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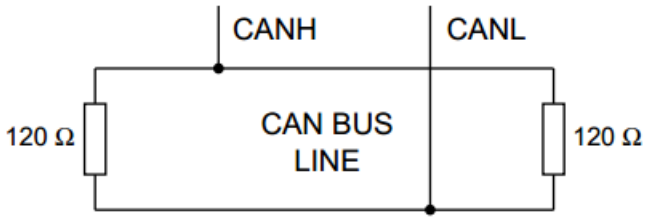
1. How to connect CAN bus:

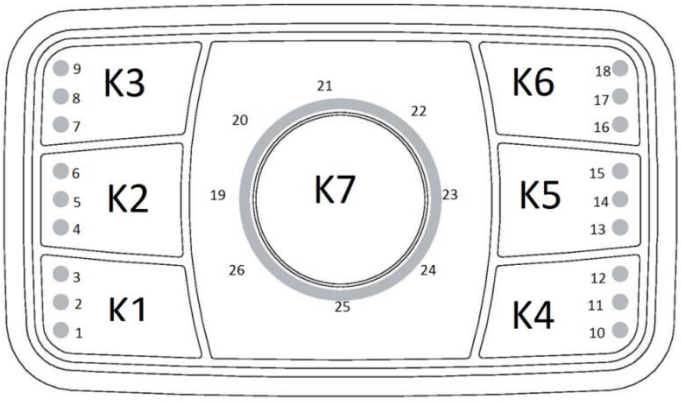
PIN	COLOUR	FUNCTION
1	Blue	CAN L
2	White	CAN H
3	Black	Negative battery
4	Red	Vbatt. (12-24V)



Each end of the CAN bus is terminated with 120Ω resistors in compliance with the standard to minimize signal reflections on the bus. You may need to place a 120Ω resistor between CAN-L and CAN-H.

Warning: to avoid breakage do not tighten the backshell nuts with a torque exceeding 0.8 Nm!

2. Reference



3. Message header description

The 29-bit CAN identifier used in J1939 is structured in the following way.

Priority	Reserved	Data Page	PDU Format	PDU Specific	Source Address
3 bits	1 bit	1 bit	8 bits	8 bits	8 bits

The proprietary format used by PowerTrack keypad is defined as follows:
Priority = 6.
Reserved = 0.
Data page = 0.
PDU Format = EFh (the message is addressable).
PDU Specific = Destination Address.
Parameter Group Number (PGN) = 61184 (EF00h).

An example of CAN identifier of messages sent to the PowerTrack is 18EF2100h where:
21h is the destination address (PowerTrack)
00h is the source address.

An example of CAN identifier of messages sent by the PowerTrack is 18EFFF21h where:
FFh refers to broadcast messages (no specific destination address)
21h is the source address (PowerTrack).

4. General Data Format

The proprietary protocol has defined a general format for the data fields in the PGN 61184. The format consists of:
1 header field (2 bytes)
1 command byte
5 bytes (the remaining field) are defined specifically for each command.

The data length is 8 bytes, unused bits and bytes are set to all 1's (0xFF).

Byte 0	04h
Byte 1	1Bh
Byte 2	Command
Byte 3-7	Data required for each specific command

5. Default Settings

Setting	Default state or level	How to change
CAN bus Baud Rate	250 kbit/s	Command 6Fh
Source Address	21h	Command 70h
Keypad Identifier	21h	Command 70h
Heartbeat Message	Disable	Command 75h
Periodic state transmission	Disable	Command 71h
Periodic transmission period	100ms	Command 77h
Event state transmission	Enable	Command 72h
Address claim	Disable	Command 74h
LED brightness level	3Fh	Command 7Bh
Startup backlight	OFF	Command 7C/D/Eh
Startup LED show	Complete LED Sequence	Command 34h
Startup encoder tick counter value	0000h	Command 0Ah
LED acknowledgment	Disable	Command 73h

6. Key Contact state (01h)

This message is sent by the PowerTrack to indicate the state of the contacts. The destination address is set to FFh: broadcast message. See chapter 2 for Key number reference.

