1 HUD Operational Modes and Voltage Range Strategies – CGEA 1.3

1.1 Functional Description

The Heads Up Display has several modes of operation for the purpose of performing various features during different ignition switch positions or operational modes. The HUD enters a sleep state where features are disabled when the Ignition is Off or ACC in order to reduce the key off current drain.
This section describes the operation of the four Heads Up Display power modes:

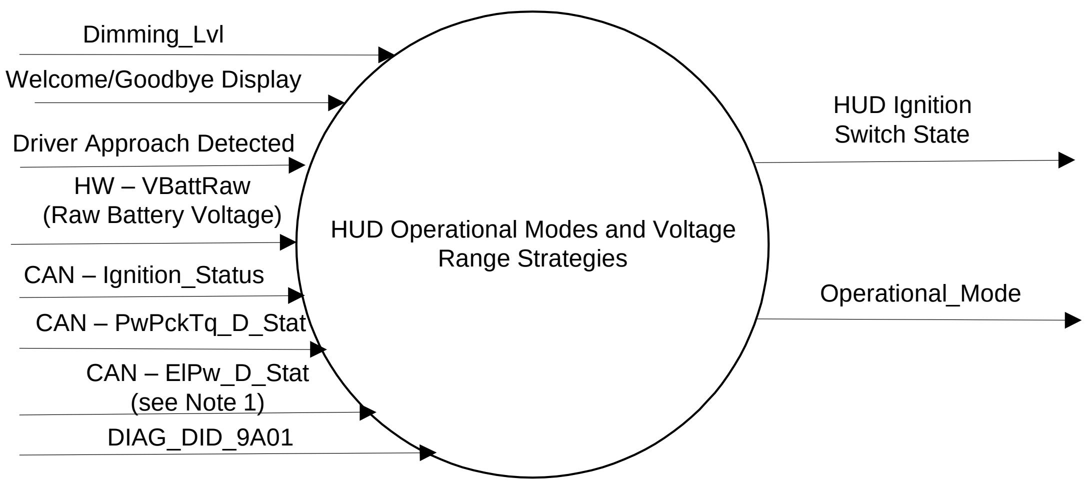
1. SLEEP Mode
2. LIMITED Mode
3. NORMAL Mode
4. CRANK Mode

Embedded within each power mode are the OVERVOLTAGE and the UNDERVOLTAGE protection modes. Examples of over/under voltage conditions include a battery connect (power removal where RAM is corrupted), a low voltage transient, a continuous low voltage condition, a high voltage transient, and a continuous high voltage condition. The detection system is comprised of a battery voltage monitor and optionally a reset indication. These items are used in the strategies described below to prevent spurious input state changes and output indications due to voltage changes, to allow different classes of features to be integrated together and to control various hardware power supplies under the detected conditions. The HUD micro samples the input Battery voltage and verifies it is within range for proper operation of all its features. If the voltage drops below or rises above certain thresholds, the microprocessor will shut down features based on the requirements below.

1.2 Interfaces

1.2.1 Interface Context Diagram (I/O Block Diagram)

Operational Modes and Voltage Range Stratagies



Note 1: ElPw_D_Stat is only required to be received and utilized in determining Diagnostic Vehicle Mode if the signal value of 0x3 (LV_Event_In_Progress) is transmitted on any vehicle programs that the HUD is present on.

1.2.2 Inputs

1.2.2.1 IR-REQ-301414/A-INTERNAL:

- DIAG_DID_9A01 (Operating Voltage)
- Welcome/Goodbye Display (From SSTS Welcome/Goodbye Stratagy)

- Backlighting (CAN Dimming_Lvl = 0 is OFF)
- Driver Approach Detected (From SSTS Welcome/Goodbye Stratagy)
- HW – VBattRaw (Raw Battery Voltage). This is the input used as the voltage monitor for features. This monitor may be chosen to be placed after the blocking diode.

1.2.2.2 MUX signals on the CAN Bus:

1.2.2.2.1 SIG-REQ-301410/A-Ignition_Status Signal

Signal Name	Size (bits)	Detail	Units	Res.	Offset	State Encoded	Min	Max
Ignition_Status	4		SED	1	0		0 (0x0)	15 (0xF)
		Unknown				0x0		
		Off				0x1		
		Accessory				0x2		
		Run				0x4		
		Start				0x8		
		Invalid				0xF		

1.2.2.2.2 SIG-REQ-301411/A-PwPckTq_D_Stat Signal

Signal Name	Size (bits)	Detail	Units	Res.	Offset	State Encoded	Min	Max
PwPckTq_D_Stat	2		SED	1	0		0 (0x0)	3 (0x3)
		PwPckOff_TqNotAvailable				0x0		
		PwPckOn_TqNotAvailable				0x1		
		StartInPrgrss_TqNotAvail				0x2		
		PwPckOn_TqAvailable				0x3		

1.2.2.2.3 SIG-REQ-301412/A-ElPw_D_Stat Signal

Signal Name	Size (bits)	Detail	Units	Res.	Offset	State Encoded	Min	Max
ElPw_D_Stat	3		SED	1	0		0 (0x0)	7 (0x7)
		Not_Supported				0x0		
		Supported				0x1		
		Not_Supported_Imminent				0x2		
		LV_Event_In_Progress				0x3		
		Fault_Limited				0x4		
		NotUsed_1				0x5		
		NotUsed_2				0x6		
		NotUsed_3				0x7		

1.2.2.2.4 SIG-REQ-301413/A-Dimming_Lvl Signal

Signal Name	Size (bits)	Detail	Units	Res.	Offset	State Encoded	Min	Max
Dimming_Lvl	8		SED	1	0		0 (0x0)	253 (0xFD)

		Off				0x0		
		Night_1				0x1		
		Night_2				0x2		
		Night_3				0x3		
		Night_4				0x4		
		Night_5				0x5		
		Night_6				0x6		
		Night_7				0x7		
		Night_8				0x8		
		Night_9				0x9		
		Night_10				0xA		
		Night_11				0xB		
		Night_12				0xC		
		Day_1				0xD		
		Day_2				0xE		
		Day_3				0xF		
		Day_4				0x10		
		Day_5				0x11		
		Day_6				0x12		
		Unknown				0xFE		
		Invalid				0xFF		

1.2.3 <u>IR-REQ-301415/A-Outputs</u>

- INTERNAL:
  - HUD Ignition Switch State
  - Operational_Mode

1.3 Function/Performance

1.3.1 F-REQ-301416/A-Operational Modes

Mode	Differentiating Vehicle Conditions
Sleep Mode	Determined per Figure 1.3-3, Operational Modes Flowchart
Limited Mode	Determined per Figure 1.3-3, Operational Modes Flowchart
Normal Mode	Determined per Figure 1.3-3, Operational Modes Flowchart
Crank Mode	Determined per Figure 1.3-3, Operational Modes Flowchart

1.3.2 SR-REQ-302446/A-Voltage Levels

All of the undervoltage limits in this section are maximum undervoltage value requirements. All of the overvoltage limits in this section are minimum overvoltage value requirements. **Nominal values must be set to insure the limits defined in this section are met over design tolerance**. It is also requested the limits set here be exceeded wherever possible without adding cost to the product. Further, it is requested a "stepped" shutdown (based on feature) be adopted. Different functions in HUD may have differing limits with respect to shutdown/overvoltage and adoption of a content based shutdown strategy which allows some limited operation outside the functional voltage limits is requested.

