

3K Gen 2.0 Keypad Modules J1939/CAN

User Manual

Grayhill PN: 3KUM1980-1

Revisions

Revision	Description	Check / Approve
A	Original. ECN#414854 JAA 4-24-2018	BMM/JLF 4-24-2018
N/A	Changed LED STATUS PGNS to PROP B Updated names of LOW POWER CONFIG parameters Minor updates to LOW POWER configuration and power up operation.	N/A
N/A	Updated descriptions of modes of operation. Removed Partial Wake mode.	JLF 7/25/2018
B	Minor formatting and corrections. ECN# 415595 JLF 8/10/2018	JAA/BMM 8/10/2018
C	-Corrected decimal equivalent of hex PGNS in 5.5.19 and 5.5.20 -Updated Run mode descriptions in 2.1.4 -Updated description of how timeout period is reset in Section 4.3.28 -Updated description of how timeout period is reset in Section 4.3.45. CAN messages are no longer sent during the LOW_POWER_DELAY_PER to allow multiple keypads on the bus to enter sleep. - Update section 3.3 with refined Watchdog operation -Added Appendix C Mode Changes illustrations ECN#420040 JLF 9/25/2019	JAA/RAL 10/25/19

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1. Overview

This document describes the functionality and communication of the Grayhill CAN-Bus Keypads Gen 2.0. Modules must be programmed with 3KPR2021-2 v1.03 or later.

1.1. Reference Documents

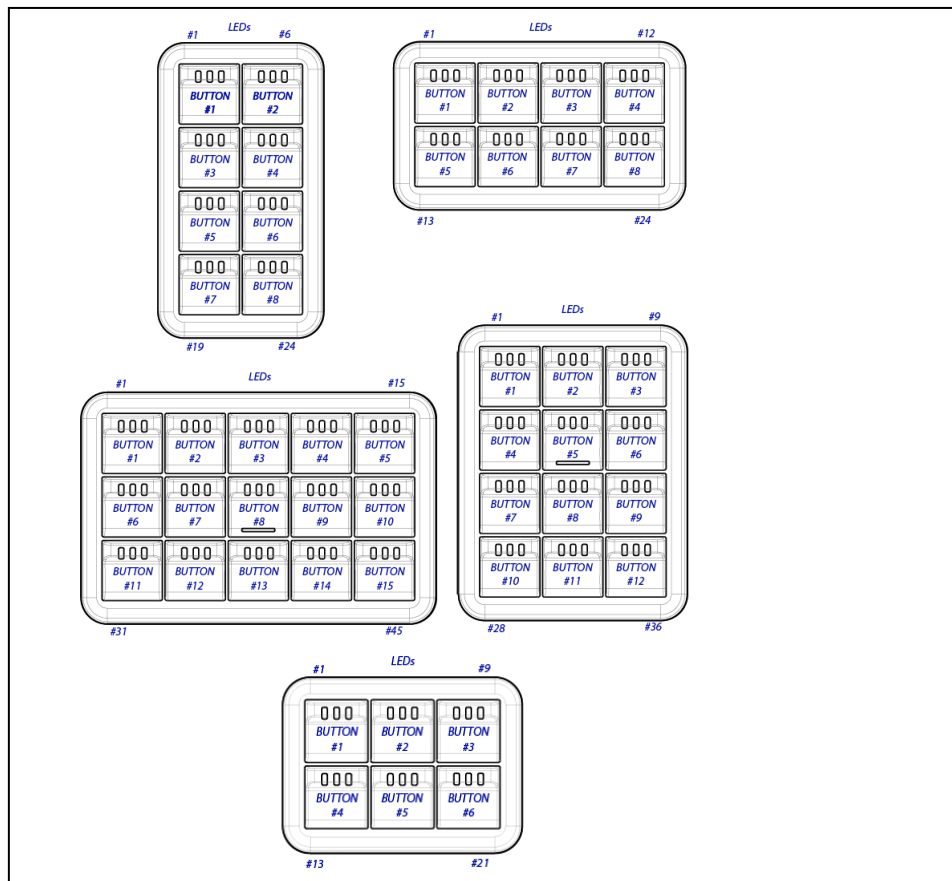
The following documents are referenced within this document.

- SAE-J1939
- SAE-J1939/11
- SAE-J1939/21
- SAE-J1939/71
- SAE-J1939/81
- ISO-11898-2

2. Keypad Operation

The button and LED indicator locations for each form factor are shown below. The numbering for buttons and indicators starts with the upper left corner and increments across the row. Numbering is continued on the left-most key of the next row and continues in this manner.

2.1.



2.1. Modes of Operation

2.1.1. Initial Power-Up

This state is when the device is powered for the first time. When this state is entered (typically at 4V), all of the peripherals are initialized. The device remains in this state until the supply voltage reaches a minimum (typically 6.5V).

- **Low Power Disabled:** (LOW_POWER_CFG = 0, 4) The device immediately enters Run mode. The FlexIO's can be used as I/O.
- **Low Power Enabled:** (LOW_POWER_CFG = 1, 2) The device immediately enters Low Power Mode.

2.1.2. Low Power

When this state is entered, the device turns off all indicators and backlights and places all peripherals in low power mode. The device will enter wake mode with one of the following events:

- **Button Press**
- **CAN Traffic**
- **FlexIO 2 goes active high (LOW_POWER_CFG = 1 or 2)**

2.1.3. Wake

- If the device entered the low power mode from initial power-up then any wake event will initiate the address claim procedure.
- **LOW_POWER_CFG = 1:** Following a wake event, the FlexIO 1 is asserted to wake the ECU or other devices. Flex IO 1 remains on for the full LOW_POWER_WAKE_SIG_PER time. If the device entered the low power mode from run mode then only the FLEXIO2 wake event will initiate the address claim procedure.
- **LOW_POWER_CFG = 2,** Following a wake event, the FlexIO 1 is asserted to wake the ECU or other devices. Flex IO 1 is de-asserted if FlexIO 2 is pulled high before the LOW_POWER_WAKE_SIG_PER time expires. The device enters Run mode when Flex IO 2 is asserted. If the device entered the low power mode from run mode then only the FLEXIO2 wake event will initiate the address claim procedure.
- **LOW_POWER_CFG = 4:** No IOs are used. The device enters Run mode. If the device entered the low power mode from run mode then only the CAN traffic or button press wake event will initiate the address claim procedure.

2.1.4. Run

Entering Run mode initiates the J1939 Address Claiming procedure as defined in section 2.1.3. If the keypad loses arbitration with another device having the same source address and a lower Name value, it will take one of two actions depending on the state of the Arbitrary Address Capable configuration:

- **AAC Enabled:** Send another Address Claimed message with a new source address until one is found. If all possible source addresses are tested, the device will claim the Cannot Claim Address message.
- **AAC Disabled:** Immediately send the Cannot Claim Address message.

If the Diagnostic Blink is enabled, the device will illuminate all indicators and backlights for the specified amount of time. This serves as a visual indicator that all lamps are operational.

Key information is sent according to its configuration, which is either upon a key press, a periodic timer, or both. When a key is pressed the corresponding bit location in the data field is set.

LED's are manipulated according to their configuration (blinking, on, off). The keypad constantly monitors for Configuration and Control Messages and takes action accordingly.

If Low Power mode is enabled, the device will enter Low Power mode when ALL of the following conditions are met and remain for a configured amount of time:

- **FlexIO2 becomes inactive** (if **LOW_POWER_CFG = 1 or 2**)
- **No Button Activity for LED_COMM_TIMEOUT_PER**
- **No CAN Traffic for LED_COMM_TIMEOUT_PER**
- **LOW_POWER_DELAY_PER begins counting down after the 3 conditions above are met. CAN traffic is halted during this time to allow the system to shut down.**
- **When LOW_POWER_DELAY_PER expires the device enters sleep mode.**

2.1.5. Demo Mode

If the parameter `DEVICE_DEMO_MODE` is programmed with a non-zero value, Demo mode is entered by powering up the keypad while simultaneously holding down `BTN#1` and the last button (`BTN#6`, `BTN#8`, `BTN#12`, and `BTN#15`) of the keypad. In demo mode, the indicators will blink twice in a one-second-time period at power-up. This will happen regardless if the `LED_DIAG_BLINK_PER` is configured. Anytime a button is pressed the corresponding indicator LED's will change. In demo mode the keypad is still fully functional. To exit demo mode cycle power. The device never enters Low Power mode even when configured to do so.