Byte 0	04h	Header bytes
Byte 1	1Bh	
Byte 2	01h	Contact state message
Byte 3	XXh	XX: Key number
Byte 4	YYh	Contact State 00: Switch OFF (Key released) 01: Switch ON (Key pressed)
Byte 5	ZZh	Keypad Identifier (default 21h)
Byte 6,7	FFh	Not used

Example

Direction	Identifier	Format	Message	Data
From Keypad	18EFFF21h	Ext	04 1B 01 01 01 21 FF FF	Key 1 ON
From Keypad	18EFFF21h	Ext	04 1B 01 01 00 21 FF FF	Key 1 OFF
From Keypad	18EFFF21h	Ext	04 1B 01 02 01 21 FF FF	Key 2 ON
From Keypad	18EFFF21h	Ext	04 1B 01 02 00 21 FF FF	Key 2 OFF
From Keypad	18EFFF21h	Ext	04 1B 01 03 01 21 FF FF	Key 3 ON
From Keypad	18EFFF21h	Ext	04 1B 01 03 00 21 FF FF	Key 3 OFF
From Keypad	18EFFF21h	Ext	04 1B 01 04 01 21 FF FF	Key 4 ON
From Keypad	18EFFF21h	Ext	04 1B 01 04 00 21 FF FF	Key 4 OFF
From Keypad	18EFFF21h	Ext	04 1B 01 05 01 21 FF FF	Key 5 ON
From Keypad	18EFFF21h	Ext	04 1B 01 05 00 21 FF FF	Key 5 OFF
From Keypad	18EFFF21h	Ext	04 1B 01 06 01 21 FF FF	Key 6 ON
From Keypad	18EFFF21h	Ext	04 1B 01 06 00 21 FF FF	Key 6 OFF
From Keypad	18EFFF21h	Ext	04 1B 01 07 01 21 FF FF	Key 7 ON
From Keypad	18EFFF21h	Ext	04 1B 01 07 00 21 FF FF	Key 7 OFF

If the Event state transmission is enabled, the Key Contact state message is sent when a key is switched.

If the Periodic state transmission is enabled, every Periodic transmission period a Key Contact state message is sent for each button of the PowerTrack.

7. LED command (01h)

This message is sent to the PowerTrack to set the state of the LED indicators. See chapter 2 for Key and LED number reference.

Byte 0	04h	Header bytes
Byte 1	1Bh	
Byte 2	01h	LED command message
Byte 3	XXh	XX: LED number
Byte 4	YYh	LED State and Color 00h: green off 01h: green on 02h: green blink 03h: green alt blink 04h: red off 05h: red on 06h: red blink 07h: red alt blink 08h: amber off (only for LED from 19 to 26) 09h: amber on (only for LED from 19 to 26) 0Ah: amber blink (only for LED from 19 to 26) 0Bh: amber alt blink (only for LED from 19 to 26) 0Ch: blue off (only for LED from 19 to 26) 0Dh: blue on (only for LED from 19 to 26) 0Eh: blue blink (only for LED from 19 to 26) 0Fh: blue alt blink (only for LED from 19 to 26)
Byte 5, 6, 7	FFh	Not used

Examples:

Direction	Identifier	Format	Message	Data
To Keypad	18EF2100h	Ext	04 1B 01 01 05 FF FF FF	LED 1 red on
To Keypad	18EF2100h	Ext	04 1B 01 01 04 FF FF FF	LED 1 red off
To Keypad	18EF2100h	Ext	04 1B 01 0A 01 FF FF FF	LED 10 green on
To Keypad	18EF2100h	Ext	04 1B 01 0C 02 FF FF FF	LED 12 green blinks
To Keypad	18EF2100h	Ext	04 1B 01 14 0D FF FF FF	LED 20 blue on
To Keypad	18EF2100h	Ext	04 1B 01 1A 0F FF FF FF 04 1B 01 1A 06 FF FF FF	LED 26 blinks red and blue in alternate mode
To Keypad	18EF2100h	Ext	04 1B 01 19 0E FF FF FF	LED 25 blue blinks

8. Set LED brightness level (02h)

This message sets the value of the indicator LED brightness. The value can be set from 0 to 3Fh from min to 100% of the LED dimming range.