1.3.3 Human-Machine Interface

1.3.3.1 Visual

1.3.3.1.1 Indicator Graphics / Display Format

1.3.3.2 Audio

None.

1.3.4 PFM-REQ-301417/A-System Accuracy

Within a 100msec of receiving a message that results in a change of state the HUD will update Operational_Mode to the proper state.

1.3.5 Operation: Performance and Functional

1.3.5.1 All Modes

1.3.5.1.1 Feature Undervoltage/Overvoltage Values

All of the undervoltage/overvoltage limits are defined per feature in Section 1.2, Component Features – Customer Requirements in the Master SPSS. A minimal version table 1.3, Master HUD Features, is reproduced here to ensure consistency.

1.3.5.1.2 <u>SR-REQ-301441/A-Master HUD Features</u>

Category	Feature / Function	S/W Control	Guaranteed Functional Voltage Range	Operational_Mode
Display	Welcome Screen (*Personal Greetings, Calendar, Weather, Trafic, Trip readiness/Maintainance etc*)	X	9 – 16	***L, N, C
	Warning (*Forward Colition Warning*)	X	9 – 16	N, C
	Notification (*Incomming Call, Text, etc*)	X	9 – 16	N, C
	Navigation (including EH)	X	9 – 16	N, C
	ADAS (*ACC, ASLD, LKA, LDW, Park Aid - RVC, RPA, 360 deg view etc*)	X	9 – 16	N, C
	Control Mirror (*Radio tuning, Volume Climate, Gear Indication, Wiper speed, Voice, etc*)	X	9 – 16	N, C
	Information 1 (*Status bar - Veh Speed, Trafic Sign, OAT, DTE Compass, etc*)	X	9 – 16	N, C
	Information 2 (*Turn Signal, BLS*)	X	9 – 16	N, C
	Setting (*Image Adjustment - Vertical position, Brightness etc*)	X	9 – 16	N, C
Illumination	Display	X	9 – 16	L, N,C
Kinematics (only CHUD)	Combiner & Cover: Open/Close	X	9 – 16	L, N,C
Communication	INFOCAN Rx	X	9 – 16 (7 – 24)*	All
	INFOCAN Tx	X	9 – 16 (7 – 24)*	L, N, C
Diagnostics	DTC Logging for missing messages	X	9 – 16**	N
	Diagnostic States	X	9 – 16	N

Category	Feature / Function	S/W Control	Guaranteed Functional Voltage Range	Operational_Mode
	Engineering Test Mode	X	9 – 16	N, C

Notes: 1. * The preferred implementation is for the HUD to not shut down either the HSCAN or INFOCAN network due to abnormal voltage ranges. Thus, it is desired that the network attempt to work all the way down until micro reset. Correspondingly, it is recommended (but not a requirement) that the telltales that are network driven be expanded to the range noted in the parentheses.

2. ** This voltage range cannot be expanded. See section 1.3.5.7.5 DTC Logging Voltage ranges. Exceptions for overvoltage and undervoltage DTC's are discussed in section 1.4.
3. ***HUD display is expected to function down to 5.5V for 100ms to allow functionality in Crank
4. Operational_Mode: S = SLEEP, L = LIMITED, N = NORMAL, C = CRANK, All = S, L, N, C.

1.3.5.1.3 <u>SR-REQ-301442/A-Quiescent Current (Q-current)</u>

The quiescent current is defined as the average current draw over a 24 hour period since key was turned to off with the vehicle in normal shut down conditions. The HUD shall have a low power draw state that is entered when the key is in the OFF/ACC position and the vehicle is in "normal" shut down conditions. Normal vehicle level shut down conditions include the parklamps OFF and the key OUT. (The key IN and in the OFF position, door OPEN, headlamps ON, etc. are "possible" conditions that shall not prevent the HUD from entering low power draw state after applicable timers expire.)

For CGEA HUDs, the maximum quiescent current draw of the HUD in OFF/ACC cannot exceed 0.2mA. When HUD is required to display information in Limited Mode (e.g. Welcome Screen), it is allowed a current draw of no more than the maximum allowed in Normal Mode.
This Q-current specification shall be met at 12.8 volts from -40 degrees C to +40 degrees C.
(

1.3.5.1.4 Sleep Mode

Sleep mode is the power mode where the HUD resides in an "OFF" or low power draw state. In this mode, the HUD is in the following configuration:

A. The microcontroller core operates in a quiescent current mode.
B. All microcontroller controlled peripherals are shut down with the exception of the microcontroller's hardware polling port which will provide wake-up events during low power modes.
C. The microcontroller will optionally periodically wake up to keep track of real time for certain features (see applicable feature STSS). Note that this may be unnecessary if no feature on a given HUD requires real time. Preferred implementation is to have software operating system capable of supporting real time accumulation on a configurable basis.

Refer to Figure 1.3-3 Operational_Mode Flowchart for a list of events that will wake the HUD from sleep mode.

1.3.5.1.4.1 <u>SR-REQ-301418/A-Sleep Mode – Undervoltage</u>

An undervoltage condition is detected by the voltage level being measured by an onboard microcontroller comparator. To maintain Sleep mode current requirements, the onboard comparator may be disabled. The HUD is not required to detect an undervoltage condition while in sleep mode.

Here is a typical implementation, values are approximate:

If the battery voltage Vbatt falls below ~6.5 Vdc, the HUD will discharge its hold-up capacitance. When the voltage falls to 3 VDC, the microcontroller core comparator may perform a hardware RESET but EEPROM shall not be corrupted.

Note: Keep-Alive-Memory (KAM), and EEPROM shall implement a data integrity verification method and a fault containment strategy in case of corruption. See ECU Software Requirement #0008. Also, the hardware shall be designed to meet ELCOMP SDS EC-0043 (Power Supply Dropout Management), with a time of 20ms before a microprocessor reset occurs.