Below is the behavior of the keypads in demo mode

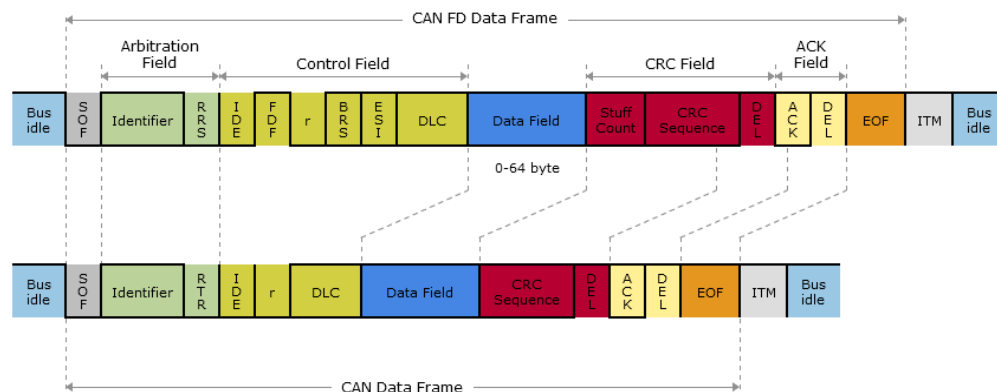
Button Pressed	Action
1 st button (upper left)	Toggles all indicators on/off
2 nd button	Decreases indicator and backlight brightness
3 rd button	Increases indicator and backlight brightness
n th button	Cycles indicators for button n, 1 LEFT 2 CENTER 3 LEFT+CENTER 4 RIGHT 5 LEFT+RIGHT 6 CENTER+RIGHT 7 LEFT+CENTER+RIGHT 8 OFF 9 Back to 1
n th button	Pressing and holding >5s blinks all button n indicators showing stuck button

2.2. CAN FD Tolerant Feature

The keypads utilize the Infineon TLE9255 HS CAN Transceiver to implement the CAN FD Tolerant feature. The keypads will not process any CAN FD frames. The FDF Bit of the Control Field of a CAN FD frame identifies the type of CAN frame:

- FDF bit = 1: CAN FD frame recognized, decoding stops
- FDF bit = 0: classical CAN frame recognized, processing of the frame continues

In this way it is possible to send mixed CAN frame formats.



3. Diagnostics

3.1. Key Diagnostics

The keypad uses an alternating key scan routine to continuously monitor the microcontroller's ability to detect a key shorted to any voltage. The microcontroller also monitors for keys that are closed longer than `BUTTON_STUCK_PER` indicating a stuck key. If an error is detected, the associated key's data value will be set to its error code. If the `DIAG_REPORTING_CFG` is set the keypad will transmit the corresponding Diagnostic Trouble Code (DM1).

3.2. LED Indicator Diagnostics

LED diagnostics are performed at initial power up; wake-up and when the indicator is commanded on steady by the corresponding PGN. The LED diagnostics are not performed when an LED is blinking or the scaled commanded indicator brightness is less than 120 (0x78). If the `DIAG_REPORTING_CFG` is set the keypad will transmit the corresponding Diagnostic Trouble Code (DM1).

3.3. Watchdog Timer Diagnostics

The watchdog ensures that the keypad is continuing to execute code as expected. It must be refreshed every 43ms. If a refresh does not occur within 43ms the device will reset and resume normal operation if able. If the device is configured to transmit DTC's then DTC 520195.31 will be set and transmitted. If a total of 3 watchdog resets are encountered before a power off or a reception of the clear DTC PGNs then the device will reset and remain in boot mode using source address 0xF5 since it is unable to perform as designed.

4. Keypad Configuration

In order to configure the device, the PC tool must send out an Address Claim message using source address 0xFD (Reserved for OEM) with the Grayhill Manufacturer Code of 294 (0x126). When the device detects this address claim, it will allow for configuration of the parameters [APPENDIX B Device Configuration Parameters](#) and will be enabled until either a power cycle or another Address Claim message using source address 0xFD with a Manufacturer Code value other than 294 (0x126).

Configuration messages use the Proprietary A PGN and will respond to the message using PDU Specific (PS) values of the device's source address or the global address of 0xFF. The first byte contains the parameter ID. The message length is variable ranging from 1 to 64 where the upper limit is the longest allowed string value for some parameters.

Unless stated otherwise, new values will not take effect until a device reset occurs.

4.1. Reading

Reading parameters is done by only sending the Parameter ID with a message size of one where the actual CAN message's DLC is one. The parameter payload is returned using the Proprietary A PGN, where the first byte is the parameter ID and the value immediately follows.

4.1.1. Example

Reading the Button PGN having the parameter ID of 0x11, with the device having a source address of 0x80, send the following:

0x18EEFFFD 00 00 C0 24 00 00 00 00 -> Tool AC using MFG code of 294

0x18EF80FD 11 -> Prop B PGN with a DLC of 1 and the data byte of 0x11

The unit responds with:

0x1CEFFD80 11 02 FF 00 00 -> Prop B, DLC=3, Param value = 0x0000FF02.

4.2. Writing

Sending the parameter ID followed does writing by the payload. The message length is the payload size plus 1 for the parameter ID. Confirmation can be done by immediately performing a read operation of the parameter ID.

4.2.1. Example

Setting the Button PGN to the AUXIO1 (0xFED9) with the tool sending to the global address.

0x18EEFFFD 00 00 C0 24 00 00 00 00 -> Tool AC using MFG code of 294

0x18EF80FD 11 D9 FE 00 00 -> Prop B PGN with a DLC of 5

4.3. Parameter List

4.3.1. ECUID Part Number

ID=0x00, Size <= 64

ECUID_PN: ASCII string up to 64 characters long occupying field 1 of the ECUID PGN request

4.3.2. ECUID Location

ID=0x01, Size <= 64

ECUID_LOC: ASCII string up to 64 characters long occupying field 3 of the ECUID PGN request

4.3.3. ECUID Type

ID=0x02, Size <= 64

ECUID_TYPE: ASCII string up to 64 characters long occupying field 4 of the ECUID PGN request

4.3.4. ECUID Manufacturer

ID=0x03, Size <= 64

ECUID_MFG: ASCII string up to 64 characters long occupying field 4 of the ECUID PGN request

4.3.5. Component ID Make

ID=0x04, Size <= 5

CI_MAKE: ASCII string up to 5 characters long occupying field 1 of the CI PGN request

4.3.6. Component ID Model

ID=0x05, Size <= 64

CI_MODEL: ASCII string up to 64 characters long occupying field 2 of the CI PGN request

4.3.7. Component ID Serial Number **ID=0x06, Size<= 64**

CI_SN: ASCII string up to 64 characters long occupying field 3 of the CI PGN request

4.3.8. Component ID Unit Number **ID=0x07, Size<= 64**

CI_UN: ASCII string up to 64 characters long occupying field 4 of the CI PGN request

4.3.9. J1939 Name Identification **ID=0x08, Size = 4**

NAME_ID: Integer value representing the ID portion of the J1939 Name

4.3.10. J1939 Name Manufacturer Code **ID=0x09, Size = 2**

NAME_MFG_CODE: Integer value representing the Manufacturer Code portion of the J1939 Name

4.3.11. J1939 Name ECU Instance **ID=0x0A, Size = 1**

NAME_ECU_INST: Integer value representing the ECU Instance portion of the J1939 Name

4.3.12. J1939 Name Function Instance **ID=0x0B, Size = 1**

NAME_FUNC_INST: Integer value representing the Function Instance portion of the J1939 Name

4.3.13. J1939 Name Function **ID=0x0C, Size = 1**

NAME_FUNCTION: Integer value representing the Function portion of the J1939 Name

4.3.14. J1939 Name Vehicle System **ID=0x0D, Size = 1**

NAME_VEH_SYS: Integer value representing the Vehicle System portion of the J1939 Name

4.3.15. J1939 Name Vehicle System Instance **ID=0x0E, Size = 1**

NAME_VEH_SYS_INST: Integer value representing the Vehicle System Instance portion of the J1939 Name

4.3.16. J1939 Name Industry Group **ID=0x0F, Size = 1**

NAME_IND_GRP: Integer value representing the Industry Group portion of the J1939 Name

4.3.17. J1939 Name Arbitrary Address Capable **ID=0x10, Size = 1**

NAME_AAC: Integer value representing the Arbitrary Address Capable portion of the J1939 Name

4.3.18. Button PGN**ID=0x11, Size = 4**

BUTTON_PGN: The lower 16 bits is the PGN used for transmitting eight data bytes containing button status. The two-bit field occupying locations 17 and 18 determine the data page where 0b00 is Data Page 0. See also: 5.5.25 Prop B (Key Press Data Default PGN) 65282 (0xFF02)

4.3.19. Button Priority**ID=0x12, Size = 1**

BUTTON_PRI: The lowest three bits set the priority of the PGN. All other bits are ignored.