Byte 0	04h	Header bytes
Byte 1	1Bh	
Byte 2	02h	LED brightness level message
Byte 3	XXh	XX: Dim Value (default 3Fh) From 00h (min) to 3Fh (100%)
Byte 4,7	FFh	Not used

Example:

Direction	Identifier	Format	Message	Data
To Keypad	18EF2100h	Ext	04 1B 02 20 FF FF FF FF	Brightness level set to 50%

9. Set backlight green level (03h)

This message sets the value of the backlight green LED brightness. The value can be set from 0 to 3Fh for 0 to 100% of the brightness range.

Byte 0	04h	Header bytes
Byte 1	1Bh	
Byte 2	03h	Backlight green brightness level message
Byte 3	XXh	XX: Value (default 00h) From 00h (0%) to 3Fh (100%)
Byte 4,7	FFh	Not used

Example:

Direction	Identifier	Format	Message	Data
To Keypad	18EF2100h	Ext	04 1B 03 10 FF FF FF FF	Backlight green level set to 25%

10. Set backlight red level (04h)

This message sets the value of the backlight red LED brightness. The value can be set from 0 to 3Fh from 0 to 100% of the brightness range.

Byte 0	04h	Header bytes
Byte 1	1Bh	
Byte 2	04h	Backlight red brightness level message
Byte 3	XXh	XX: Value (default 00h) From 00h (0%) to 3Fh (100%)
Byte 4,7	FFh	Not used

Example:

Direction	Identifier	Format	Message	Data
To Keypad	18EF2100h	Ext	04 1B 04 30 FF FF FF FF	Backlight red level set to 75%

11. Set backlight blue level (05h)

This message sets the value of the backlight blue LED brightness. The value can be set from 0 to 3Fh from 0 to 100% of the brightness range.

Byte 0	04h	Header bytes
Byte 1	1Bh	
Byte 2	05h	Backlight blue brightness level message
Byte 3	XXh	XX: Value (default 00h) From 00h (0%) to 3Fh (100%)
Byte 4,7	FFh	Not used

Example:

Direction	Identifier	Format	Message	Data
To Keypad	18EF2100h	Ext	04 1B 05 00 FF FF FF FF	Backlight blue OFF

12. Set startup keys message(28h)

This command enables the transmission during power up of the state of the keys.

Byte 0	04h	Header bytes
Byte 1	1Bh	
Byte 2	28h	Startup keys message
Byte 3	XXh	XX: 00h Disabled (default) 01h Enabled
Byte 4,7	FFh	Not used

Example:

Direction	Identifier	Format	Message	Data
To Keypad	18EF2100h	Ext	04 1B 28 01 FF FF FF FF	Startup keys message enabled

13. Get software revision (2Ah)

Byte 0	04h	Header bytes
Byte 1	1Bh	
Byte 2	2Ah	Get software revision
Byte 3,7	FFh	Not used

Answer:

Byte 0	04h	Header bytes
Byte 1	1Bh	
Byte 2	2Ah	Get software revision
Byte 3,6	XXh XXh XXh XXh	SW revision ASCII
Byte 7	00h	Not used

Example:

Direction	Identifier	Format	Message	Data
To Keypad	18EF2100h	Ext	04 1B 2A FF FF FF FF FF	Get software revision
From Keypad	18EFFF21h	Ext	04 1B 2A 56 32 2E 33 00	V2.3

14. Encoder state message (0Ah)

This message is sent by the PowerTrack to indicate the state of the encoder. The destination address is set to FFh: broadcast message.