1.3.5.1.4.2 SR-REQ-301419/A-Sleep Mode - Overvoltage

An overvoltage condition is detected by the voltage level being measured by the microcontroller's A/D converter. During an overvoltage condition, the HUD shuts down certain peripherals to protect them from increased currents due to an overvoltage event. The HUD is not required to detect an overvoltage condition while in sleep mode.

1.3.5.1.5 Limited Mode

A HUD shall enter or be in Limited mode only when in ignition state OFF or ACCESSORY. Limited mode supports HUD functions as per Table 1.3, Master HUD Features.

When operating in Limited mode, the HUD's current draw shall be no more than 300 mA. When HUD is required to display information in Limited Mode (e.g. Welcome Screen), it is allowed a current draw of no more than the maximum allowed in Normal Mode.
Refer to Figure 1.3-3 Operational_Mode Flowchart for a list of events that will allow the HUD to transition from Normal mode to Limited mode, and from Limited mode to Sleep mode.

1.3.5.1.5.1 SR-REQ-301420/A-Limited Mode – Undervoltage

During low voltage events, a HUD in limited mode behaves as follows (reference Voltage Range Monitor for details):

7 Vdc<Vbatt < 9 Vdc: The features shown to operate in this voltage range in Table 1.3, Master HUD Features, will continue to operate as specified. All other HUD functions may be shut off. The HUD's A/D converter will remain active to monitor voltage recovery.

Here is a typical implementation, values are approximate:
If the battery voltage Vbatt falls below ~6.5 Vdc, the HUD will discharge its hold-up capacitance. When the voltage falls to 3 VDC, the microcontroller core comparator may perform a hardware RESET but EEPROM shall not be corrupted.

Note: Keep-Alive-Memory (KAM), and EEPROM shall implement a data integrity verification method and a fault containment strategy in case of corruption. See ECU Software Requirement #0008. Also, the hardware shall be designed to meet ELCOMP SDS EC-0043 (Power Supply Dropout Management), with a time of 20ms before a microprocessor reset occurs.

1.3.5.1.5.2 SR-REQ-301421/A-Limited Mode - Overvoltage

During high voltage events, a HUD in limited mode behaves as follows (reference Voltage Range Monitor for details):

16 Vdc < Vbatt ≤ 24 Vdc: The features shown to operate in this voltage range in Table 1.3, Master HUD Features, will continue to operate as specified. All other HUD functions may be shut off. The HUD's A/D converter will remain active to monitor voltage recovery.

1.3.5.1.6 Normal Mode

Normal mode represents the HUD's normal operating mode. Normal mode supports HUD functions as per Table 1.3, Master HUD Features. The maximum current draw of the HUD when in normal mode will be no more than 3.9A.

Refer to Figure 1.3-3 Operational_Mode Flowchart for a list of events that will allow the HUD to transition from Crank mode to Normal mode, and from Normal mode to Limited mode.

1.3.5.1.6.1 SR-REQ-301422/A-Normal Mode – Undervoltage

During low voltage events, a HUD in normal mode behaves as follows (reference Voltage Range Monitor for details):

7 Vdc<Vbatt < 9 Vdc: The features shown to operate in this voltage range in Table 1.3, Master HUD Features, will continue to operate as specified. All other HUD functions may be shut off. The HUD's A/D converter will remain active to monitor voltage recovery.

Here is a typical implementation, values are approximate:
If the battery voltage Vbatt falls below ~6.5 Vdc, the HUD will discharge its hold-up capacitance. When the voltage falls to 3 VDC, the microcontroller core comparator may perform a hardware RESET but EEPROM shall not be corrupted.

Note: Keep-Alive-Memory (KAM), and EEPROM shall implement a data integrity verification method and a fault containment strategy in case of corruption. See ECU Software Requirement #0008. Also, the hardware shall be designed to meet ELCOMP SDS EC-0043 (Power Supply Dropout Management), with a time of 20ms before a microprocessor reset occurs.

1.3.5.1.6.2 SR-REQ-301423/A-Normal Mode - Overvoltage

During high voltage events, a HUD in normal mode behaves as follows (reference Voltage Range Monitor for details):

16 Vdc < Vbatt ≤ 24 Vdc: The features shown to operate in this voltage range in Table 1.3, Master HUD Features, will continue to operate as specified. All other HUD functions may be shut off. The HUD's A/D converter will remain active to monitor voltage recovery.

1.3.5.1.7 Crank Mode

Crank mode represents the HUD's operating mode when in ignition state START (during engine cranking). The maximum current draw when the HUD is in Crank mode is 3.9 A. Crank mode supports HUD functions as per Table 1.3, Master HUD Features.

1.3.5.1.7.1 SR-REQ-301424/A-Crank Mode – Undervoltage

During low voltage events, a HUD in crank mode behaves as follows (reference Voltage Range Monitor for details):

7 Vdc<Vbatt < 9 Vdc: The features shown to operate in this voltage range in Table 1.3, Master HUD Features, will continue to operate as specified. All other HUD functions may be shut off. The HUD's A/D converter will remain active to monitor voltage recovery.

Here is a typical implementation, values are approximate:
If the battery voltage Vbatt falls below ~6.5 Vdc, the HUD will discharge its hold-up capacitance. When the voltage falls to 3 VDC, the microcontroller core comparator may perform a hardware RESET but EEPROM shall not be corrupted.

Note: Keep-Alive-Memory (KAM), and EEPROM shall implement a data integrity verification method and a fault containment strategy in case of corruption. See ECU Software Requirement #0008. Also, the hardware shall be designed to meet ELCOMP SDS EC-0043 (Power Supply Dropout Management), with a time of 20ms before a microprocessor reset occurs.