4.3.20. Button Send On Event**ID=0x13, Size = 1**

BUTTON_SOE: A non-zero value causes the button PGN to transmit immediately on a button state change.

4.3.21. Button Transmit Period**ID=0x14, Size = 1**

BUTTON_TX_PER: The value sets the transmission period of the button PGN in units of 10ms. Example: A value of 20 sets the period to 200ms. A value of zero inhibits periodic transmission.

4.3.22. Indicator Status 1 PGN**ID=0x15, Size = 4**

LED_STAT_1_PGN: The lower 16 bits is the PGN used for transmitting eight data bytes containing the indicator status of indicators 1 through 32. The two-bit field occupying locations 17 and 18 determine the data page where 0b00 is Data Page 0.

4.3.23. Indicator Status 2 PGN**ID=0x16, Size = 4**

LED_STAT_2_PGN: The lower 16 bits is the PGN used for transmitting eight data bytes containing the indicator status of indicators 33 to 64. The two-bit field occupying locations 17 and 18 determine the data page where 0b00 is Data Page 0.

4.3.24. Indicator Status PRI**ID=0x17, Size = 1**

LED_STAT_PRI: The lowest three bits set the priority of the PGN. All other bits are ignored.

4.3.25. Indicator Status Send On Event**ID=0x18, Size = 1**

LED_STAT_SOE: A non-zero value causes the indicator PGNs to transmit immediately on an indicator state change.

4.3.26. Indicator Status Transmit Period
Size = 1**ID=0x19,**

LED_STAT_TX_PER: The value sets the transmission period of the indicator PGNs in units of 10ms. Example: A value of 20 sets the period to 200ms. A value of zero inhibits periodic transmission.

4.3.27. Diagnostic Blink Period

ID=0x1A, Size = 1

LED_DIAG_BLINK_PER: The value in units of 100ms determines the length of time after power-up that all of the indicators and backlights illuminate at full brightness. Example: A value of 30 will illuminate the lights for 3 seconds. A value of zero inhibits the diagnostic blink at power up.

4.3.28. LED COMM Timeout Period

ID=0x1B, Size = 1

LED_COMM_TIMEOUT_PER: The value in units of 100ms, determine the length of time that needs to pass with the absence of any CAN traffic responsible for controlling the LEDs. A value of zero disables this feature. The maximum timeout period is 25.5 seconds. The Indicators and Backlights will flash at a 2Hz rate to indicate loss of LED communication when the timer has expired. *The timeout period is reset when a Cab Illumination message or a non-global, address specific, message is received.*
See also LOW_POWER_DELAY_PER.

4.3.29. LED Stuffing Configuration 1

ID=0x1C, Size = 3

**** GRAYHILL INTERNAL USE ONLY **** DO NOT MODIFY ***

Each bit within the three bytes represents an indicator LED controlled by the first driver and determines if that LED is stuffed or not. This is needed to prevent false failures during LED diagnostics.

4.3.30. LED Stuffing Configuration 2

ID=0x1D, Size = 3

**** GRAYHILL INTERNAL USE ONLY **** DO NOT MODIFY ***

Each bit within the three bytes represents an indicator LED controlled by the second driver and determines if that LED is stuffed or not. This is needed to prevent false failures during LED diagnostics.

4.3.31. Default Indicator Intensity Size = 1

ID=0x1E,

LED_IND_DEFAULT: This parameter determines the indicator intensity before the device is commanded to change it. The default value is maximum brightness.

4.3.32. Default Backlight Intensity

ID=0x1F, Size = 1

LED_BKLT_DEFAULT: This parameter determines the backlight intensity before the device is commanded to change it. The default value is maximum brightness.

4.3.33. Stuck Button Error Timeout Period

ID=0x20, Size = 1

BUTTON_STUCK_PER: The value indicates the number of seconds a button needs to register an active press until it throws an error code for the corresponding button.

4.3.34. LED PWM BASE 1

ID=0x21, Size = 24

**** GRAYHILL INTERNAL USE ONLY **** DO NOT MODIFY ***

Each byte corresponds to an indicator LED and is used for balancing the intensity of the indicators when different LED types with different forward voltage drops are used. The valid range is between 0 and 255.

4.3.35. LED IREF BASE 1 ID=0x22, Size = 24

**** GRAYHILL INTERNAL USE ONLY **** DO NOT MODIFY ***

Each byte corresponds to an indicator LED and is used to fine tune the reference current when different LED types with different forward voltage drops are used.

4.3.36. LED PWM BASE 2 ID=0x23, Size = 24

**** GRAYHILL INTERNAL USE ONLY **** DO NOT MODIFY ***

Refer to [LED PWM BASE 1](#), ID=0x21, Size = 24

4.3.37. LED IREF BASE 2 ID=0x24, Size = 24

**** GRAYHILL INTERNAL USE ONLY **** DO NOT MODIFY ***

Refer to [LED IREF BASE 1](#), ID=0x22, Size = 24

4.3.38. DEVICE CONFIG ID=0x25, Size = 2

**** GRAYHILL INTERNAL USE ONLY **** DO NOT MODIFY ***

Byte 1 => Number of Buttons. Valid values (6, 8, 12, and 15)

4.3.39. FLEXIO CONFIG ID=0x26, Size = 1

FLEXIO_CFG: Each nibble within the byte value is used to configure the two Flex IO peripherals. Refer to [AUXIO 4 PGN](#) for FlexIO Control.

Flex IO 1 is configured with the lower nibble. Configuration is as follows:

- 0 => Sourcing driver disabled. Input with hardware pulldown only.
- 1 => Sourcing driver enabled (default)

Flex IO 2 is configured with the upper nibble. Configuration is as follows:

- 0 => Sourcing and sinking drivers disabled. Input only. (default)
- 1 => Sourcing enabled, sinking disabled.
- 2 => Sourcing disabled, sinking enabled.
- 3 => Push-Pull Enabled.

4.3.40. Demo Mode ID=0x27, Size = 1

DEVICE_DEMO_MODE: A non-zero value, with the exception of FFh, causes the keypad to have the ability to enter demo mode. Demo mode is entered by powering up the keypad while simultaneously holding down BTN#1 and the last button (BTN#6, BTN#8, BTN#12, and BTN#15) of the keypad. All of the indicators will blink twice and demo mode is entered regardless of the LED_DIAG_BLINK_PER setting.

4.3.41. Baud Rate**ID=0x28, Size=1**

DEVICE_BAUD: The value sets the baud rate of the device

Data Value	Baud Rate
0	1000K
1	800K
2	500K
3 (default)	250K
4	125K
5	100K
6	50K
7	20K
8	10K

4.3.42. AUXIO1 Priority**ID=0x29, Size=1**

AUXIO1_PRI: The lowest three bits set the priority of the PGN. All other bits are ignored.

4.3.43. AUXIO1 Send On Event**ID=0x2A, Size=1**

AUXIO1_SOE: A non-zero value causes the AUXIO PGN to transmit immediately on a FLEXIOx state change when configured as input.

4.3.44. AUXIO1 TX Period**ID=0x2B, Size=1**

AUXIO1_TX_PER: The value sets the transmission period of the button PGN in units of 10ms. Ex. A value of 20 sets the period to 200ms. A value of zero inhibits periodic transmission.