The state of the encoder is represented by 2 counter fields:
- The Direction counter (Byte1) transmit the number of ticks and the direction of the encoder rotation since the last message sent. The MSB of the counter defines the direction.
- The Tick counter (Byte 2 and 3) is a two bytes counter incremented each clockwise tick and decremented each counterclockwise tick.

Byte 0	04h	Header bytes
Byte 1	1Bh	
Byte 2	0Ah	Encoder state message
Byte 3	Encoder Direction counter X Y Y Y – Y Y Y Y b	X = 0 clockwise, X = 1 counterclockwise. YYYYYYY = number of Ticks. 1 Turn (360° rotation) = 20 Ticks
Byte 4, 5	Encoder Tick counter ZZ ZZh	
Byte 6	ZZh	Keypad Identifier (default 21h)
Byte 7	FFh	Not used

Examples:

Direction	Identifier	Format	Message	Data
From Keypad	18EFFF21h	Ext	04 1B 0A 01 00 01 21 FF	1 Tick CW
From Keypad	18EFFF21h	Ext	04 1B 0A 81 FF FF 21 FF	1 Tick CCW

If the Event state transmission is enabled, the Encoder state message is sent when the knob is rotated for 1 or more ticks.

15. Set startup encoder tick counter value (0Ah)

The following command allows to set the desired encoder tick counter value at the startup.

Byte 0	04h	Header bytes
Byte 1	1Bh	
Byte 2	0Ah	Startup encoder tick counter value
Byte 3	YYh	Tick counter value LSByte
Byte 4	XXh	Tick counter value MSByte
Byte 5,7	FFh	Not used

Encoder tick counter value: XXYYh (from 0000h to FFFFh: from 0 to 65535)

Examples:

Direction	Identifier	Format	Message	Data
To Keypad	18EF2100h	Ext	04 1B 0A 0F 00 FF FF FF	Encoder tick counter value set to 15
From Keypad	18EFFF21h	Ext	04 1B 0A 01 00 10 21 FF	1 Tick CW
From Keypad	18EFFF21h	Ext	04 1B 0A 81 00 0E 21 FF	1 Tick CCW

16. Set startup LED show (34h)

Byte 0	04h	Header bytes
Byte 1	1Bh	
Byte 2	34h	Startup LED show
Byte 3	XXh	XX: 00h OFF 01h Complete LED show (default)
Byte 4,7	FFh	Not used

Example:

Direction	Identifier	Format	Message	Data
To Keypad	18EF2100h	Ext	04 1B 34 00 FF FF FF FF	Set startup LED show OFF

17. Baud rate setting (6Fh)

This message is used to change the baud rate of the CAN bus. Connecting only one PowerTrack to the bus when changing the baud rate is recommended. If an invalid value is chosen, then no change is done to the stored value.

Byte 0	04h	Header bytes
Byte 1	1Bh	
Byte 2	6Fh	Set baud rate message
Byte 3	02h	500kbit/s
	03h	250kbit/s
Byte 4,7	FFh	Not used

Example:

Direction	Identifier	Format	Message	Data
To Keypad	18EF2100h	Ext	04 1B 6F 02 FF FF FF FF	Set baud rate = 500kbit/s

18. Set Source Address (70h)

This message is used to change the keypad CAN Source Address and/or the Keypad Identifier. Either or both the Source Address or Keypad Identifier may be changed independently. Connecting only one PowerTrack to the bus when changing the keypad address is recommended. If an invalid value is chosen, then no change is done to the stored value.