1.3.5.1.7.2 SR-REQ-301425/A-Crank Mode - Overvoltage

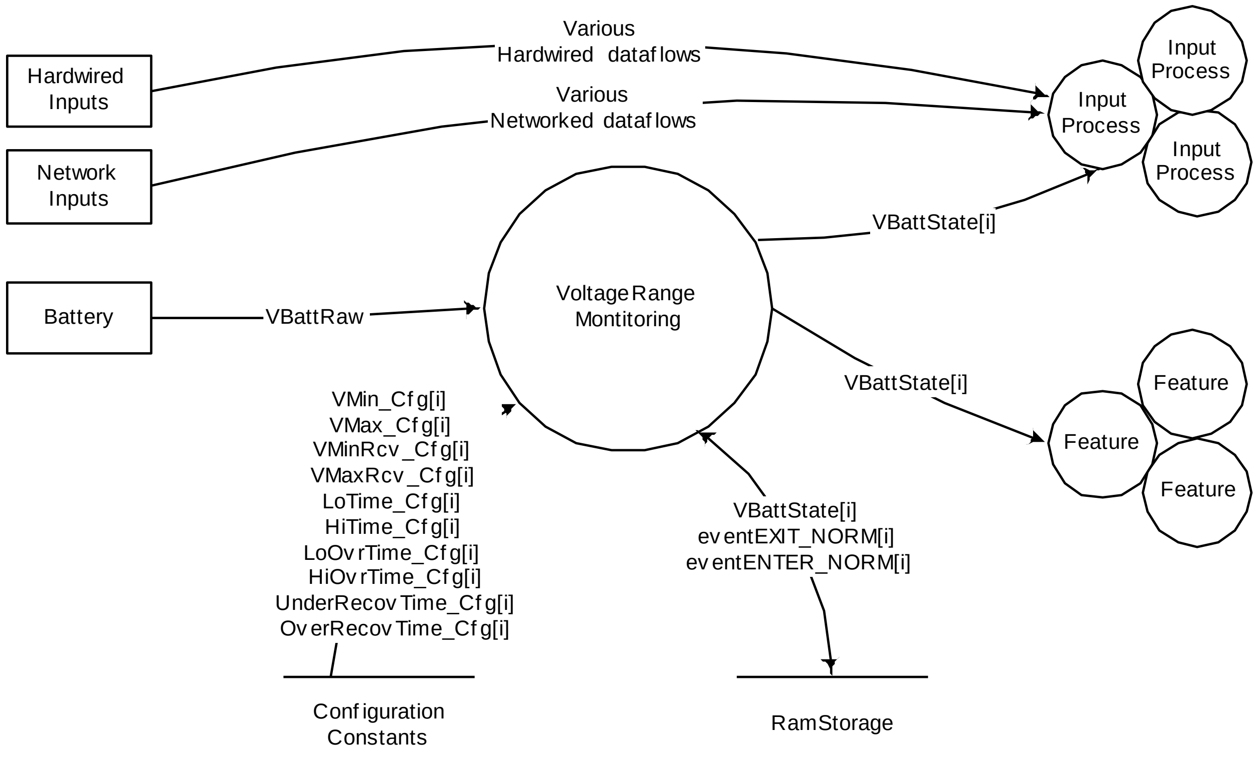
During high voltage events, a HUD in normal mode behaves as follows (reference Voltage Range Monitor for details):

16 Vdc < Vbatt ≤ 24 Vdc: The features shown to operate in this voltage range in Table 1.3, Master HUD Features, will continue to operate as specified. All other HUD functions may be shut off. The HUD's A/D converter will remain active to monitor voltage recovery.

1.3.5.1.8 Voltage Range Monitor

The fundamental intent of the Voltage Range Monitor requirements is to never trust an input that is out of its designed voltage range, and ensure that the debounce routines aren't using bad values.

1.3.5.1.8.1 SR-REQ-301449/A-VBATT Monitor & Input Sampling Controller Context Diagram



Notice in the Figure that the VBattState[i] dataflow is sent to both *Features* and *Input Processes*. VBattState[i] is sent to *Input Processes* so that input debounce routine can take appropriate action when the input circuits are no longer reliable. It is sent to the *Feature* so that the feature can respond to OVER_V and UNDER_V conditions (and possibly to LO_V and HI_V too).

A module may support several features. And since each feature may have a different operational voltage range, a module may have to deal with multiple *Voltage Ranges*. Driver Information uses five voltage ranges. Thus, there are 5 VbattState[i]'s, per Table 1.3, Master HUD Features. Where i = 9-16V, i = 7-24V, i = 8 – 18V, i = 7 – 18V, and i = DTC_Logging. Note that if the 9-16V range is expanded to 8-18V, then there are only 4 VbattState[I]'s.

A *voltage range* is defined to be in one of five different states. Table 1.4 lists all of these states along with the associated voltage definition, what is expected of the input processes and what is expected of the feature. Each voltage range is mapped to an entry in the VBattState[i] array.

1.3.5.1.8.2 SR-REQ-301426/A-VBattState[i] Defintions

VBattState[i]	Voltage	Input Processes	Feature Behavior
NORM_V	Normal	Sample all input channels	Normal feature behavior
LO_V	Temporary Low	Sample Vbatt and all applicable feature inputs	Feature operates normally (exceptions are noted in each feature SPSS, section 1.3.2 Voltage Levels)
HI_V	Temporary High	Sample Vbatt and all applicable feature inputs	Feature operates normally (exceptions are noted in each feature SPSS, section 1.3.2 Voltage Levels)
UNDER_V	Too low too long, Under Voltage	Only sample VBatt.	Feature may be shut off (to protect HW as necessary)
OVER_V	Too high too long, Over Voltage	Only sample VBatt.	Feature may be shut off (to protect HW as necessary)

A *Voltage Range* (and multiple *Voltage Ranges*) is defined by several dataflows arrays. A specific *Voltage Range* definition is accessed by using the same index in the dataflow arrays listed in Table 1.4.

Note that whenever VBatt is outside the normal range (NORM_V), VBattState[i] **immediately** changes to LO_V or HIGH_V and the input circuits can no longer be trusted.

1.3.5.1.8.3 SR-REQ-301427/A-“Voltage Range” Dataflows

Dataflow Name	Description
VMin_Cfg[i]	Defines minimum voltage for a *Voltage Range* (see Table 1.3, Master HUD Features)
VMax_Cfg[i]	Defines maximum voltage for a *Voltage Range* (see Table 1.3, Master HUD Features)
VMinRcv_Cfg[i]	Voltage hysteresis for recovering from an UNDER_V condition
VMaxRcv_Cfg[i]	Voltage hysteresis for recovering from an OVER_V condition
LoTime_Cfg[i]	Recovery time to NORM_V from LO_V
HiTime_Cfg[i]	Recovery time to NORM_V from HI_V
LoOvrTime_Cfg[i]	Defines the amount of time to wait in a low voltage (LO_V) condition before declaring an UNDER_V condition.

HiOvrTime_Cfg[i]	Defines the amount of time to wait in a high voltage (HI_V) condition before declaring an OVER_V condition.
UnderRecovTime_Cfg[i]	Defines the amount of time that the voltage must be above VMinRcv_Cfg[i] before recovering from an UNDER_V condition and allowing input sampling again.
OverRecovTime_Cfg[i]	Defines the amount of time that the voltage must be below VMaxRcv_Cfg[i] before recovering from an OVER_V condition and allowing input sampling again.
VBattState[i]	Current State of a specific *Voltage Range*.