4.3.45. LOW_POWER_DELAY_PER**ID=0x2C, Size=1**

LOW_POWER_DELAY_PER: This value, in units of 100ms, determines how long to wait until finally entering low power mode after all of the conditions to enter low power mode are satisfied. If LED timeout is configured, the sleep timeout period will begin after LED timeout (and FLEXIO2 input low). During the low power delay period all CAN communication is halted to allow all devices on the network to enter sleep. This counter is reset any time a button is pressed or if CAN traffic is detected. LOW_POWER_DELAY_PER must be greater than 1 when LOW_POWER_CFG is enabled.

4.3.46. LOW_POWER_WAKE_SIG_PER
Size=1**ID=0x2D,**

LOW_POWER_WAKE_SIG_PER: This value, in units of 100ms, determines how long to assert the Wake Output signal on FLEXIO1. A value of 255 asserts the FLEXIO1 Wake Output for as long as the device is awake. A value of zero disables the FLEXIO1 Wake Output.

4.3.47. LOW_POWER_CFG Size=1

ID=0x2E,

LOW_POWER_CFG enables or disables the wakeup/sleep functionality according to the table below.

LOW_POWER_CFG =0	Disabled No Feedback. Device enters run mode when power is applied to pin 1.
LOW_POWER_CFG =1	Enabled No Feedback. After Wake event, Device turns on FLEXIO1 for LOW_POWER_WAKE_SIG_PER. Device will wake on CAN, button press or FLEXIO2 toggle.
LOW_POWER_CFG =2	Enabled with Feedback: After Wake event, Device turns on FLEXIO1 for LOW_POWER_WAKE_SIG_PER or until FLEXIO2 goes high. If FLEXIO2 does not go high device enters sleep mode after LOW_POWER_DELAY_PER. Device will wake on CAN, button press or FLEXIO2 toggle.
LOW_POWER_CFG =4	FLEXIO1 and FLEXIO2 are not used but the device will enter sleep mode after the LED_TIMEOUT_PER and LOW_POWER_DELAY_PER if configured. Device will wake on CAN or button press only. Device will not wake on FLEXIO2 toggle.

4.3.48. DIAG_REPORTING_CFG

ID=0x2F, Size=1

DIAG_REPORTING_CFG:

- **Bit 0:** This bit determines if DTC reporting is enabled or not. When enabled (bit 0 set) the device will monitor the possible trouble codes as defined in [Active Diagnostic Trouble Codes \(DM1\)](#). Active trouble codes will be reported over the bus on the DM1 message. Active trouble codes that become inactive will be reported on DM2 message. Disabled by default.
- **Bit 1:** This bit determines if the DM1 message is continuously transmitted every second when no active faults exist. When set, the DM1 message is transmitted every second regardless if active faults exist or not. When cleared, a DM1 message is only sent every second when active faults exist. In the event that all faults are cleared, the DM1 message is sent only once indicating that no faults are active. Disabled by default.

4.3.49. Source Address

ID=0x30, Size=1

DEVICE_SA: The preferred J1939 source address

4.3.50. Source Address Save

ID=0x31, Size=1

DEVICE_SA_SAVE: When the device is configured for Arbitrary Address Capable and it successfully claims a different address than when it started, this option determines if this new source address is attempted at the next power-up (enabled) or if it tries the default source address.

4.3.51. Brightness Control Configuration

ID=0x32, Size = 1

LED_BRIGHTNESS_CTRL_CONFIG: One of three options is used for LED brightness control.

LED_BRIGHTNESS_CTRL_CONFIG =0	Cab Illumination message ignored. Responds to Normal Mode Proprietary A Brightness Command only.
LED_BRIGHTNESS_CTRL_CONFIG =1	Cab Illumination Message Byte 1 is used for both the indicator brightness and the backlight brightness.
LED_BRIGHTNESS_CTRL_CONFIG =2	Cab Illumination Message Byte 2 is used for the backlight brightness and Byte 3 is used for Indicator Brightness.

5. Communications

5.1. Message Header Description

The following figure illustrates the format of the CAN 2.0B message ID. A brief description of each field follows.

S O F	Identifier 11 Bits											S R R	I D E	Identifier Extension 18 Bits																		R T R		
	Priority			R	D P	PDU Format (PF) 6 Bits (MSB)								S R R	I D E	PF (cont.)		PDU Specific (PS) (Destination Address, Group Extension or Proprietary)										Source Address						
3	2	1				8	7	6	5	4	3			2	1	8	7	6	5	4	3	2	1	8	7	6	5	4	3	2	1			
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	23	25	26	27	28	29	30	31	32			
	28	27	26	25	24	23	22	21	20	19	18			17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0			

5.1.1. Priority

This 3-bit field is used to define the priority during arbitration. '000' is the highest priority and is usually associated with high-speed control messages. Low priority is used for non-critical configuration and information messages.

5.1.2. DP (Data Page)

This 2-bit field defines on which data page (0,1 or 2) the message is defined in the J1939 specification. Page 0 contains the messages that are presently defined, while Pages 1 and 2 are for future expansion according to J1939.

5.1.3. Protocol Data Unit (PDU) - PDU Format (PF)

This 8-bit field determines the format of the message and is one of the fields that determine the Parameter Group Number of the message (see 5.1.6). If the value is between 0 and 239, the message is a PDU 1 Format message. These messages are sent to specific addresses.

5.1.4. Protocol Data Unit (PDU) - PDU Specific (PS)

The PDU Specific (PS) field is the Destination Address (DA). If the value is between 240 and 255, the message is a PDU 2 Format message. These messages are not sent to a specific address, but are instead broadcast to the entire network. The PS then becomes the Group Extension (GE) field.

5.1.5. Source Address

This 8-bit field is the source address of the device that sent the message.

5.1.6. Parameter Group Number

J1939 defines allowable messages by their Parameter Group Number (PGN). The Parameter Group Number is a 3-byte value that uniquely defines the message purpose. A PGN has the following format: If the PDU Format value for a message is less than 240, then the last 8 bits of the PGN are set to '0'. The specification gives the decimal equivalent of the PGNs. To obtain the PF and PS values to use for a specific message, convert the decimal value from the specification to hexadecimal and use the last two bytes. These values can then be used to either send messages on the network or to request messages from other source addresses.

5.2. Bit-field Location and Byte Ordering

The byte and bit ordering and location within the data field are per the J1939 specification. The first data byte is sent first and is referenced as Byte 1. The LSB of the data bytes are on the right and are referenced as Bit 1.

The convention used to locate a parameter in the data field is the same as specified in SAE-J1939/71. The format used is "Rx" where R is the byte number and x is the starting bit number within the byte. The length is the number of bits starting at this point.

Example 1: Location 4.3 with a length of 3 bits would have the value of 1 as illustrated below.

Byte 4 = 0x67 = 0b011**00**111. The bold value is the three-bit field holding a value of 0b001.

Example 2: Location 4.3 with a length of 3 bits would have the value of 6 as illustrated below.

Byte 4 = 0x7b = 0b011**11**011. The bold value is the three-bit field holding a value of 0b110.

5.3. Keypad Source Address

The source address of the Grayhill standard keypad is set to 128 (80h) at the factory. This may be modified either dynamically if Dynamic Addressing is turned on, with the Commanded Address message in accordance with J1939-81, or with the Configuration Command (requires a reset). The source address value is stored in non-volatile memory. The ability to change the source address will allow multiple keypads to coexist in the same system.

5.4. Physical Layer

The default bit rate is 250kbps per J1939/11. J1939/14 defines 500k. ISO11898-2 defines CAN-FD.

