	0	125
Generating Torque Limit	24	8	0.5	0	%	0	0	125
Secondary Voltage Limiting Setpoint	32	16	0.03125	0	V	0	0	2007.9
Secondary Speed Limiting Setpoint	48	16	1	0	RPM	0	0	64255

2.3.1.7. Bus Dissipation Command

This message is received by the inverter. This message allows commanding of the inverter in Bus Dissipation mode.

Table 12: Bus Dissipation Command

Byte	0	1	2	3	4	5	6	7	
Bit	0 – 7	8 – 15	16 - 23	24 – 31	32 – 39	40 – 47	48 – 55	56 – 59	60 - 63
Usage	0xFB	0x02	0xFF	0xFF	0xFF	0xFF	State Transition Command	0x0	0x1F

Format	Priority	PGN	PDU Format	PDU Specific	Source Address
Proprietary A	2	0xEF00	0xEF	Inverter Source Address	Vehicle Controller Source Address

Data Item	Start Bit	Len	Gain	Offset	Units	Default	Min	Max
Command Byte 1	0	8	-	-	-	251 (0xFB)	-	-
Command Byte 2	8	8	-	-	-	2 (0x02)	-	-
Unused	16	8	-	-	-	0xFF	-	-
Unused	24	8	-	-	-	0xFF	-	-
Unused	32	8	-	-	-	0xFF	-	-
Unused	40	8	-	-	-	0xFF	-	-
State Transition Command – 0 – 99 = Defined in OSM Diagram in User Manual and section 2.3.3 – 100-255 = Diagnostic Functions defined in section 2.3.5	48	8	-	-	-	-	-	-
Reserved	56	4	-	-	-	0x0	-	-
Unused	60	4	-	-	-	0x1F	-	-

2.3.1.8. AC Supply Command

This message is received by the inverter. This message allows commanding of the inverter when configured as an AC Supply.

Table 13: AC Supply Command

Byte	0	1	2	3	4	5	6	7		
Bit	0 – 7	8 – 15	16 - 23	24 – 31	32 – 39	40 – 47	48 – 55	56 – 58	59 - 61	62-63
Usage	0xF9	0x54	AC Volts Command		Frequency Command		State Transition Command	0x0	AC Mode	0x3

Format	Priority	PGN	PDU Format	PDU Specific	Source Address
Proprietary A	2	0xEF00	0xEF	Inverter Source Address	Vehicle Controller Source Address

Data Item	Start Bit	Len	Gain	Offset	Units	Default	Min	Max
Command Byte 1	0	8	-	-	-	249 (0xF9)	-	-
Command Byte 2	8	8	-	-	-	84 (0x54)	-	-
AC Volts Command	16	16	1	0	Vrms	-	0	64255
Frequency Command	32	16	1	0	Hz	-	0	64255
State Transition Command – 0 – 99 = Defined in OSM Diagram in User Manual and section 2.3.3 – 100-255 = Diagnostic Functions defined in section 2.3.5	48	8	-	-	-	-	-	-
Reserved	56	3	-	-	-	0x0	-	-
AC Mode – 0 = Freq Mode – 1 = Volt Mode	59	3	-	-	-	-	-	-
Unused	62	2	-	-	-	3 (0x03)	-	-

2.3.1.9. AC Supply Limits

This message is received by the inverter. This message allows commanding of the inverter AC Supply limits. This message does not need to be transmitted periodically.

Table 14: AC Supply Limits

Byte	0	1	2	3	4	5	6	7
Bit	0 – 7	8 – 15	16 - 23	24 – 31	32 – 39	40 – 47	48 – 55	56-63
Usage	0xF9	0x55	AC Current Limit		0xFF	0xFF	0xFF	0xFF

Format	Priority	PGN	PDU Format	PDU Specific	Source Address
Proprietary A	2	0xEF00	0xEF	Inverter Source Address	Vehicle Controller Source Address

Data Item	Start Bit	Len	Gain	Offset	Units	Default	Min	Max
Command Byte 1	0	8	-	-	-	249 (0xF9)	-	-
Command Byte 2	8	8	-	-	-	85 (0x55)	-	-
AC Current Limit	16	16	1	0	Arms	-	0	64255
Unused	32	8	-	-	-	0xFF	-	-
Unused	40	8	-	-	-	0xFF	-	-
Unused	48	8	-	-	-	0xFF	-	-
Unused	56	3	-	-	-	0xFF	-	-

2.3.1.1. Three Phase Short Command

This message is received by the inverter. This message allows commanding of the inverter to create a 3-phase short on the motor phase outputs.

Table 15: Three-Phase Short Command

Byte	0	1	2	3	4	5	6	7
Bit	0 – 7	8 – 15	16 - 23	24 – 31	32 – 39	40 – 47	48 – 55	56-63
Usage	0xF9	0x56	3-Phase Short Enable	0xFF	0xFF	0xFF	0xFF	0xFF

Format	Priority	PGN	PDU Format	PDU Specific	Source Address
Proprietary A	2	0xEF00	0xEF	Inverter Source Address	Vehicle Controller Source Address

Data Item	Start Bit	Len	Gain	Offset	Units	Default	Min	Max
Command Byte 1	0	8	-	-	CMD	249 (0xF9)	-	-
Command Byte 2	8	8	-	-	CMD	86 (0x56)	-	-
3-Phase Short Enable – 0 = Disable 3-Phase Short – 1 = Enable 3-Phase Short – 2-255 = Reserved	16	8	-	-	-	-	-	-
Unused	24	8	-	-	-	0xFF	-	-
Unused	32	8	-	-	-	0xFF	-	-
Unused	40	8	-	-	-	0xFF	-	-
Unused	48	8	-	-	-	0xFF	-	-
Unused	56	3	-	-	-	0xFF	-	-

2.3.1.2. DC Link Power Limiting

This message is received by the inverter. This message allows commanding of the inverter to set the DC Link Power Limit Ratio for both motoring and generating. This message does not need to be transmitted periodically. The actual motoring/generating power limit will be based off of a user defined reference power in mW multiplied by the ratio.