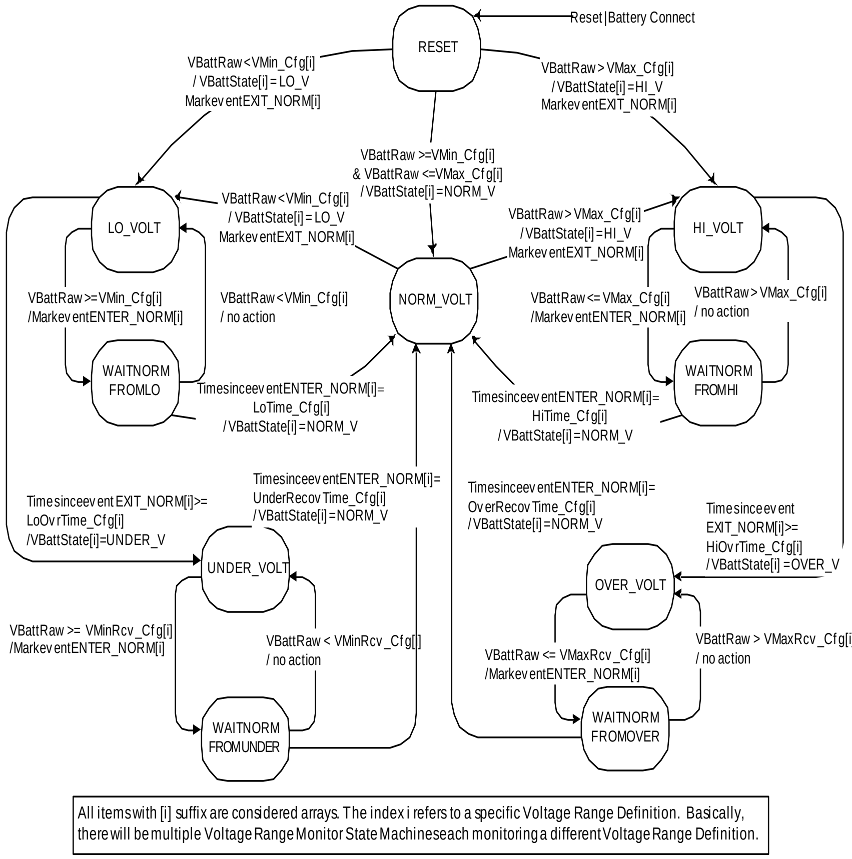
1.3.5.1.8.4 SR-REQ-301428/A-Basic Voltage Ranges Requirements

Input circuits may or may not be shared by several features. However, each input circuit will be designed to support a specific *voltage range*, which leads to these basic requirements.

1.3.5.1.8.5 SR-REQ-301429/A-Basic Voltage Range Requirements

Rqm't No.	**Requirement**
R: 1.00	Each feature must be mapped to one *Voltage Range* (each *Voltage Range* can support multiple features and input circuits)
R: 1.05	Each input circuit must be mapped to one *Voltage Range*.
R: 1.10	The *Voltage Range* of any input circuit must be at least as wide as the *Voltage Range* of any feature/function that uses the circuit.
R: 1.15	VBatt will always be readable (whenever the micro is running).
R: 1.20	If a feature is implemented without using a microprocessor, then the design must guarantee the fundamental concept in this document of not responding to input values when VBatt voltage makes the input circuit unreliable. The design must be approved in a Design Review.
R: 1.25	VBatt must be sampled every 10 milliseconds or faster.

1.3.5.1.8.6 SR-REQ-301430/A-Voltage Range State Machine



Voltage Range Monitoring, Finite State Machine (Reference ONLY)
(this is a reference to provide a conceptual view.
If any conflicts exist with the FSM table below, the FSM is master)

R: 2.00	Each defined *Voltage Range* must be evaluated using this state machine.

1.3.5.1.8.7 SR-REQ-301431/A-Finite State Machine for VBatt Monitor

Rqm't No.	Current State	Event	Action	Next State
R: 2.01	Any except RESET	Reset	(no action)	RESET
R: 2.10	RESET	VBattRaw > VMax_Cfg[i]	VBattState[i] = HI_V Mark event EXIT_NORM[i]	HI_VOLT
R: 2.11	RESET	VBattRaw < VMin_Cfg[i]	VBattState[i] = LO_V Mark event EXIT_NORM[i]	LO_VOLT
R: 2.12	RESET	VBattRaw ≤ VMax_Cfg[i] & VBattRaw ≥ VMin_Cfg[i]	VBattState[i] = NORM_V	NORM_VOLT
R: 2.20	NORM_VOLT	VBattRaw > VMax_Cfg[i]	VBattState[i] = HI_V Mark event EXIT_NORM[i]	HI_VOLT

Rqm't No.	Current State	Event	Action	Next State
R: 2.21	NORM_VOLT	VBattRaw < VMin_Cfg[i]	VBattState[i] = LO_V Mark event EXIT_NORM[i]	LO_VOLT
R: 2.30	HI_VOLT	VBattRaw ≤ VMax_Cfg[I]	Mark event ENTER_NORM[i]	WAIT NORM FROM HI
R: 2.31	HI_VOLT	Time since event EXIT_NORM[i] >= HiOvrTime_Cfg[i]	VBattState[i] = OVER_V	OVER_VOLT
R: 2.40	WAIT NORM FROM HI	VBattRaw > VMax_Cfg[i]	(no action)	HI_VOLT
R: 2.41	WAIT NORM FROM HI	Time since event ENTER_NORM[i] = HiTime_Cfg[i]	VBattState[i] = NORM_V	NORM_VOLT
R: 2.50	LO_VOLT	VBattRaw ≥ VMin_Cfg[i]	Mark event ENTER_NORM[i]	WAIT NORM FROM LO
R: 2.51	LO_VOLT	Time since event EXIT_NORM[i] >= LoOvrTime_Cfg[i]	VBattState[i] = UNDER_V	UNDER_VOLT
R: 2.60	WAIT NORM FROM LO	VBattRaw < VMin_Cfg[i]	(no action)	LO_VOLT
R: 2.61	WAIT NORM FROM LO	Time since event ENTER_NORM[i] = LoTime_Cfg[i]	VBattState[i] = NORM_V	NORM_VOLT
R: 2.70	OVER_VOLT	VBattRaw ≤ VMaxRcv_Cfg[i]	Mark event ENTER_NORM[i]	WAIT NORM FROM OVER
R: 2.80	WAIT NORM FROM OVER	VBattRaw > VMaxRcv_Cfg[i]	(no action)	OVER_VOLT
R: 2.81	WAIT NORM FROM OVER	Time since event ENTER_NORM[i] = OverRecovTime_Cfg[i]	VBattState[i] = NORM_V	NORM_VOLT
R: 2.90	UNDER_VOLT	VBattRaw ≥ VMinRcv_Cfg[i]	Mark event ENTER_NORM[i]	WAIT NORM FROM UNDER
R: 2.100	WAIT NORM FROM UNDER	VBattRaw < VMinRcv_Cfg[i]	(no action)	UNDER_VOLT
R: 2.101	WAIT NORM FROM UNDER	Time since event ENTER_NORM[i] = UnderRecovTime_Cfg[i]	VBattState[i] = NORM_V	NORM_VOLT

1.3.5.1.8.8 SR-REQ-301432/A-General Voltage ranges

Most of the HUD features have been defined to operate between 9 and 16 volts. The table below shows the applicable voltage range thresholds for this range. The values in the following tables may be modified with Ford Core Driver Information approval.