The connector is a 6 pin Deutsch equivalent with the following pin out:

1. Power
2. Ground
3. FIO1
4. FIO2
5. CAN_H
6. CAN_L

5.5. Standard PGNs

5.5.1. AUXIO 1 (FlexIO Status)

65241 (0xFED9)

Direction – Transmit

Data Length – 8

Transmission Rate – 100ms (Configurable)

Start	Length	Desc.	Values
1.1	2 bits	Control/Status FlexIO 1	0b00 -> Low 0b01 -> High 0b10 -> Reserved 0b11 -> Not Applicable
1.3	2 bits	Control/Status FlexIO 2	0b00 -> Low 0b01 -> High 0b10 -> Reserved 0b11 -> Not Applicable
1.5	4 bits	N/A	All Bits Set
2	3 Bytes	N/A	All Bits Set
5	2 Bytes	N/A	All Bits Set
7	2 Bytes	N/A	All Bits Set

5.5.2. AUXIO 2 (Indicator Set 1)**42752 (0xA700)****Direction – Receive (LED Control)****Priority – 6 (configurable)****Data Length – 8****Transmission Rate – 100ms (configurable)**

Start	Length	Button	LED Pos	Values
1.1	2 bits	1	Left	0b00-Indicator Off 0b01-Indicator On 0b10-Indicator Blink 0b11-No Change
1.3	2 bits	1	Center	Same
1.5	2 bits	1	Right	Same
1.7	2 bits	2	Left	Same
2.1	2 bits	2	Center	Same
2.3	2 bits	2	Right	Same
2.5	2 bits	3	Left	Same
2.7	2 bits	3	Center	Same
3.1	2 bits	3	Right	Same
3.3	2 bits	4	Left	Same
3.5	2 bits	4	Center	Same
3.7	2 bits	4	Right	Same
4.1	2 bits	5	Left	Same
4.3	2 bits	5	Center	Same
4.5	2 bits	5	Right	Same
4.7	2 bits	6	Left	Same
5.1	2 bits	6	Center	Same
5.3	2 bits	6	Right	Same
5.5	2 bits	7	Left	Same
5.7	2 bits	7	Center	Same
6.1	2 bits	7	Right	Same
6.3	2 bits	8	Left	Same
6.5	2 bits	8	Center	Same
6.7	2 bits	8	Right	Same
7.1	2 bits	9	Left	Same
7.3	2 bits	9	Center	Same
7.5	2 bits	9	Right	Same
7.7	2 bits	10	Left	Same
8.1	2 bits	10	Center	Same
8.3	2 bits	10	Right	Same
8.5	4 bits	N/A	N/A	Unused

5.5.3. AUXIO 3 (Indicator Set 2)**42496 (0xA600)****Direction – Receive (LED Control)****Priority – 6 (configurable)****Data Length – 8****Transmission Rate – 100ms (configurable)**

Start	Length	Button	LED Pos	Values
1.1	2 bits	11	Left	0b00-Indicator Off 0b01-Indicator On 0b10-Indicator Blink Medium 0b11-No Change
1.3	2 bits	11	Center	Same
1.5	2 bits	11	Right	Same
1.7	2 bits	12	Left	Same
2.1	2 bits	12	Center	Same
2.3	2 bits	12	Right	Same
2.5	2 bits	13	Left	Same
2.7	2 bits	13	Center	Same
3.1	2 bits	13	Right	Same
3.3	2 bits	14	Left	Same
3.5	2 bits	14	Center	Same
3.7	2 bits	14	Right	Same
4.1	2 bits	15	Left	Same
4.3	2 bits	15	Center	Same
4.5	2 bits	15	Right	Same
4.7	2 bits	N/A	N/A	Unused
5	8 bits	N/A	N/A	Unused
6	8 bits	N/A	N/A	Unused
7	8 bits	N/A	N/A	Unused
8	8 bits	N/A	N/A	Unused

5.5.4. AUXIO 4 (FlexIO Control)**42240 (0xA500)****Direction –Receive****Data Length – 8**

Start	Length	Desc.	Values *
1.1	2 bits	FlexIO 1 Control	0b00-Inactive or Weak Pulldown 0b01-Active Source (config dependent) 0b10-Reserved 0b11-No Change
1.3	2 bits	FlexIO 2 Control	0b00-Inactive or Weak Pulldown 0b01-Active Source (config dependent) 0b10-Reserved 0b11-No Change
1.5	4 bits	Unused	N/A
2-8	7 Bytes	Unused	N/A

5.5.5. Cab Illumination**53248 (0xD000)****Direction –Receive****Data Length – 8**

Start	Length	Desc.	Values *
1	1 Byte	Cab Display Illumination Percentage (if BRIGHTNESS_CTRL_CONFIG = 1; otherwise ignored)	Valid Range 0 ~ 250 Resolution: 0.4%/Bit
2	1 Byte	Switch Backlight Illumination Percentage (if BRIGHTNESS_CTRL_CONFIG = 2; otherwise ignored)	Valid Range 0 ~ 250 Resolution: 0.4%/Bit
3	1 Byte	Switch Indication Illumination Brightness Percentage (if BRIGHTNESS_CTRL_CONFIG = 2; otherwise ignored)	Valid Range 0 ~ 250 Resolution: 0.4%/Bit
4	5 Bytes	Unused	N/A

5.5.6. Memory Access Request (DM14)**55552 (0xD900)**

Used for memory reading/writing during device re-flashing. Refer to SAE J1939/73 for more detail.

5.5.7. Memory Access Response (DM15)**55296 (0xD800)**

Used for memory reading/writing during device re-flashing. Refer to SAE J1939/73 for more detail.

5.5.8. Binary Data Transfer (DM16)**55040 (0xD700)**

Used for memory reading/writing during device re-flashing. Refer to SAE J1939/73 for more detail.

5.5.9. Boot Load Data (DM17)**54784 (0xD600)**

Used for entering and exiting the bootloader for device re-flashing. Refer to SAE J1939/73 for more detail.

5.5.10. Acknowledgement Message

59392 (0xE800)
PGN = 59392 (0xE800)
Direction - Transmit
Data Length – 8
Priority - 6
Transmission Rate – Upon appropriate response

Start	Length	Desc.	Values *
1	1 Byte	Control Byte	0 = Positive Acknowledgement 1 = Negative Acknowledgement 2 = Access Denied 3 = Cannot Respond
2	1 Byte	Group Function	Refer to SAE-J1939-21
3-5	3 Bytes	Reserved by SAE	
6-8	3 Bytes	Parameter Group being Acknowledged	

This message is send in response to a PGN Request of an unsupported PGN with the Control Byte having a value of one.

5.5.11. PGN Request

59904 (0xEA00)
Direction - Receive
Data Length – 3

Start	Length	Desc.	Values
1.1	1 Byte	Byte 1 of PGN being requested (LSB)	0 to 255
2.1	1 Byte	Byte 2 of PGN being requested	0 to 255
3.1	2 bits	Data Page	0b00 -> Data Page 1 0b01 -> Data Page 2 0b10 -> Data Page 3 0b11 -> Reserved
3.3	6 bits	N/A	Bits cleared

5.5.12. Transport Protocol Data Transfer

60160 (0xEB00)

Used for messages that requires nine bytes or more. Refer to J1939/21

5.5.13. Transport Protocol Connection Mgmt (0xEC00)

60416

Used for messages that requires nine bytes or more. Refer to J1939/21

5.5.14. Address Claimed**60928 (0xEE00)****Direction – Transmit and receive****Data Length – 8****Priority - 6****Transmission Rate – Upon boot or whenever requested**

Start	Length	Desc.	Values
1.1	21 Bits	Identity Number	0 to 2 ²¹ -1
3.6	11 Bits	Manufacturers Code	294 (Assigned to Grayhill by SAE)
5.1	3 Bits	ECU Instance	0 (Default)
5.4	5 Bits	Function Instance	0 (Default)
6.1	8 Bits	Function	135 (Keypad, Default) *
7.1	1 Bit	Reserved	0 (Defined by SAE)
7.2	7 Bits	Vehicle System	0 (Default) *
8.1	4 Bits	Vehicle System Instance	0 (Default)
8.5	3 Bits	Industry Group	0 = Global (Default) * 1 = On-Highway Equipment 2 = Agricultural and Forestry Equipment 3 = Construction Equipment 4 = Marine 5 = Industrial-Process Control-Stationary 6 & 7 = Reserved
8.8	1 Bit	Arbitrary Address Capable	0 = Not Capable 1 = Capable (Default)

*Refer to J1939 base document for the Function value based on the Industry Group and Vehicle System combinations

5.5.15. Prop A (Normal Mode)**61184 (0xEF00)****Direction –Receive****Priority – 7****Data Length – Variable****Messages sent from SA 0xFD will be ignored.****When Byte 1 is less than or equal to the button count**