Table 16: DC Link Power Limiting Command

Byte	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Bit	0 – 7	8 – 15	16 - 23	24 – 31	32 – 39	40 – 47	48 – 55	56-63
Usage	0xF9	0x57	0xFF	0xFF	Power Limit Ratio Generating		Power Limit Ratio Motoring	

Format	**Priority**	**PGN**	**PDU Format**	**PDU Specific**	**Source Address**
Proprietary A	2	0xEF00	0xEF	Inverter Source Address	Vehicle Controller Source Address

Data Item	**Start Bit**	**Len**	**Gain**	**Offset**	**Units**	**Default**	**Min**	**Max**
Command Byte 1	0	8	-	-	CMD	249 (0xF9)	-	-
Command Byte 2	8	8	-	-	CMD	87 (0x57)	-	-
Unused	16	8	-	-	-	-	-	-
Unused	24	8	-	-	-	0xFF	-	-
Power Limit Ratio Generating	32	16	0.001	0	Ratio	-	0	64.255
Power Limit Ratio Motoring	48	16	0.001	0	Ratio	-	0	64.255

2.3.1.1. DC Link Current Limiting

This message is received by the inverter. This message allows commanding of the inverter to set the DC Link Current Limit Ratio for both motoring and generating. This message does not need to be transmitted periodically. The actual motoring/generating current limit will be based off of a user defined reference current in mA multiplied by the ratio.

Table 17: DC Link Current Limiting Command

Byte	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Bit	0 – 7	8 – 15	16 - 23	24 – 31	32 – 39	40 – 47	48 – 55	56-63
Usage	0xF9	0x58	0xFF	0xFF	Current Limit Ratio Generating		Current Limit Ratio Motoring	

Format	**Priority**	**PGN**	**PDU Format**	**PDU Specific**	**Source Address**
Proprietary A	3	0xEF00	0xEF	Inverter Source Address	Vehicle Controller Source Address

Data Item	**Start Bit**	**Len**	**Gain**	**Offset**	**Units**	**Default**	**Min**	**Max**
Command Byte 1	0	8	-	-	CMD	249 (0xF9)	-	-
Command Byte 2	8	8	-	-	CMD	88 (0x58)	-	-
Unused	16	8	-	-	-	-	-	-
Unused	24	8	-	-	-	0xFF	-	-
Current Limit Ratio Generating	32	16	0.001	0	Ratio	-	0	64.255
Current Limit Ratio Motoring	48	16	0.001	0	Ratio	-	0	64.255

2.3.1.2. Command Configurable Messages

The inverter supports up to 8 configurable command messages as defined by J1939-74. The PGN's for these messages are listed. If the standard messages defined above are undesirable for your application, a configurable message may be used. The various data items that can be added to the configurable messages are listed below. The configuration of these messages is stored in the EOL file that gets programmed onto the inverter.

Table 18: Command Configurable Messages

Byte	0	1	2	3	4	5	6	7
Bit	0 – 7	8 – 15	16 - 23	24 – 31	32 – 39	40 – 47	48 – 55	56-63
Usage	Configurable Bytes 0 - 7							

Format	Priority	PGNs	PDU Formats	PDU Specific	Source Address
J1939	6	0xB100 0xB200 0xB300 0xB400 0xB500 0xB600 0xB700 0xB800	0xB1 0xB2 0xB3 0xB4 0xB5 0xB6 0xB7 0xB8	Inverter Source Address	Vehicle Controller Source Address

Data Item	Len	Gain	Offset	Units	Default	Min	Max
AC Frequency Command	16	1	0	Hz	-	0	64255
AC Current Limit	16	1	0	Arms	-	0	64255
AC Mode – 0 = Freq Mode – 1 = Volt Mode	3	-	-	-	-	-	-
AC Volts Command	16	1	0	Vrms	-	0	64255
DC Current Limit Ratio Generating	16	0.001	0	Ratio	-	0	64.255
DC Current Limit Ratio Motoring	16	0.001	0	Ratio	-	0	64.255
Generating Torque Limit	8	0.5	0	%	0	0	125
Motoring Torque Limit	8	0.5	0	%	0	0	125
DC Power Limit Ratio Generating	16	0.001	0	Ratio	-	0	64.255
DC Power Limit Ratio Motoring	16	0.001	0	Ratio	-	0	64.255
Speed Command	16	0.5	16000	RPM	0	-16000.0	16127.5
Secondary Speed Limiting Setpoint	16	1	0	RPM	0	0	64255
State Transition Command – 0 – 99 = Defined in OSM Diagram in User Manual and section 2.3.3 – 100-255 = Diagnostic Functions defined in section 2.3.5	8	-	-	-	-	-	-
3-Phase Short Enable – 0 = Disable 3-Phase Short – 1 = Enable 3-Phase Short – 2-255 = Reserved	8	-	-	-	-	-	-
Torque Command NM	16	0.1	3200	NM	0	-3200	3255.5

Torque Percent Command	16	0.00390625	125	%	0	-125	125.99
Volts Command	16	0.03125	0	V	0	0	2007.97
Brake Resistor On Volts	16	0.03125	0	V	0	0	2007.96875
Brake Resistor Off Volts	16	0.03125	0	V	0	0	2007.96875
Brake Resistor Duty	8	0.5	0	%	0	0	125
Brake Resistor Mode – 0 = Hysteretic only – 3 = Hysteretic and PWM->Use Commanded Duty Cycle	8	-	-	-	-	-	-
Secondary Voltage Limiting Setpoint	16	0.03125	0	V	0	0	2007.9
Flow Rate Command – 0 = High Flow – 1 = Low Flow	8	-	-	-	0	-	-

2.3.2. CAN Status Messages

Status messages are periodically broadcast by the inverter. These messages convey information such as inverter temperature, speed, torque, etc. Multiple status messages are defined for the inverter, however, not all messages may be needed for all applications.

2.3.2.1. Inverter Status 1 (Relative Torque/Speed)

This message is transmitted by the inverter. This message transmits relative torque and speed information.