Byte 0	04h	Header bytes
Byte 1	1Bh	
Byte 2	70h	Set Address message
Byte 3	XXh	XX: CAN Source Address From 00h to FDh FEh: reserved FFh: no change
Byte 4	YYh	YY: Keypad Identifier From 00h to FDh FEh: reserved FFh: no change
Byte 5,7	FFh	Not used

Example:

Direction	Identifier	Format	Message	Data
To Keypad	18EF2100h	Ext	04 1B 70 05 21 FF FF FF	Set source address = 05h, Set keypad identifier = 21h.

19. Periodic state transmission (71h)

This message enables or disables the periodic transmission of the Key state.
When enabled, one contact state message is periodically sent for each button of the PowerTrack.
The period is set to 100ms as default value but can be changed by command 77h.

Byte 0	04h	Header bytes
Byte 1	1Bh	
Byte 2	71h	Periodic state transmission message
Byte 3	XXh	XX: 00h Disabled (default) 01h Enabled
Byte 4,7	FFh	Not used

Example:

Direction	Identifier	Format	Message	Data
To Keypad	18EF2100h	Ext	04 1B 71 01 FF FF FF FF	Periodic state transmission enabled

20. Event state transmission (72h)

This message enables or disables event driven key state transmissions. When this feature is enabled, the PowerTrack transmits the state of a contact at the time that the contact changes state (pressed or released).

Byte 0	04h	Header bytes
Byte 1	1Bh	
Byte 2	72h	Event state transmission
Byte 3	XXh	XX: 00h Disabled 01h Enabled (default)
Byte 4,7	FFh	Not used

Example:

Direction	Identifier	Format	Message	Data
To Keypad	18EF2100h	Ext	04 1B 72 00 FF FF FF FF	Event state transmission disabled

21. LED Acknowledgment (73h)

This message enables or disables the transmission of the LED Acknowledgement message. When this feature is enabled the PowerTrack transmits an acknowledgement message each time a LED Command is received.

Byte 0	04h	Header bytes
Byte 1	1Bh	
Byte 2	73h	LED Acknowledgement
Byte 3	XXh	XX: 00h Disabled (default) 01h Enabled
Byte 4,7	FFh	Not used

Example:

Direction	**Identifier**	**Format**	**Message**	**Data**
To Keypad	18EF2100h	Ext	04 1B 73 01 FF FF FF FF	LED acknowledgement enabled
To Keypad	18EF2100h	Ext	04 1B 01 01 01 FF FF FF	LED Command
From Keypad	18EFFF21h	Ext	00 01 01 FF FF FF FF FF	LED Ack message

LED Acknowledgement message:

Byte 0	00h	
Byte 1	XXh	XX: LED number
Byte 2	YYh	YY: LED state
Byte 3,7	FFh	

22. Address Claim at boot (74h)

This message enables or disables the address claim procedure.

Byte 0	04h	Header bytes
Byte 1	1Bh	
Byte 2	74h	Address claim at boot
Byte 3	XXh	XX: 00h Disabled (default) 01h Enabled
Byte 4,7	FFh	Not used

Example:

Direction	Identifier	Format	Message	Data
To Keypad	18EF2100h	Ext	04 1B 74 01 FF FF FF FF	Address claim enabled

Address claiming procedure:

Under normal operation, the PowerTrack application sends an Address Claim parameter group at start up and waits up to 250 ms for the other devices connected to the same network to send a message containing the device's address and name. The PowerTrack checks every response and compares the names to see who has the highest priority. If a device is already using the address and has a higher priority, then a new address is selected and the process starts over. If the PowerTrack has a higher priority than the device in use then it waits for other systems to reply, while the responding device will have to change its address and send an address claim itself. If no message is received after the time (250ms) is up, then the device has claimed the address.

Address claim parameter group:

Priority = 6.
Destination Address should always be the Global Address FFh
Parameter Group Number (PGN) = 60928(EE00h).
Data Length = 8
Data = NAME field

Example:

Direction	Identifier	Format	Message	Data
From Keypad	18EEFF21h	Ext	3F 42 6F 1A 00 82 3C C0	

23. Heartbeat (75h)

This message enables or disables the transmission of Heartbeat message. This message is designed to indicate to other devices on the bus that this unit continues to function.