R: 3.00	Shown below in *Table 1.8 Voltage Range Configuration for9-16V Features*, are the Operating Voltages that have been specified and are to be monitored in dataflow VBattState[VRange_9-16]. (Reference *Table 1.4 - VBattState[i] Defintions* & *Table 1.5 - "Voltage Range" Dataflows*.) This voltage range may be merged into another, wider voltage range.

1.3.5.1.8.9 SR-REQ-301433/A-Voltage Range Thresholds for 9-16V Features

Rqm't No.	Dataflow/Other	Value	Description
R: 3.01	VMin_Cfg[VRange_9-16]	8.6 volts*	Minimum voltage threshold for 9 -16V features (This value selected with hardware tolerances taken into account to guarantee operation at 9 volts per WCCA)
R: 3.02	VMinRcv_Cfg[VRange_9-16]	9.0 volts*	Low voltage shutdown voltage hysteresis for recovery from UNDER_V
R: 3.03	VMax_Cfg[VRange_9-16]	16.9 volts*	Maximum voltage for 9 – 16V features (This value selected with hardware tolerances taken into account to guarantee operation at 16 volts per WCCA)
R: 3.04	VMaxRcv_Cfg[VRange_9-16]	16.4 volts*	High voltage shutdown voltage hysteresis for recovery from OVER_V
R: 3.05	LoTime_Cfg[VRange_9-16]	0 *m*sec	Recovery time to NORM_V from LO_V (1 sample)
R: 3.06	HiTime_Cfg[VRange_9-16]	0 *m*sec	Recovery time to NORM_V from HI_V (1 sample)
R: 3.07	LoOvrTime_Cfg[VRange_9-16]	500 *m*sec	LO_V too long, enter UNDER_V
R: 3.08	HiOvrTime_Cfg[VRange_9-16]	500 *m*sec	HI_V too long, enter OVER_V
R: 3.09	UnderRecovTime_Cfg[VRange_9-16]	500 *m*sec	Recovery time to NORM_V from UNDER_V
R: 3.10	OverRecovTime_Cfg[VRange_9-16]	500 *m*sec	Recovery time to NORM_V from OVER_V

* (typical but may be different per WCCA)

1.3.5.1.8.10 SR-REQ-301434/A-Shutdown Detection Voltage Range

Some HUD functions may be defined to operate between 7 and 24 volts. The table below shows the applicable voltage range thresholds for this range.

R: 4.00	Shown below in *Table 1.9 Voltage Range Thresholds for 7 – 24V Features* is the Shutdown Detection and Recovery voltages and are to be monitored in dataflow VBattState[VRange_7-24]. (Reference *Table 1.4 - VBattState[i] Defintions* & *Table 1.5 - "Voltage Range" Dataflows*.) This voltage range shall not be merged into another, wider voltage range. Note: for faster shutdown detection, battery voltage may be sampled using a sampling period less than 10 *m*sec, but the number of samples and the timing must be approved by Ford.

1.3.5.1.8.11 SR-REQ-301435/A-Voltage Range Thresholds for 7-24V Features

Rqm't No.	Dataflow/Other	Value	Description
R: 4.01	VMin_Cfg[VRange_7-24]	6.0 volts*	Low voltage shutdown for power dropout requirement in EMC spec.
R: 4.02	VMinRcv_Cfg[VRange_7-24]	8.0 volts*	Low voltage shutdown voltage hysteresis for recovery from UNDER_V
R: 4.03	VMax_Cfg[VRange_7-24]	25.0 volts*	No need for high voltage shutdown
R: 4.04	VMaxRcv_Cfg[VRange_7-24]	25.0 volts*	No need for high voltage shutdown
R: 4.05	LoTime_Cfg[VRange_7-24]	0 *m*sec	Recovery time to NORM_V from LO_V (1 sample)

R: 4.06	HiTime_Cfg[VRange_7-24]	0 *m*sec	Recovery time to NORM_V from HI_V (1 sample)
R: 4.07	LoOvrTime_Cfg[VRange_7-24]	0 *m*sec	LO_V too long, enter UNDER_V
R: 4.08	HiOvrTime_Cfg[VRange_7-24]	0 *m*sec	HI_V too long, enter OVER_V
R: 4.09	UnderRecovTime_Cfg[VRange_7-24]	0 *m*sec	Recovery time to NORM_V from UNDER_V
R: 4.10	OverRecovTime_Cfg[VRange_7-24]	0 *m*sec	Recovery time to NORM_V from OVER_V

* (typical but may be different per WCCA)

1.3.5.1.8.12 SR-REQ-301436/A-DTC Logging Voltage ranges

Some HUD features have allowed DTC reporting during voltage transients causing false DTCs to be logged. In order to avoid logging false DTCs, the *VRange_DTC* voltage range is defined. This voltage range must be used to avoid setting any false DTCs.

Rule – If you think you need to log a DTC outside this range, acquire permission from Ford EESE/DI.

R: 7.00	Shown below in *Table 1.10 - Voltage Range Configuration for DTC Logging* are the Operating Voltages that have been specified as critical for proper logging of Diagnostic_Trouble_Codes_Logging [VRange_DTC] and are to be monitored in dataflow VBattState[VRange_DTC]. (Reference *Table 1.4 - VBattState[i] Defintions* & *Table 1.5 - “Voltage Range” Dataflows*.) This voltage range shall not be merged into another, wider voltage range.
R: 7.01	When accounting for worst-case analysis, the ECU shall always report DTCs when the voltage is within the defined range (9v – 16 v). This means that DTCs will sometimes be set when the actual voltage (versus the ECU measured voltage) is outside this range.