Table 19: Inverter Status 1 (Relative Torque/Speed)

Byte	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Bit	0 – 7	8 – 15	16 – 23	24 – 31	32 – 39	40 - 47	48 – 55	56 – 63
Usage	0x79	0xFF	Average Torque Percent		Machine Speed		0xFF	0xFF

Format	**Transmit Rate**	**Priority**	**PGN**	**PDU Format**	**PDU Specific**	**Source Address**
Proprietary B	Configurable	4	0xFFFE	0xFF	0xFE	Inverter Source Address

Data Item	**Start Bit**	**Len**	**Gain**	**Offset**	**Units**	**Default**	**Min**	**Max**
Command Byte 1	0	8	-	-	-	121 (0x79)	-	-
Unused	8	8	-	-	-	255 (0xFF)	-	-
Average Torque Percent	16	16	.00390625	125	%	0	-125	125.996 09375
Machine Speed	32	16	0.5	16000	RPM	0	-16000	16127.5
Unused	8	8	-	-	-	255 (0xFF)	-	-
Unused	8	8	-	-	-	255 (0xFF)	-	-

2.3.2.2. Inverter Status 2 (State/Voltage)

This message is transmitted by the inverter. This message transmits state and DC bus voltage information.

Table 20: Inverter Status 2 (State/Voltage)

Byte	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	
Bit	0 – 7	8 – 15	16 – 23	24 – 31	32 – 39	40 - 47	48 – 55	56 – 60	61 - 63
Usage	0x77	0xFF	Motor Control Unit State	DC Bus Volts		Derate Owner	Diagnostics Function		Diagnostics Status

Format	**Transmit Rate**	**Priority**	**PGN**	**PDU Format**	**PDU Specific**	**Source Address**
Proprietary B	Configurable	4	0xFFFE	0xFF	0xFE	Inverter Source Address

Data Item	**Start Bit**	**Len**	**Gain**	**Offset**	**Units**	**Default**	**Min**	**Max**
Command Byte 1	0	8	-	-	-	119 (0x77)	-	-
Unused	8	8	-	-	-	255 (0xFF)	-	-
Motor Control Unit State – Defined in Section 2.3.4	16	8	1	0	-	0	0	250
DC Bus Volts	24	16	0.03125	0	V	0	0	2007.96875
Derate Owner – Defined in Section 2.3.6	40	8	1	0	-	-	0	250
Diagnostics Function – Defined in Section 2.3.5	48	13	1	0	-	255	0	8186
Diagnostics Status – 0 = Not running – 1 = Running – 2 = Failed – 3 = Passed – 4 = Unable to start	61	3	1	0	-	-	0	4

2.3.2.3. Inverter Status 3 (Absolute Torque/Speed)

This message is transmitted by the inverter. This message transmits absolute torque and speed information.

Table 21: Inverter Status 3 (Absolute Torque/Speed)

Byte	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Bit	0 – 7	8 – 15	16 – 23	24 – 31	32 – 39	40 - 47	48 – 55	56 – 63
Usage	0x00	0x51	Average Absolute Torque		Machine Speed		0xFF	0xFF

Format	**Transmit Rate**	**Priority**	**PGN**	**PDU Format**	**PDU Specific**	**Source Address**
Proprietary B	Configurable	4	0xFFFB	0xFF	0xFB	Inverter Source Address

Data Item	**Start Bit**	**Len**	**Gain**	**Offset**	**Units**	**Default**	**Min**	**Max**
Command Byte 1	0	8	-	-	-	0 (0x00)	-	-
Command Byte 2	8	8	-	-	-	81 (0x51)	-	-
Average Absolute Torque	16	16	0.1	3200	Nm	0	-3200	3255.5
Machine Speed	32	16	0.5	16000	RPM	0	-16000	16127.5
Unused	48	8	-	-	-	255 (0xFF)	-	-
Unused	56	8	-	-	-	255 (0xFF)	-	-

2.3.2.1. Inverter Status 4 (Torque/Power Stage/Overload)

This message is transmitted by the inverter. This message transmits available torque, power stage status, and overload percent.

Table 22: Inverter Status 4 (Torque/Power Stage/Overload)

Byte	0	1	2	3	4	5	6	7
Bit	0 – 7	8 – 15	16 – 23	24 – 31	32 – 39	40 - 47	48 – 55	56 – 63
Usage	0x32	0xFF	Negative Torque Available		Positive Torque Available		Power Stage Status	Overload Percent

Format	Transmit Rate	Priority	PGN	PDU Format	PDU Specific	Source Address
Proprietary B	Configurable	4	0xFFF4	0xFF	0xF4	Inverter Source Address

Data Item	Start Bit	Len	Gain	Offset	Units	Default	Min	Max
Command Byte 1	0	8	-	-	-	50 (0x32)	-	-
Command Byte 2	8	8	-	-	-	255 (0xFF)	-	-
Negative Torque Available	16	16	0.1	3200	Nm	0	-3200	3255.5
Positive Torque Available	32	16	0.1	3200	Nm	0	-3200	3255.5
Power Stage Status – 0 = Outputs Off – 1 = Normal Switching – 2 = High Side Three Phase Short – 3 = Low Side Three Phase Short	48	8	1	0	-	0	0	250
Overload Percent	56	8	0.5	0	%	0	0	125

2.3.2.2. Inverter Temperature 1 (IGBT)

This message is transmitted by the inverter. This message transmits IGBT temperature information.

Table 23: Inverter Temperature 1 (IGBT)

Byte	0	1	2	3	4	5	6	7
Bit	0 – 7	8 – 15	16 - 23	24 – 31	32 – 39	40 – 47	48 – 55	56 – 63
Usage	0x90	IGBT 1 Temp	IGBT 2 Temp	IGBT 3 Temp	IGBT 4 Temp	IGBT 5 Temp	IGBT 6 Temp	Brake Chopper Temp

Format	Transmit Rate	Priority	PGN	PDU Format	PDU Specific	Source Address
Proprietary B	Configurable	6	0xFFFE	0xFF	0xFE	Inverter Source Address

Data Item	Start Bit	Len	Gain	Offset	Units	Default	Min	Max
Command Byte 1	0	8	-	-	-	144 (0x90)	-	-
IGBT 1 Temp	8	8	1	40	°C	-	-40	210
IGBT 2 Temp	16	8	1	40	°C	-	-40	210
IGBT 3 Temp	24	8	1	40	°C	-	-40	210
IGBT 4 Temp	32	8	1	40	°C	-	-40	210
IGBT 5 Temp	40	8	1	40	°C	-	-40	210
IGBT 6 Temp	48	8	1	40	°C	-	-40	210
Brake Chopper IGBT Temp	56	8	1	40	°C	-	-40	210

2.3.2.3. Inverter Temperature 2 (Machine/Inverter)

This message is transmitted by the inverter. This message transmits machine and inverter temperature information.