Byte 0	04h	Header bytes
Byte 1	1Bh	
Byte 2	75h	Heartbeat
Byte 3	XXh	XX: 00h Disabled (default) 01h Enabled
Byte 4	YYh	YY: Heartbeat Period [ms] ÷ 10 From 05h (50ms) to FEh (2.54 sec)
Byte 5,7	FFh	Not used

Example:

Direction	Identifier	Format	Message	Data
To Keypad	18EF2100h	Ext	04 1B 75 01 32 FF FF FF	Heartbeat enabled with 500ms period

Heartbeat generated message:

Byte 0	04h	Header bytes
Byte 1	1Bh	
Byte 2	F9h	Heartbeat message
Byte 3	XXh	XX: Message counter, incremented each message sent
Byte 4	00 K7 K6 K5 K4 K3 K2 K1	Button state indicators Each bit represents a button state 0: OFF 1: ON
Byte 5	00 00 00 00 00 00 00 00	
Byte 6	ZZh	Keypad Identifier (default 21h)
Byte 7	FFh	Not used

Example:

Direction	Identifier	Format	Message	Data
From Keypad	18EFFF21h	Ext	04 1B F9 03 02 21 00 00	Heartbeat message with button 2 pressed

24. Periodic Key message period (77h)

This message sets the period time for the Key state messages (71h). This does not enable or disable the messages.

Byte 0	04h	Header bytes
Byte 1	1Bh	
Byte 2	77h	Periodic key message period
Byte 3	XXh	XX: Period in milliseconds ÷ 10 From 05h (50ms) to FEh (2.54 sec)
Byte 4,7	FFh	Not used

Example:

Direction	Identifier	Format	Message	Data
To Keypad	18EF2100h	Ext	04 1B 77 0A FF FF FF FF	Period set to 100ms

25. Start Demo mode(7Ah)

This message enables the Demo mode function. Demo mode is a special feature that consists in different LED states for button pressing. Refer to the paragraph “Demo mode instructions” to try these special features. Disconnect and reconnect the PowerTrack after the enable message to enter this mode.

To exit the Demo mode, send the Disable Demo mode command or another command message.

Byte 0	04h	Header bytes
Byte 1	1Bh	
Byte 2	7Ah	Demo mode
Byte 3	XXh	XX: 00h Disabled (Default) 01h Enabled
Byte 4,7	FFh	Not used

Example:

Direction	Identifier	Format	Message	Data
To Keypad	18EF2100h	Ext	04 1B 7A 01 FF FF FF FF	Demo mode enabled

26. LED dim at startup (7Bh)

This message sets the value of the indicator LED brightness at PowerTrack power up. The value can be set from 0 to 3Fh from min to max of the LED dimming range.

Byte 0	04h	Header bytes
Byte 1	1Bh	
Byte 2	7Bh	LED dim at startup
Byte 3	XXh	XX: Value From 00h (min) to 3Fh (100%)
Byte 4,7	FFh	Not used

Example:

Direction	Identifier	Format	Message	Data
To Keypad	18EF2100h	Ext	04 1B 7B 10 FF FF FF FF	LED dim set to 25%

27. Set backlight green level at startup (7Ch)

This message sets the value of the backlight green color at PowerTrack power up. The value can be set from 0 to 3Fh for 0 to 100% of the brightness range.

Byte 0	04h	Header bytes
Byte 1	1Bh	
Byte 2	7Ch	Set backlight green at startup
Byte 3	XXh	XX: Value From 00h (0%) to 3Fh (100%)
Byte 4,7	FFh	Not used

Example:

Direction	Identifier	Format	Message	Data
To Keypad	18EF2100h	Ext	04 1B 7C 20 FF FF FF FF	Backlight green at startup 50%

28. Set backlight red level at startup (7Dh)

This message sets the value of the backlight red at PowerTrack power up. The value can be set from 0 to 3Fh for 0 to 100% of the brightness range.