1.3.5.1.8.13 SR-REQ-301437/A-Voltage Range Configuration for DTC Logging

Rqm't No.	Dataflow/Other	Value	Description
R: 7.01	VMin_Cfg[VRange_DTC]	8.6 volts*	Minimum voltage threshold for DTC reporting (This value selected with hardware tolerances taken into account to guarantee operation at 9 volts)
R: 7.02	VMinRcv_Cfg[VRange_DTC]	9.0 volts*	Low voltage shutdown voltage hysteresis for recovery from UNDER_V
R: 7.03	VMax_Cfg[VRange_DTC]	16.9 volts*	Maximum voltage for DTC reporting (This value selected with hardware tolerances taken into account to guarantee operation at 16 volts)
R: 7.04	VMaxRcv_Cfg[VRange_DTC]	16.4 volts*	High voltage shutdown voltage hysteresis for recovery from OVER_V
R: 7.05	LoTime_Cfg[VRange_DTC]	0 *m*sec	Recovery time to NORM_V from LO_V (1 sample)
R: 7.06	HiTime_Cfg[VRange_DTC]	0 *m*sec	Recovery time to NORM_V from HI_V (1 sample)
R: 7.07	LoOvrTime_Cfg[VRange_DTC]	500 *m*sec	LO_V too long, enter UNDER_V
R: 7.08	HiOvrTime_Cfg[VRange_DTC]	500 *m*sec	HI_V too long, enter OVER_V
R: 7.09	UnderRecovTime_Cfg[VRange_DTC]	500 *m*sec	Recovery time to NORM_V from UNDER_V
R: 7.10	OverRecovTime_Cfg[VRange_DTC]	500 *m*sec	Recovery time to NORM_V from OVER_V

* (typical but may be different per WCCA)

Note: This is for all DTC's except overvoltage and undervoltage DTC's which are described in section 1.4.

1.3.5.1.9 Ignition Status Provider Function

The HUD has several modes of operation for the purpose of performing various features during different ignition switch positions or operational modes. The SPDJB is the ignition node for the vehicle network (HS CAN) and sends out the ignition switch status. The HUD uses this information from HS CAN to determine the ignition switch state.

1.3.5.1.9.1 SR-REQ-301438/A-Ignition Status Determination State Diagram

	INPUT	OUTPUT	DTC Logging (F00A64)
#	HS-CAN - Ignition_Status - Current	HUD Ignition Switch State	Log Ignition Switch signal plausibility failure DTC
1	RUN	RUN	NO
2	START (≤ 15 seconds continuously)	START	NO
3	START (> 15 seconds continuously)	RUN	YES
4	OFF	OFF	NO
5	ACC	ACC	NO
6	UNKNOWN	OFF	NO
7	INVALID	OFF	NO
16	Never Received	OFF	NO
17	UNDEFINED	OFF	NO

DESIGN ASSUMPTIONS

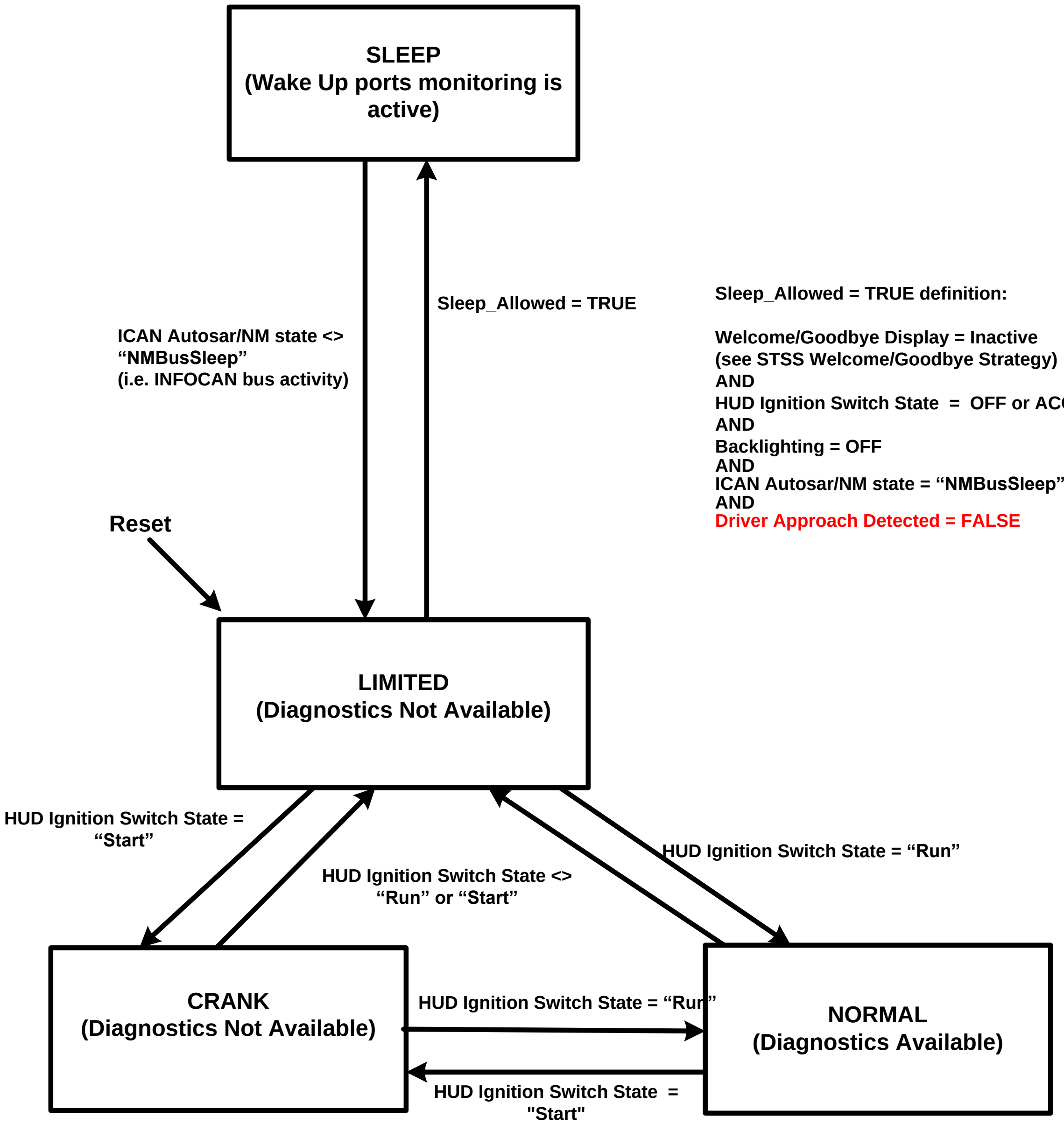
1. "Never Received" is the state of no message received since network wake-up and missing message timer not yet expired.
2. HUD Ignition Switch State may conflict with the CAN Ignition_Status signal.
3. UNDEFINED values for Ignition_Status are 0x3,0x5,0x6,0x7,0x9,0xA,0xB,0xC,0xD,0xE.
4. Upon Wakeup, the default Ignition Switch State shall be OFF and the CAN Ignition_Status shall default to Never Received

1.3.5.1.10 HUD Sleep / Wake Requirements

The HUD has several modes of operation for the purpose of performing various features during different ignition switch positions or operational modes. The HUD enters a sleep state where features are disabled when the Ignition is Off in order to reduce the key off current drain.