Table 24: Inverter Temperature 2 (Machine/Inverter)

Byte	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Bit	0 – 7	8 – 15	16 - 23	24 – 31	32 – 39	40 – 47	48 – 55	56 – 63
Usage	0xE4	Motor Temp 1	Motor Temp 2	Motor Temp 3	0xFF	Brake Resistor Temp	Control Board Temp	Inverter Coolant Temp

Format	**Transmit Rate**	**Priority**	**PGN**	**PDU Format**	**PDU Specific**	**Source Address**
Proprietary B	Configurable	6	0xFFFF	0xFF	0xFF	Inverter Source Address

Data Item	**Start Bit**	**Len**	**Gain**	**Offset**	**Units**	**Default**	**Min**	**Max**
Command Byte 1	0	8	-	-	-	228 (0xE4)	-	-
Motor Temp 1	8	8	1	40	°C	0	-40	210
Motor Temp 2	16	8	1	40	°C	0	-40	210
Motor Temp 3	24	8	1	40	°C	0	-40	210
Unused	32	8	-	-	-	255 (0xFF)	-	-
Brake Resistor Temp	40	8	1	40	°C	0	-40	210
Control Board Temp	48	8	1	40	°C	0	-40	210
Inverter Coolant Temp	56	8	1	40	°C	0	-40	210

2.3.2.4. Prognostics Message 1 (RMS Current)

This message is transmitted by the inverter. This message transmits RMS current information.

Table 25: Prognostics Message 1 (RMS Current)

Byte	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Bit	0 – 7	8 – 15	16 - 23	24 – 31	32 – 39	40 – 47	48 – 55	56 – 63
Usage	0x7A	Machine RMS Current Phase A		Machine RMS Current Phase B		Machine RMS Current Phase C		Brake Resistor RMS Current

Format	**Transmit Rate**	**Priority**	**PGN**	**PDU Format**	**PDU Specific**	**Source Address**
Proprietary B	Configurable	6	0xFFFE	0xFF	0xFE	Inverter Source Address

Data Item	**Start Bit**	**Len**	**Gain**	**Offset**	**Units**	**Default**	**Min**	**Max**
Command Byte 1	0	8	-	-	-	122 (0x7A)	-	-
Machine RMS Current Phase A	8	16	0.0625	0	A	0	0	4015.9375
Machine RMS Current Phase B	24	16	0.0625	0	A	0	0	4015.9375
Machine RMS Current Phase C	40	16	0.0625	0	A	0	0	4015.9375
Brake Resistor RMS Current	56	8	1	0	A	0	0	64255

2.3.2.5. Prognostics Message 2 (Diagnostic)

This message is transmitted by the inverter. This message transmits diagnostic information.

Table 26: Prognostics Message 2 (Diagnostic)

Byte	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Bit	0 – 7	8 – 15	16 - 23	24 – 31	32 – 39	40 – 47	48 – 55	56 – 63
Usage	0xF7	Brake Resistance		DC Link Capacitance		Motor BEMF		EMI Capacitance

Format	Transmit Rate	Priority	PGN	PDU Format	PDU Specific	Source Address
Proprietary B	On Change	6	0xFFFE	0xFF	0xFE	Inverter Source Address

Data Item	Start Bit	Len	Gain	Offset	Units	Default	Min	Max
Command Byte 1	0	8	-	-	-	247 (0xF7)	-	-
Brake Resistance	8	16	0.5	0	mΩ	0	0	32127.5
DC Link Capacitance	24	16	0.5	0	µF	0	0	32127.5
Motor BEMF	40	16	0.000030517578125	0	V/RPM	0	0	1.96090
EMI Capacitance	56	8	32	0	nF	0	0	8000

2.3.2.6. Prognostics Message 3 (Diagnostic)

This message is transmitted by the inverter. This message transmits diagnostic information.

Table 27: Prognostics Message 3 (Diagnostic)

Byte	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Bit	0 – 7	8 – 15	16 - 23	24 – 31	32 – 39	40 – 47	48 – 55	56 – 63
Usage	0xF8	Machine Speed 200ms Average		Machine Torque Percent 200ms Average		0xFF	0xFF	0xFF

Format	Transmit Rate	Priority	PGN	PDU Format	PDU Specific	Source Address
Proprietary B	Configurable	6	0xFFFE	0xFF	0xFE	Inverter Source Address

Data Item	Start Bit	Len	Gain	Offset	Units	Default	Min	Max
Command Byte 1	0	8	-	-	-	248 (0xF8)	-	-
Machine Speed 200ms Average	8	16	0.5	16000	RPM	0	-16000	16127.5
Machine Torque Percent 200ms Average	24	16	0.00390625	125	%	0	-125	125.99
Unused	40	8	-	-	-	0xFF	-	-
Unused	48	8	-	-	-	0xFF	-	-
Unused	56	8	-	-	-	0xFF	-	-

2.3.2.7. Prognostics Message 5 (Position)

This message is transmitted by the inverter. This message transmits position offset information.

Table 28: Prognostics Message 5 (Position)

Byte	0	1	2	3	4	5	6	7
Bit	0 – 7	8 – 15	16 - 23	24 – 31	32 – 39	40 – 47	48 – 55	56 – 63
Usage	0x81	0xFF	Stored Position Offset		Calculated Position Offset		0xFF	0xFF

Format	Transmit Rate	Priority	PGN	PDU Format	PDU Specific	Source Address
Proprietary B	On Change	6	0xFFFE	0xFF	0xFE	Inverter Source Address

Data Item	Start Bit	Len	Gain	Offset	Units	Default	Min	Max
Command Byte 1	0	8	-	-	-	129 (0x81)	-	-
Unused	8	8	-	-	-	0xFF	-	-
Stored Position Offset	16	16	0.0078125	0	Elec. Degrees	0	0	501.9921875
Calculated Position Offset	32	16	0.0078125	0	Elec. Degrees	0	0	501.9921875
Unused	48	8	-	-	-	0xFF	-	-
Unused	56	8	-	-	-	0xFF	-	-

2.3.2.8. **Motor Feed Forward**

This message is transmitted by the inverter on HS CAN. This message transmits feedforward power information.