Byte 0	04h	Header bytes
Byte 1	1Bh	
Byte 2	7Dh	Set backlight at startup
Byte 3	XXh	XX: Value From 00h (0%) to 3Fh (100%)
Byte 4,7	FFh	Not used

Example:

Direction	Identifier	Format	Message	Data
To Keypad	18EF2100h	Ext	04 1B 7D 30 FF FF FF FF	Backlight red at startup 75%

29. Set backlight blue level at startup (7Eh)

This message sets the value of the backlight blue at PowerTrack power up. The value can be set from 0 to 3Fh for 0 to 100% of the brightness range.

Byte 0	04h	Header bytes
Byte 1	1Bh	
Byte 2	7Eh	Set backlight at startup
Byte 3	XXh	XX: Value From 00h (0%) to 3Fh (100%)
Byte 4,7	FFh	Not used

Example:

Direction	Identifier	Format	Message	Data
To Keypad	18EF2100h	Ext	04 1B 7E 10 FF FF FF FF	Backlight blue at startup 25%

30. Set CANopen protocol

This set of messages are used to change to the desired CANbus protocol.

- Change from J1939 to CANopen:

Direction	Identifier	Format	Message	Data
To Keypad	18EF2100h	Ext	04 1B 80 00 FF FF FF FF	Change to CANopen

- Change from CANopen to J1939:

Direction	Identifier	Format	Message	Data
To Keypad	615h	Std	2F FF 20 01 01	Change to J1939

APPENDIX: DEMO Mode instructions

In DEMO Mode you can try these functions by pressing buttons on the PowerTrack.

For the Key 1, each time that you press the button, there are different steps in this sequence:

1) No LEDs on and no backlight;
2) All LEDs green on and backlight red;
3) All LEDs red on and backlight green;
4) Keys LEDs red-green on, keys backlight blue on and encoder ring backlight red-green on
5) Return in step 1.

Pressing Key 2 you can see backlight white color on, while keys LEDs and encoder/ring backlight blink in alternate mode red-green.

For the Key 3, each time that you press the button, you can change backlight in this sequence:

1) Red;
2) Green;
3) Blue, red cursor on the encoder ring;
4) Amber/orange and encoder yellow/green, red cursor on the encoder ring;
5) Cyan, red cursor on the encoder ring;
6) Magenta, red cursor on the encoder ring;
7) White/light blue, red cursor on the encoder ring;
8) Return in step 1.

Pressing Key 4 you can see backlight blue.

In the case that you press key 5, 6 and 7 and/or rotate the encoder (clockwise or counterclockwise) there are no events.

31. Revision history

Date	Manual Revision	Comment	Related SW version
06/06/2017	1.0	First Release PowerTrack J1939	SW2.0
20/02/2018	1.1	Second Release • Corrected the values of byte 2 in the commands for backlight red and blue brightness level messages • Replaced the symbol 'h' (hexadecimal) with the correct one 'b' (binary) in the encoder state message table. • Added appendix ''DEMO mode instructions''	x.x
20/03/2018	1.2	Third release: • Added a note in the ''LED COMMAND'' to explain how the color amber is obtained • Corrected some default states and commands in the ''DEFAULT SETTINGS'' table	x.x
07/05/2019	1.3	Fourth release: • Added warning note at page 2 • Added command {0Ah}: set startup encoder tick counter value • In compliance with the SAE J1939 standard, in the command {70h} the value FEh has been excluded from the list of the addresses assignable by the user to the keypad	x.x
16/09/2021	1.4	Fifth release: • In "LED command (01h)" indicated the possibility to switch on with amber color for ring LEDs only	x.x