Start	Length	Desc.	Values
1.1	1 Byte	Indicator Bank (Button number)	1.15 (Corresponding to the key number)
2.1	4 Bits	Left Indicator	0b0000-Off 0b0001-On 0b0010 – Blink Slow (approx.. ½ Hertz) 0b0011 – Blink Med. (approx.. 1 Hertz) 0b0100 – Blink Fast (approx. 2 Hertz) 0b1111 – Not Available
2.4	4 Bits	Center Indicator	Same
3.1	4 Bits	Right Indicator	Same
4	5 Bytes	Not Used	N/A

When Byte 1 has the value of 0x80 (Brightness Command)

Start	Length	Desc.	Values
1	1 Byte	LED Intensity Command	0x80
2	1 Byte	Switch Indication Illumination Brightness Pct	Valid Range 0 ~ 250 Resolution: 0.4%/Bit
3	1 Byte	Switch Backlight Illumination Pct	Valid Range 0 ~ 250 Resolution: 0.4%/Bit
4	5 Bytes	Not Used	N/A

5.5.16. Prop A (Configuration Mode*)**61184 (0xEF00)**

***Device is placed in this mode by sending the Address Claimed message from a Source Address of 0xFD with Manufacturer Code of 294 (Grayhill).**

Direction – Transmit and Receive**Priority – 7****Data Length – Variable**

Start	Length	Desc.	Values
1.1	1 Byte	Parameter ID Byte	Parameter ID
2.1	2~(DLC-1)	Configuration Data	Variable as described in Sec. 4

5.5.17. ECU Identification Information**64965 (0xFDC5)**

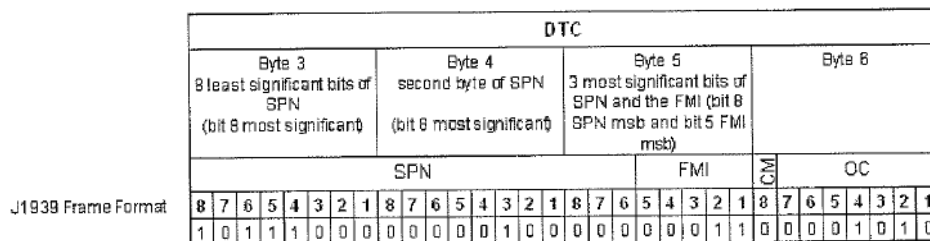
Direction - Transmit
Data Length – Variable
Transmission Rate – Upon Request
Multi Packet Transferred – Yes

Start	Length	Desc.	Values *
A	<=64	ECU Part Number	Ex. "3KYY1001-1"
B	<=64	ECU Serial Number	Ex. "123456"
C	<=64	ECU Location	Ex. "CAB"
D	<=64	ECU Type	"KEYPAD"

5.5.18. Active Diagnostic Trouble Codes (DM1)**65226 (0xFECA)**

The Diagnostic Trouble Code PGN uses the format described in J1939-73 that broadcasts to no specific address the diagnostic status of the keys, LEDs, IO etc. See APPENDIX A Diagnostic Trouble Codes

PGN: 65226 (0xFECA)
Direction: Transmit
Data Page: 0
PDU Format: 254
PDU Specific: 202
Priority: 6
Data Length: Variable (see transport protocol defined in SAE J1939-21)
TX Rate: 1s or On Change or On Request

**5.5.19. Previously Active Trouble Codes (DM2)****65227 (0xFECB)**

Faults that go active then inactive can be read doing a PGN request for the DM2 message.

PGN: 65227 (0xFECB)
Direction: Transmit
Data Page: 0
PDU Format: 254
PDU Specific: 203
Priority: 6
Data Length: Variable (see transport protocol defined in SAE J1939-21)
TX Rate: On Request

5.5.20. Clear/Reset of Previously Active DTCs (DM3) 65228 (0xFECC)

Previously sending a PGN Request for the DM3 PGN clears active trouble codes (DM2).

PGN: 65228 (0xFECC)
Direction: Not Directly Transmitted or Received
Data Page: 0
PDU Format: 254
PDU Specific: 204
Priority: N/A
Data Length: N/A
TX Rate: A request clears the previously active trouble codes then a Positive Acknowledgement is sent

5.5.21. Clear/Reset of Active DTCs (DM11) 65235 (0xFED3)

Sending a PGN Request for the DM11 PGN clears currently active trouble codes.

PGN: 65235 (0xFED3)
Direction: Not Directly Transmitted or Received
Data Page: 0
PDU Format: 254
PDU Specific: 211
Priority: N/A
Data Length: N/A
TX Rate: A request clears the active trouble codes then a Positive Acknowledgement is sent

5.5.22. Commanded Address 65240 (0xFED8)

Direction - Reception

Data Length – 9

Multi Packet Transferred – Yes

Start	Length	Desc.	Values *
1	8 Bytes	J1939 Name of the target device	Variable
9	1 Byte	New Source Address	0x00 ~ 0xFC

5.5.23. Software Identification**65242 (0xFEDA)****Direction - Transmit****Data Length – Variable****Transmission Rate – Upon Request****Multi Packet Transferred – Yes**

Start	Length	Desc.	Values
1	1 Byte	Number of software fields	1 to 125
2-N	Variable	Software ID field	ASCII characters. Each field delimited with an asterisk and up to 200 characters

Commas with the following sub fields further delimit each asterisk-delimited field

- Grayhill Software parts number.
- Software revision
- Compile Date
- Compile Time.

When executing from the bootloader, only the bootloader's firmware information will be reported with the first byte containing a value of 1. When executing from the application, both the bootloader and application is reported with the first byte having a value of 2 and delimited with an asterisk.

5.5.24. Component ID**65259 (0xFEED)****Direction - Transmit****Data Length – Variable****Transmission Rate – Upon Request****Multi Packet Transferred – Yes**

Start	Length	Desc.	Values *
A	<=5	Make	Ex. "GHILL"
B	<=64	Model	Ex. "Keypad 12 Btn"
C	<=64	Serial Number	Ex. "1234"
D	<=64	Unit Number	"ABCD"

*All fields are ASCII characters and asterisk delimited

5.5.25. Prop B (Key Press Data Default PGN)**65282 (0xFF02)****Direction - Transmit****Priority – 6 (configurable)****Data Length - 8****Transmission Rate – 100ms (configurable)**

Start	Length	Desc.	Values
1.1	2 bits	Key 1	0b00-Key Not Pressed 0b01-Key Pressed 0b10-Error 0b11-Unused Key
1.3	2 bits	Key 2	Same
1.5	2 bits	Key 3	Same
1.7	2 bits	Key 4	Same
2.1	2 bits	Key 5	Same
2.3	2 bits	Key 6	Same
2.5	2 bits	Key 7	Same
2.7	2 bits	Key 8	Same
3.1	2 bits	Key 9	Same
3.3	2 bits	Key 10	Same
3.5	2 bits	Key 11	Same
3.7	2 bits	Key 12	Same
4.1	2 bits	Key 13	Same
4.3	2 bits	Key 14	Same
4.5	2 bits	Key 15	Same
4.7	2 bits	N/A	Unused
5	8 bits	N/A	Unused
6	8 bits	N/A	Unused
7	8 bits	N/A	Unused
8	8 bits	N/A	Unused

Example: Pressing key 12 will cause the following message to be transmitted. (Assume a 12 key device).

ID=0x18FF0280, LEN=8, DATA=0x00, 0x00, 0x40, 0xFF, 0xFF, 0xFF, 0xFF, 0xFF

Example: Pressing keys 12 and 13 will cause the following message to be transmitted. (Assume a 15 key device).