Table 29: Motor Feed Forward

Byte	**0**	**1**	**2**	**3**
Bit	0 – 7	8 – 15	16 - 23	24 – 31
Usage	Motor Power			

Format	**Transmit Rate**	**Priority**	**PGN**	**PDU Format**	**PDU Specific**	**Source Address**
Proprietary B	Configurable	4	0xFF24	0xFF	0x24	Inverter Source Address

Data Item	**Start Bit**	**Len**	**Gain**	**Offset**	**Units**	**Default**	**Min**	**Max**
Motor Power	0	32	1	2000000000	W	0	-2000000000	2211081215

2.3.2.9. **Generator Heartbeat**

This message is transmitted by the inverter on HS CAN. This message transmits status information.

Table 30: Generator Heartbeat

Byte	**0**	**1**	**2**	**3**
Bit	0 – 7	8 – 15	16 - 23	24 – 31
Usage	Machine Power		Machine Enabled	Source Address

Format	**Transmit Rate**	**Priority**	**PGN**	**PDU Format**	**PDU Specific**	**Source Address**
Proprietary B	Configurable	4	0xFF25	0xFF	0x25	Inverter Source Address

Data Item	**Start Bit**	**Len**	**Gain**	**Offset**	**Units**	**Default**	**Min**	**Max**
Machine Power	0	16	0.5	16000	kW	0	-16000	16127.5
Machine Enabled – 0 = Disabled – 1 = Enabled	16	8	1	0	-	0	0	250
Source Address	24	8	1	0	-	-	0	250

2.3.2.10. Slave Status Message (Torque Sharing)

This message is transmitted by the inverter. This message transmits information used for the torque sharing feature and is transmitted by the slave inverter.

Table 31: Slave Status Message (Torque Sharing)

Byte	0	1	2	3	4	5	6	7
Bit	0 – 7	8 – 15	16 - 23	24 – 31	32 – 39	40 – 47	48 – 55	56 – 63
Usage	0xCE	0xFF	Motor Control Unit State	Motoring Torque Percent Limit	Generating Torque Percent Limit	Reference Torque Out		0xFF

Format	Transmit Rate	Priority	PGN	PDU Format	PDU Specific	Source Address
Proprietary B	Configurable	2	0xFFF8	0xFF	0xF8	Inverter Source Address

Data Item	Start Bit	Len	Gain	Offset	Units	Default	Min	Max
Command Byte 1	0	8	-	-	-	206 (0xCE)	-	-
Unused	8	8	-	-	-	0xFF	-	-
Motor Control Unit State – Defined in Section 2.3.4	16	8	1	0	-	0	0	255
Motoring Torque Percent Limit	24	8	0.5	0	%	0	0	125
Generating Torque Percent Limit	32	8	0.5	0	%	0	0	125
Reference Torque Out	40	16	1	0	NM	0	0	64255
Unused	56	8	-	-	-	0xFF	-	-

2.3.2.11. **AC Supply Status**

This message is transmitted by the inverter. This message transmits AC Supply voltage command (at the inverter terminals), frequency command, and voltage desired (at the load).

Table 32: AC Supply Status

Byte	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Bit	0 – 7	8 – 15	16 - 23	24 – 31	32 – 39	40 – 47	48 – 55	56 – 63
Usage	0x31	0xFF	AC Voltage Output		AC Frequency		AC Voltage Desired	

Format	**Transmit Rate**	**Priority**	**PGN**	**PDU Format**	**PDU Specific**	**Source Address**
Proprietary B	Configurable	4	0xFFF4	0xFF	0xF4	Inverter Source Address

Data Item	**Start Bit**	**Len**	**Gain**	**Offset**	**Units**	**Default**	**Min**	**Max**
Command Byte 1	0	8	-	-	-	49 (0x31)	-	-
Unused	8	8	-	-	-	0xFF	-	-
AC Voltage Command	16	16	1	0	Vrms	0	0	64255
AC Frequency	32	16	1	0	Hz	0	0	64255
AC Voltage Desired	48	16	1	0	Vrms	0	0	64255

2.3.2.1. DC Link Power Status

This message is transmitted by the inverter. This message transmits the actual DC Link Power Ratio value along with the maximum available power motoring and generating ratios. The ratio will be based off of a user defined reference power in mW.

Table 33: DC Link Power Status

Byte	0	1	2	3	4	5	6	7
Bit	0 – 7	8 – 15	16 - 23	24 – 31	32 – 39	40 – 47	48 – 55	56 – 63
Usage	0x00	0x56	Actual Power		Max Power Generating		Max Power Motoring	

Format	Transmit Rate	Priority	PGN	PDU Format	PDU Specific	Source Address
Proprietary B	Configurable	4	0xFFFB	0xFF	0xFB	Inverter Source Address

Data Item	Start Bit	Len	Gain	Offset	Units	Default	Min	Max
Command Byte 1	0	8	-	-	CMD	0 (0x00)	-	-
Command Byte 2	8	8	-	-	CMD	86 (0x56)	-	-
Actual Power	16	16	0.001	32	Ratio	-	0	32.255
Max Power Generating	32	16	0.001	0	Ratio	-	0	64.255
Max Power Motoring	48	16	0.001	0	Ratio	-	0	64.255

2.3.2.1. **DC Link Current Status**

This message is transmitted by the inverter. This message transmits the actual DC Link Current Ratio value along with the maximum available current motoring and generating ratios. The ratio will be based off of a user defined reference current in mA.

Table 34: DC Link Current Status

Byte	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Bit	0 – 7	8 – 15	16 - 23	24 – 31	32 – 39	40 – 47	48 – 55	56 – 63
Usage	0x36	0xFF	Actual Current		Max Current Generating		Max Current Motoring	

Format	**Transmit Rate**	**Priority**	**PGN**	**PDU Format**	**PDU Specific**	**Source Address**
Proprietary B	Configurable	5	0xFFF4	0xFF	0xF4	Inverter Source Address

Data Item	**Start Bit**	**Len**	**Gain**	**Offset**	**Units**	**Default**	**Min**	**Max**
Command Byte 1	0	8	-	-	CMD	54 (0x36)	-	-
Command Byte 2	8	8	-	-	CMD	255 (0xFF)	-	-
Actual Current	16	16	0.001	32	Ratio	-	0	32.255
Max Current Generating	32	16	0.001	0	Ratio	-	0	64.255
Max Current Motoring	48	16	0.001	0	Ratio	-	0	64.255

2.3.2.2. Voltage RMS 1

This message is transmitted by the inverter. This message transmits RMS voltage information.