Figure 1.3-3 below defines the conditions to transition between different HUD operational modes during normal voltage conditions.

1.3.5.1.10.1 SR-REQ-301439/A-OperationAL_Mode Flowchart (NORMAL VOLTAGE)



Notes:

- For HUD Ignition States, see **Error! Reference source not found.Error! Reference source not found.**
- The HUD is an integral part of the vehicle's INFO_CAN Network Management ("Autosar/NM" or "NM") strategy. The Autosar/NM allows the INFO_CAN bus to realize the following states:
    - NMBusSleep

- NMAwake
- NMWaitBusSleep
- NMBusOff

(See CAN specifications listed in section 1.6, Reference Specification, for further descriptions of the Autosar/NM strategy).

1.3.5.2 FS-REQ-302447/A;1- Function Safety Classification (EMC)

The Function Safety Classification of this feature is the highest class of any feature in this module. See program specific feature list in section 1.2 of the Master SPSS. (Note, class "C" is the highest)

1.3.5.3 NVM-REQ-301443/A-Memory Storage

Parameter Name	Description
See Table 1.8	Voltage Range Thresholds for 9-16V features
See Table 1.9	Voltage Range Thresholds for 7-24V features
See Table 1.10	Voltage Range Thresholds for DTC Logging
Operational_Mode	4 state indicator for HUD operational mode

1.4 Error Handling

1.4.1 SR-REQ-301447/A-Missing Message Strategy

Per the Diagnostic Fault Coverage and DTC Numbers Design Consideration document (00.06.15.601) from Netcom, the HUD shall only log DTC's when the Diagnostic Vehicle Mode is IGNITION_ON and the fault condition has been present for > 5000ms during IGNITION_ON. This is a similar requirement to the legacy "DTC_Possible" implementation.
The Diagnostic Vehicle Mode is IGNITION_ON when ALL the following are true:

- Signal Ignition_Status is 0x4 (Run) and has NOT changed state in > 1000ms
- Signal PwPckTq_D_Stat has NOT changed state in > 1000ms
- Signal ElPw_D_Stat has NOT changed state in > 1000ms (May not be implemented on all programs, see Note 1, Section 1.2.1)
- The voltage is within the DTC Logging voltage range

1.4.2 SR-REQ-301448/A-Low Voltage and High Voltage DTC

These 2 DTCs can only be logged when:

- Signal Ignition_Status is 0x4 (Run) and has NOT changed state in > 1000ms
- Signal PwPckTq_D_Stat has NOT changed state in > 1000ms
- Signal ElPw_D_Stat has NOT changed state in > 1000ms (May not be implemented on all programs, see Note 1, Section 1.2.1)

If the above is not met, these DTCs shall not be logged.

F00316 Battery Voltage (Circuit Voltage Below Threshold) shall be logged when the above conditions are continuously true, and the HUD is in the UNDER_VOLT state for 9-16V features (see Figure 1.3-2 and Table 1.8) for 5 seconds. If any of these conditions change, the 5s timer shall be stopped and reset.

F00317 Battery Voltage (Circuit Voltage Above Threshold) be logged when the above conditions are continuously true, and the HUD is in the OVER_VOLT state for 9-16V features (see Figure 1.3-2 and Table 1.8) for 5 seconds. If any of these conditions change, the 5s timer shall be stopped and reset.

1.4.3 SR-REQ-301446/A-Ignition Switch Signal Plausibility

This DTC can only be logged as per **Error! Reference source not found.Error! Reference source not found.** and the Design Assumptions listed with this table.

1.5 Diagnostics

1.5.1 DIR-REQ-302448/A-Self Test

F00316 Battery Voltage (Circuit Voltage Below Threshold) and F00317 Battery Voltage (Circuit Voltage Above Threshold) should be included in Self Test portion of Part II Diagnostic Specification.

1.5.2 Engineering Test Mode

Reference section "Dealer / Engineering Test Mode (ETM)".

1.5.3 Part II Performance

1.5.3.1 DCR-REQ-301444/A-Supported Diagnostic DIDs (Service $22 and $2F)

Number	PID / CommonID Name	PID Type
9A01	Operating Voltage	Numeric

1.5.3.2 DTC-REQ-301445/A-Supported Diagnostic Trouble Codes (DTCs)

DTC	Description	When Logged
DTC F00A64	Ignition Switch signal plausibility failure	Per Table 1.11, Ignition Status Determination state diagram. Also, see design assumptions beneath the table.
DTC F00317	Battery Voltage (Circuit Voltage Above Threshold)	Ignition switch state is RUN and stable per1.4.2, and HUD is in OVER_VOLT for 9-16V features continuously for 5s.
DTC F00316	Battery Voltage (Circuit Voltage Below Threshold)	Ignition switch state is RUN and stable per 1.4.2, and HUD is in UNDER_VOLT for 9-16V features continuously for 5s.

1.6 Reference Specification

The HUD is a sleep node on HS_CAN and optionally the gateway to the INFOCAN (multimedia) network. The HUD will conform to the following Ford CAN specifications.

Reference CORE MULTIPLEX TECHNOLOGY STATEMENT OF WORK

Reference EESE NETWORK COMMUNICATIONS DIAGNOSTIC STATEMENT OF WORK

1.7 Revision History

SPSS Module Revision History

Revision Level	Name	Change Description	Date
1.0	A. Mathai	Initial version for the HUD, based on Cluster OM&VRS CGEA1.3 version 3.3	04.24.2014
1.1	A. Mathai	Added Kinematics for CHUD in Master feature list 1.4	03.14.2016
1.2	A. Mathai	Deleted the missing message stratagy and DTC C14000 logging when Diagnostic Vehicle Mode is not IGNITION_ON in section 1.4.1 - Deleted the missing message requirement (#15) from Table 1.12 - Deleted DTC C14000 from section 1.5.3	09.06.2016
1.3	A. Salameh	-Initial VSEM RM Release	3/14/2018