ID=0x18FF0280, LEN=8, DATA=0x00, 0x00, 0x40, 0xC1, 0xFF, 0xFF, 0xFF, 0xFF

5.5.26. Prop B (Indicator Set 1 Status)
(0xFFA7)
65447**Direction – Transmit (LED Status)****Priority – 6 (configurable)****Data Length – 8****Transmission Rate – 100ms (configurable)**

Start	Length	Button	LED Pos	Values
1.1	2 bits	1	Left	0b00-Indicator Off 0b01-Indicator On 0b10-Indicator Error (short or Open)
1.3	2 bits	1	Center	Same
1.5	2 bits	1	Right	Same
1.7	2 bits	2	Left	Same
2.1	2 bits	2	Center	Same
2.3	2 bits	2	Right	Same
2.5	2 bits	3	Left	Same
2.7	2 bits	3	Center	Same
3.1	2 bits	3	Right	Same
3.3	2 bits	4	Left	Same
3.5	2 bits	4	Center	Same
3.7	2 bits	4	Right	Same
4.1	2 bits	5	Left	Same
4.3	2 bits	5	Center	Same
4.5	2 bits	5	Right	Same
4.7	2 bits	6	Left	Same
5.1	2 bits	6	Center	Same
5.3	2 bits	6	Right	Same
5.5	2 bits	7	Left	Same
5.7	2 bits	7	Center	Same
6.1	2 bits	7	Right	Same
6.3	2 bits	8	Left	Same
6.5	2 bits	8	Center	Same
6.7	2 bits	8	Right	Same
7.1	2 bits	9	Left	Same
7.3	2 bits	9	Center	Same
7.5	2 bits	9	Right	Same
7.7	2 bits	10	Left	Same
8.1	2 bits	10	Center	Same
8.3	2 bits	10	Right	Same
8.5	4 bits	N/A	N/A	Unused

5.5.27. Prop B (Indicator Set 2 Status) (0xFFA6)

65446

Direction – Transmit (LED Status)

Priority – 6 (configurable)

Data Length – 8

Transmission Rate – 100ms (configurable)

Start	Length	Button	LED Pos	Values
1.1	2 bits	11	Left	0b00-Indicator Off 0b01-Indicator On 0b10-Indicator Error (short or Open)
1.3	2 bits	11	Center	Same
1.5	2 bits	11	Right	Same
1.7	2 bits	12	Left	Same
2.1	2 bits	12	Center	Same
2.3	2 bits	12	Right	Same
2.5	2 bits	13	Left	Same
2.7	2 bits	13	Center	Same
3.1	2 bits	13	Right	Same
3.3	2 bits	14	Left	Same
3.5	2 bits	14	Center	Same
3.7	2 bits	14	Right	Same
4.1	2 bits	15	Left	Same
4.3	2 bits	15	Center	Same
4.5	2 bits	15	Right	Same
4.7	2 bits	N/A	N/A	Unused
5.1	2 bits	N/A	N/A	Unused
5.3	2 bits	N/A	N/A	Unused
5.5	2 bits	N/A	N/A	Unused
5.7	2 bits	N/A	N/A	Unused
6.1	2 bits	N/A	N/A	Unused
6.3	2 bits	N/A	N/A	Unused
6.5	2 bits	N/A	N/A	Unused
6.7	2 bits	N/A	N/A	Unused
7.1	2 bits	N/A	N/A	Unused
7.3	2 bits	N/A	N/A	Unused
7.5	2 bits	N/A	N/A	Unused
7.7	2 bits	N/A	N/A	Unused
8.1	2 bits	N/A	N/A	Unused
8.3	2 bits	N/A	N/A	Unused
8.5	4 bits	N/A	N/A	Unused

APPENDIX A Diagnostic Trouble Codes

Failure Mode Description	SPN.FMI
EEPROM Corrupt	520196.31
Bus Idle Error ⁽¹⁾	520197.31
Watchdog Timer Error ⁽²⁾	520195.31
Button XX Shorted	5202 XX .31
Button XX Stuck	5202 XX .07
LED X Error ^(3,4,5)	(520220+ X).31

(1) Based on LED_COM_TMEOUT_PER

(2) Watchdog timeout is fixed at 43ms.

(3) LED Shorted Error reporting is disabled when Indicator Brightness is < 120.

(4) LED Error reporting is disabled when LED is commanded blinking.

(5) LED Error Reporting is off if the LED is commanded off.

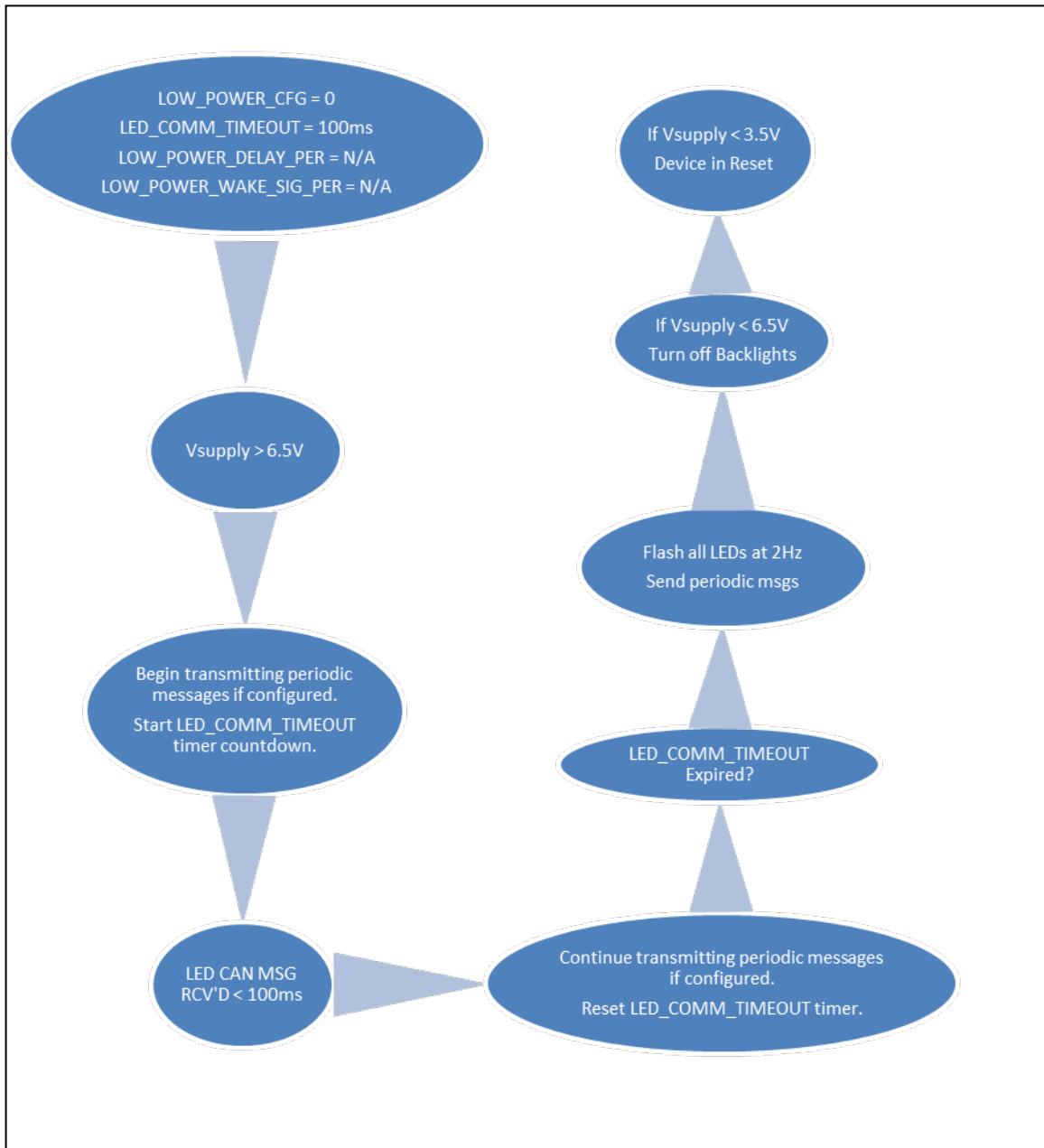
APPENDIX B Device Configuration Parameters