Table 35: Voltage RMS 1

Byte	0	1	2	3	4	5	6	7
Bit	0 – 7	8 – 15	16 - 23	24 – 31	32 – 39	40 – 47	48 – 55	56 – 63
Usage	0x00	0x54	RMS Voltage Phase A		RMS Voltage Phase B		RMS Voltage Phase C	

Format	Transmit Rate	Priority	PGN	PDU Format	PDU Specific	Source Address
Proprietary B	Configurable	6	0xFFFB	0xFF	0xFB	Inverter Source Address

Data Item	Start Bit	Len	Gain	Offset	Units	Default	Min	Max
Command Byte 1	0	8	-	-	-	0 (0x00)	-	-
Command Byte 2	8	8	-	-	-	84 (0x54)	-	-
RMS Voltage Phase A	16	16	0.03125	0	V	0	0	2007.96875
RMS Voltage Phase B	32	16	0.03125	0	V	0	0	2007.96875
RMS Voltage Phase C	48	16	0.03125	0	V	0	0	2007.96875

2.3.2.3. Status Configurable Messages

The inverter supports up to 8 configurable status messages as defined by J1939-74. The PGN's for these messages are listed. If the standard messages defined above are undesirable for your application, a configurable message may be used. The various data items that can be added to the configurable messages are listed below. The configuration of these messages is stored in the EOL file that gets programmed onto the inverter.

Table 36: Status Configurable Messages

Byte	0	1	2	3	4	5	6	7
Bit	0 – 7	8 – 15	16 - 23	24 – 31	32 – 39	40 – 47	48 – 55	56-63
Usage	Configurable Bytes 0 - 7							

Format	Priority	PGNs	PDU Formats	PDU Specific	Source Address
J1939	6	0xB900 0xBA00 0xBB00 0xBC00 0xBD00 0xBE00 0xBF00 0xC000	0xB9 0xBA 0xBB 0xBC 0xBD 0xBE 0xBF 0xC0	0xFF	Inverter Source Address

Data Item	Length	Gain	Offset	Units	Default	Min	Max
AC Voltage Command	16	1	0	Vrms	0	0	64255
AC Frequency	16	1	0	Hz	0	0	64255
AC Voltage Desired	16	1	0	Vrms	0	0	64255
DC Actual Current	16	0.001	32	Ratio	-	0	32.255
DC Max Current Generating	16	0.001	0	Ratio	-	0	64.255
DC Max Current Motoring	16	0.001	0	Ratio	-	0	64.255
DC Actual Power	16	0.001	32	Ratio	-	0	32.255
DC Max Power Generating	16	0.001	0	Ratio	-	0	64.255
DC Max Power Motoring	16	0.001	0	Ratio	-	0	64.255
RMS Voltage Phase A	16	0.03125	0	V	0	0	2007.96875
RMS Voltage Phase B	16	0.03125	0	V	0	0	2007.96875
RMS Voltage Phase C	16	0.03125	0	V	0	0	2007.96875
Machine Speed 200ms Average	16	0.5	16000	RPM	0	-16000	16127.5
Machine Torque Percent 200ms Average	16	0.00390625	125	%	0	-125	125.99
Machine RMS Current Phase A	16	0.0625	0	A	0	0	4015.9375
Machine RMS Current Phase B	16	0.0625	0	A	0	0	4015.9375
Machine RMS Current Phase C	16	0.0625	0	A	0	0	4015.9375
Brake Resistor RMS Current	8	1	0	A	0	0	64255
Motor Temp 1	8	1	40	°C	0	-40	210

Motor Temp 2	8	1	40	°C	0	-40	210
Motor Temp 3	8	1	40	°C	0	-40	210
Brake Resistor Temp	8	1	40	°C	0	-40	210
Control Board Temp	8	1	40	°C	0	-40	210
Inverter Coolant Temp	8	1	40	°C	0	-40	210
IGBT 1 Temp	8	1	40	°C	-	-40	210
IGBT 2 Temp	8	1	40	°C	-	-40	210
IGBT 3 Temp	8	1	40	°C	-	-40	210
IGBT 4 Temp	8	1	40	°C	-	-40	210
IGBT 5 Temp	8	1	40	°C	-	-40	210
IGBT 6 Temp	8	1	40	°C	-	-40	210
Brake Chopper IGBT Temp	8	1	40	°C	-	-40	210
Negative Torque Available	16	0.1	3200	Nm	0	-3200	3255.5
Positive Torque Available	16	0.1	3200	Nm	0	-3200	3255.5
Power Stage Status – 0 = Outputs Off – 1 = Normal Switching – 2 = High Side Three Phase Short – 3 = Low Side Three Phase Short	8	1	0	-	0	0	250
Overload Percent	8	0.5	0	%	0	0	125
Average Absolute Torque	16	0.1	3200	Nm	0	-3200	3255.5
Machine Speed	16	0.5	16000	RPM	0	-16000	16127.5
Motor Control Unit State – Defined in Section 2.3.4	8	1	0	-	0	0	250
DC Bus Volts	16	0.03125	0	V	0	0	2007.96875
Derate Owner – Defined in Section 2.3.6	8	1	0	-	-	0	250
Diagnostics Function – Defined in Section 2.3.5	13	1	0	-	255	0	8186
Diagnostics Status – 0 = Not running – 1 = Running – 2 = Failed – 3 = Passed – 4 = Unable to start	3	1	0	-	-	0	4
Average Torque Percent	16	.00390625	125	%	0	-125	125.99609375
Flow Rate Status – 0 = High Flow – 1 = Low Flow – 2 = No Flow	8	1	0	-	-	0	2

2.3.3. State Transition Command

- 0 = No Change
- 3 = Standby to Functional Diagnostics
- 6 = Power Ready to Power Diagnostics
- 8 = Drive Ready to Normal Operation
- 9 = Normal Operation to Discharge Diagnostics
- 15 = Fault Class A to Standby
- 16 = Ignition Ready to Advanced Diagnostics Class A
- 17 = Fault Class A to Advanced Diagnostics Class A
- 22 = Fault Class B to Power Ready
- 23 = Normal Operation to Drive Ready
- 24 = Power Ready to Advanced Diagnostics Class B
- 25 = Fault Class B to Advanced Diagnostics Class B
- 26 = Drive Ready to Advanced Diagnostics Class B
- 29 = Class B to Fail Safe
- 31 = Fault Class B/Advanced Diagnostics Class B to Fail Safe
- 35 = Power Ready to Drive Ready
- 37 = Standby to Advanced Diagnostics Class A
- 38 = Standby to Ignition Ready
- 91 = Advanced Diagnostics Class B to Power Ready
- 92 = Advanced Diagnostics Class A to Standby
- 93 = Fault Class B to Standby
- 94 = Ignition Ready to Standby
- 95 = Power Ready to Standby
- 96 = Drive Ready to Standby
- 97 = Normal Operation to Standby
- 98 = Normal Operation to Power Ready
- 99 = Drive Ready to Power Ready

2.3.4. Motor Control Unit State Definitions

- 0 = Power Up
- 0 = Standby
- 1 = Functional Diagnostics
- 2 = Fault Class A
- 3 = Ignition Ready
- 4 = Power Ready
- 5 = Power Diagnostics
- 6 = Drive Ready
- 8 = Normal Operation
- 9 = Fault Class B
- 10 = Controlled Power Down
- 11 = Fail Safe
- 13 = Advanced Diagnostics Class A
- 15 = Discharge Diagnostics
- 17 = Advanced Diagnostics Class B

2.3.5. Diagnostics Function

- 255 = Not in a diagnostic state
- 100 = Advanced Diagnostics A - Do nothing
- 102 = Advanced Diagnostics A - Current sensor zero offset calibration
- 103 = Advanced Diagnostics A – Phase A current sensor disable
- 104 = Advanced Diagnostics A - Phase A current sensor enable
- 105 = Advanced Diagnostics A – Phase B current sensor disable
- 106 = Advanced Diagnostics A – Phase B current sensor enable
- 107 = Advanced Diagnostics A – Phase C current sensor disable
- 108 = Advanced Diagnostics A – Phase C current sensor enable

- 109 = Advanced Diagnostics A - Brake resistor current sensor disable
- 110 = Advanced Diagnostics A - Brake resistor current sensor enable
- 111 = Advanced Diagnostics A - Winding temperature sensor A disable
- 112 = Advanced Diagnostics A - Winding temperature sensor A enable
- 113 = Advanced Diagnostics A - Winding temperature sensor B disable
- 114 = Advanced Diagnostics A - Winding temperature sensor B enable
- 115 = Advanced Diagnostics A - Winding temperature sensor C disable
- 116 = Advanced Diagnostics A - Winding temperature sensor C enable
- 118 = Advanced Diagnostics A - IGBT temperature sensor A disable
- 119 = Advanced Diagnostics A - IGBT temperature sensor A enable
- 120 = Advanced Diagnostics A - IGBT temperature sensor B disable
- 121 = Advanced Diagnostics A - IGBT temperature sensor B enable
- 122 = Advanced Diagnostics A - IGBT temperature sensor C disable
- 123 = Advanced Diagnostics A - IGBT temperature sensor C enable
- 136 = Advanced Diagnostics A - IGBT temperature sensor chopper disable
- 137 = Advanced Diagnostics A - IGBT temperature sensor chopper enable
- 138 = Advanced Diagnostics A - Brake resistor temperature sensor disable
- 139 = Advanced Diagnostics A - Brake resistor temperature sensor enable
- 140 = Advanced Diagnostics A - Functional Diagnostics Switch Test
- 200 = Advanced Diagnostics B - Do nothing
- 201 = Advanced Diagnostics B - Cable orientation
- 204 = Advanced Diagnostics B - Bleed down voltage check
- 207 = Advanced Diagnostics B - Motor position sensor calibration
- 208 = Advanced Diagnostics B - Generator position sensor calibration
- 209 = Advanced Diagnostics B - Power Diagnostics Generator Position Sensor/Cable Orientation Test

2.3.6. Derate Owner

- 0 = No Derate
- 1 = IGBT (Base Plate) Temperature Limit
- 2 = Winding Temperature Limit
- 4 = Speed Limiting
- 5 = Voltage Limiting
- 6 = Overload Current Protection (I2T) Fast Limit
- 11 = Direct Torque Limit (CAN Command)
- 12 = Terminal Voltage
- 13 = IGBT Junction Temperature
- 14 = Overload Current Protection (I2T) Slow Limit
- 16 = Peak Torque Curve
- 17 = User Defined Torque Curve
- 18 = Master Speed Torque Curve
- 20 = Current Limiting (includes Inverter Current Overload)
- 22 = Current Limiting(AC Supply)

2.4. Fault Handling

All faults are reported over the CAN bus using the standard J1939 DM1 diagnostics reporting message. The inverter periodically broadcasts the DM1 diagnostic messages at a rate of once per second. If there are no faults present, then 0 is transmitted for SPN and FMI and other information within the DM1 is set to 0xFF (unavailable). If more than one DTC is active, they are all transmitted in the same DM1 message using J1939 Transport Protocol. The following figure shows how the diagnostic information is formatted in the data field of the message assuming only one DTC is active:

Byte	0				1				2	3	4		5	
Bit	0 – 1	2 – 3	4 – 5	6 – 7	8 – 9	10 – 11	12 – 13	14 – 15	16-23	24–31	32–36	37–39	40-46	47
Usage	PL	AWL	RSL	MIL	FPL	FAWL	FRSL	FMIL	SPN		FMI	SPN	Occ. Count	C

Transmit Rate	Priority	PGN	PDU Format	PDU Specific	Source Address
1s	6	0xFECA	0xFE	0xCA	Inverter Source Address

Table 37: Data Field Formatting Detail For DM1 Message[5]

Name and Description	Value (no faults)	Min	Max
MIL — Multi Indicator Lamp Status – 0 = Lamp Off – 1 = Lamp On – 2 = Reserved Not Used – 3 = Reserved Not Used This status data is used with the FMIL to determine how the lamp is illuminated (on, flash slow, flash fast). This lamp is generally used to indicate an emissions-related fault. It is not used by the inverter, so its status is always set to 0.	0	0	3
FMIL — Flash Multi Indicator Lamp Status – 0 = Lamp Slow Flash – 1 = Lamp Fast Flash – 2 = Reserved Not Used – 3 = Lamp On Not Flashing This lamp status data is only meaningful if the MIL status is 1 (Lamp On). Like the MIL, it is not used by the inverter so its status is always set to 0.	0	0	3
RSL — Red Stop Lamp Status – 0 = Lamp Off – 1 = Lamp On – 2 = Reserved Not Used – 3 = Reserved Not Used This status data is used with the FMIL to determine how the lamp is illuminated (on, flash slow, flash fast). This lamp is used to indicate that a Critical fault occurred.	0	0	3

[5] Table copied from J1939 Specification for reference only.