Section	Field Name	Parameter ID	Valid Range	Default
4.3.1	ECUID_PN	0 (0x00)		
4.3.2	ECUID_LOC	1 (0x01)		
4.3.3	ECUID_TYPE	2 (0x02)		
4.3.4	ECUID_MFG	3 (0x03)		
4.3.5	CI_MAKE	4 (0x04)		
4.3.6	CI_MODEL	5 (0x05)		
4.3.7	CI_SN	6 (0x06)		
4.3.8	CI_UN	7 (0x07)		
4.3.9	NAME_ID	8 (0x08)		
4.3.10	NAME_MFG_CODE	9 (0x09)	0-2047	294 (0x0126)
4.3.11	NAME_ECU_INST	10 (0x0A)	0-7	0
4.3.12	NAME_FUNC_INST	11 (0x0B)	0-31	0
4.3.13	NAME_FUNCTION	12 (0x0C)	0-255	135 (0x87)
4.3.14	NAME_VEH_SYS	13 (0x0D)	0-127	0
4.3.15	NAME_VEH_SYS_INST	14 (0x0E)	0-15	0
4.3.16	NAME_IND_GRP	15 (0x0F)	0-7	0
4.3.17	NAME_AAC	16 (0x10)	0,1	0 (DISABLED)
4.3.18	BUTTON_PGN	17 (0x11)		65282 (0xFF02)
4.3.19	BUTTON_PRI	18 (0x12)	0-7	6
4.3.20	BUTTON_SOE	19 (0x13)	0,1	1 (ENABLED)
4.3.21	BUTTON_TX_PER	20 (0x14)	0-255	10 (0x0A) 100ms
4.3.22	LED_STAT_1_PGN	21 (0x15)		65447 (0xFFA7)
4.3.23	LED_STAT_2_PGN	22 (0x16)		65446 (0xFFA6)
4.3.24	LED_STAT_PRI	23 (0x17)	0-7	6
4.3.25	LED_STAT_SOE	24 (0x18)	0,1	0 (DISABLED)
4.3.26	LED_STAT_TX_PER	25 (0x19)	0-255	0 (0x00) DISABLED
4.3.27	LED_DIAG_BLINK_PER	26 (0x1A)	0-255	10 (0x0A) 1000ms
4.3.28	LED_TIMEOUT_PER	27 (0x1B)	0-255	30 (0x1E) 3000ms
4.3.29	LED_STUFFING_1~24	28 (0x1C)	DO NOT MODIFY	Grayhill Use Only
4.3.30	LED_STUFFING_25~48	29 (0x1D)	DO NOT MODIFY	Grayhill Use Only
4.3.31	LED_IND_DEFAULT	30 (0x1E)	0-255	255 (0xFF) 100%
4.3.32	LED_BKLT_DEFAULT	31 (0x1F)	0-255	255 (0xFF) 100%
4.3.33	BUTTON_STUCK_PER	32 (0x20)	0-254	5 (0x05) 5 seconds
4.3.34	LED_PWM_BASE_1	33 (0x21)	DO NOT MODIFY	Grayhill Use Only

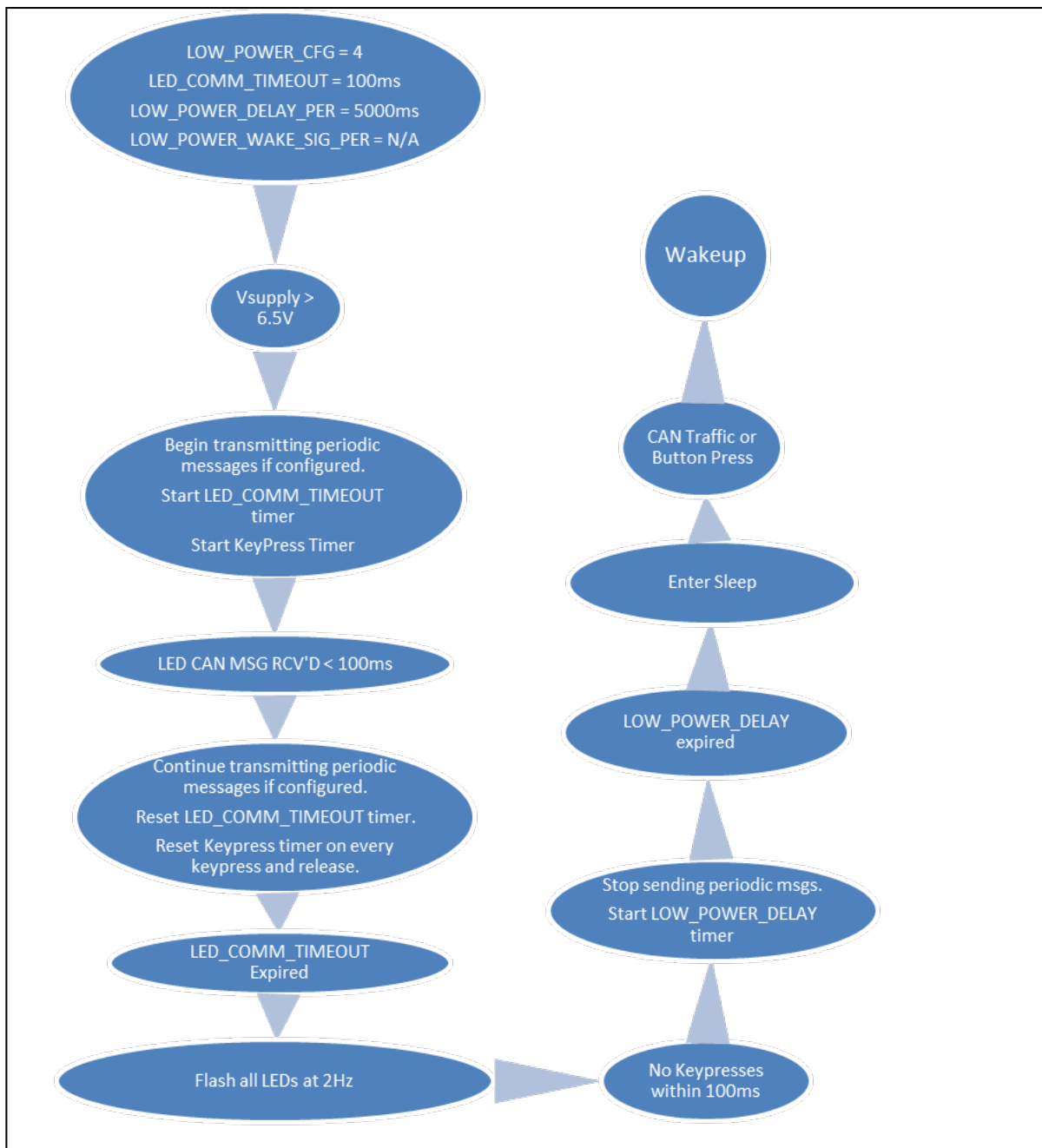
4.3.35	LED_IREF_BASE_1	34 (0x22)	DO NOT MODIFY	Grayhill Use Only
4.3.36	LED_PWM_BASE_2	35 (0x23)	DO NOT MODIFY	Grayhill Use Only
4.3.37	LED_IREF_BASE_2	36 (0x24)	DO NOT MODIFY	Grayhill Use Only
4.3.38	DEVICE_CFG	37 (0x25)	DO NOT MODIFY	Grayhill Use Only
4.3.39	FLEXIO_CFG	38 (0x26)	0-3	1 (0x01) FLEXIO1->Source FLEXIO2->Input Only
4.3.40	DEVICE_DEMO_MODE	39 (0x27)	0-255	1 (ENABLED)
4.3.41	DEVICE_BAUD	40 (0x28)	0-8	3 (250K)
4.3.42	AUXIO1_PRI	41 (0x29)	0-7	6
4.3.43	AUXIO1_SOE	42 (0x2A)	0-255	0 (DISABLED)
4.3.44	AUXIO1_TX_PER	43 (0x2B)	0-255	0 (DISABLED)
4.3.45	LOW_POWER_DELAY_PER	44 (0x2C)	0-255	100 (0x64) 10000ms
4.3.46	LOW_POWER_WAKE_SIG_PER	45 (0x2D)	0-255	50 (0x32) 5000ms
4.3.47	LOW_POWER_CFG	46 (0x2E)	0,1,2,4	1 (ENABLED NO FEEDBACK)
4.3.48	DIAG_REPORTING_CFG	47 (0x2F)	0,1,3	0 (DISABLED NOT CONTINUOUS)
4.3.49	DEVICE_SA	48 (0x30)		128 (0x80)
4.3.50	DEVICE_SA_SAVE	49 (0x31)	0-255	0 (DISABLED)
4.3.51	BRIGHTNESS_CTRL_CONFIG	50 (0x32)	0,1,2	2 (USE CAB ILLUMINATION MESSAGE BYTES 2 & 3)

APPENDIX C Mode Changes

Example C.1



Example C.2



Example C.3