Table 38: Data Field Formatting Detail For DM1 Message[6] (continued)

Name and Description	Value (no faults)	Min	Max
FRSL — Flash Red Stop Lamp Status – 0 = Lamp Slow Flash – 1 = Lamp Fast Flash – 2 = Reserved Not Used – 3 = Lamp On Not Flashing This lamp status data is only meaningful if the RSL status is 1 (Lamp On).	0	0	3
AWL — Amber Warning Lamp Status – 0 = Lamp Off – 1 = Lamp On – 2 = Reserved Not Used – 3 = Reserved Not Used This status data is used with the FAWL to determine how the lamp is illuminated (on, flash slow, flash fast). This lamp is used to indicate that a Non-Critical fault occurred.	0	0	3
FAWL — Flash Amber Warning Lamp Status – 0 = Lamp Slow Flash – 1 = Lamp Fast Flash – 2 = Reserved Not Used – 3 = Lamp On Not Flashing This lamp status data is only meaningful if the AWL status is 1 (Lamp On).	0	0	3
PL — Protect Lamp Status – 0 = Lamp Off – 1 = Lamp On – 2 = Reserved Not Used – 3 = Reserved Not Used This status data is used with the FPL to determine how the lamp is illuminated (on, flash slow, flash fast). It is not used by the inverter so its status is always set to 0.	0	0	3
FPL — Flash Protect Lamp Status – 0 = Lamp Slow Flash – 1 = Lamp Fast Flash – 2 = Reserved Not Used – 3 = Lamp On Not Flashing This lamp status data is only meaningful if the PL status is 1 (Lamp On). Like the PL, it is not used by the inverter, so its status is always set to 0.	0	0	3
SPN — Suspect Parameter Number This identifies the actual fault. Refer to the Inverter Fault List for the complete list of SPNs used by the inverter.	0	0	524,287
FMI — Failure Mode Identifier This identifies the type of failure detected for the fault. Rather than reporting that the fault exists or does not exist, this attempts to classify the degree or seriousness of the fault. Please refer to the Inverter Fault List for a complete list of all FMIs used by the inverter.[7] FMI codes are used to determine the type of fault and its severity. When identifying an actual fault, the FMI number must be monitored with its corresponding SPN number, since SPN numbers are sometimes used to indicate more than one type of fault.	0	0	31

[6] Table copied from J1939 Specification for reference only.
[7] Refer to SAE J1939-73, Appendix A for more complete information about Failure Mode Indicators.

Table 39: Data Field Formatting Detail For DM1 Message[8] (continued)

Name and Description	Start Bit	Bit Length	Value (no faults)	Min	Max
C — SPN Conversion Method This is always set to 0.	40	1	0	0	1
Occurrence Count This is the number of times the fault has been independently detected. Once the count reaches 126, it will stop incrementing and must be reset using a DM3 or DM11 message.	41	7	0	0	126

FMI Codes are used to determine the type of fault and its severity. When identifying an actual fault, the FMI number must be monitored with its corresponding SPN number, since SPN numbers are sometimes used to indicate more than one type of fault.

! Note

Although lamp statuses are part of the standard DM1 message, it is recommended that the system define when to light/flash lamps to the user based on faults broadcasted from the inverter. For this reason, JDES is not providing flash/lamp status within this documentation for each fault.

[8] Table copied from J1939 Specification for reference only.

Table 40: FMI Codes Used by Inverter

FMI No.	FMI Description (From J1939 Standard)	Specific Use in Inverter
0	Data valid but above normal operational range (most severe level).	This FMI covers faults that exceed critical thresholds such as overcurrents
1	Data valid but below normal operational range (most severe level).	Typically an under-voltage event on high-voltage supply or low-voltage battery connection that affect the operation of the inverter
2	Data erratic, intermittent, or incorrect.	Usually related to position feedback device or communication issue
3	Voltage above normal, or shorted to high source	Related to critical power supply voltages going too high
4	Voltage below normal, or shorted to low source	Related to critical power supply voltages going too low
5	Current below normal or open circuit	Phase missing faults
6	Current above normal or grounded circuit	Brake chopper failing to turn off
7	Mechanical system not responding or out of adjustment.	Typically only seen when phase cable connection is lost or inverter is trying to run without a motor connected
8	Abnormal frequency or pulse width or period.	Fault related to circuits that measure pulse widths, such as some temperature sensors, or produce PWM waveforms
9	Abnormal update rate.	Related to something not executing within a given time period
10	Abnormal rate of change	Related to something not executing within a given time period
11	Root cause not known.	Calibration failure for undetermined reason
12	Bad intelligent device or component	Watchdog failure
13	Out of calibration.	Usually inverter detects internal calibration is missing or inconsistent, or EOL or EEPROM checksum is incorrect
14	Special instructions.	Position not being calibrated
15	Data valid but above normal operating range (least severe level)	Motor and coolant temperature warnings
16	Data valid but above normal operational range (moderately severe level).	Overvoltage and over-speed events
17	Data valid but below normal operating range (least severe level)	Under voltage events
18	Data valid but below normal operational range (moderately severe level).	Under voltage lockout
31	Condition exists.	This is used for faults that exist, but have no other relevant characteristics

For the case where more than one DTC is active, the DM1 message will broadcast them using Transport Protocol, in the order of occurrence as shown below (only the relevant data fields are shown):
This implies that the data fields indicating the Lamp Status and Flash Lamp Status are determined by only the most critical or worst-case DTC in the message.

Bit	Status of All Lamps		1st DTC				2nd DTC					nth DTC			
DM1	Lamp Status	Flash Lamp Status	SPN	FMI	C	Occurrence	SPN	FMI	C	Occurrence	...	SPN	FMI	C	Occurrence

The section below defines the various DTC faults that may be reported by the DM1 message. In addition to broadcasting the DM1 message, the inverter will respond to DM1, DM2, DM3, DM5, DM11 and DM13 requests. Detailed descriptions of these other Diagnostic Messages are beyond the scope of this document, but a brief description is provided in the Definitions Table 3.