Intelligent Power Distribution System

Distribute battery power programmatically with current feedback
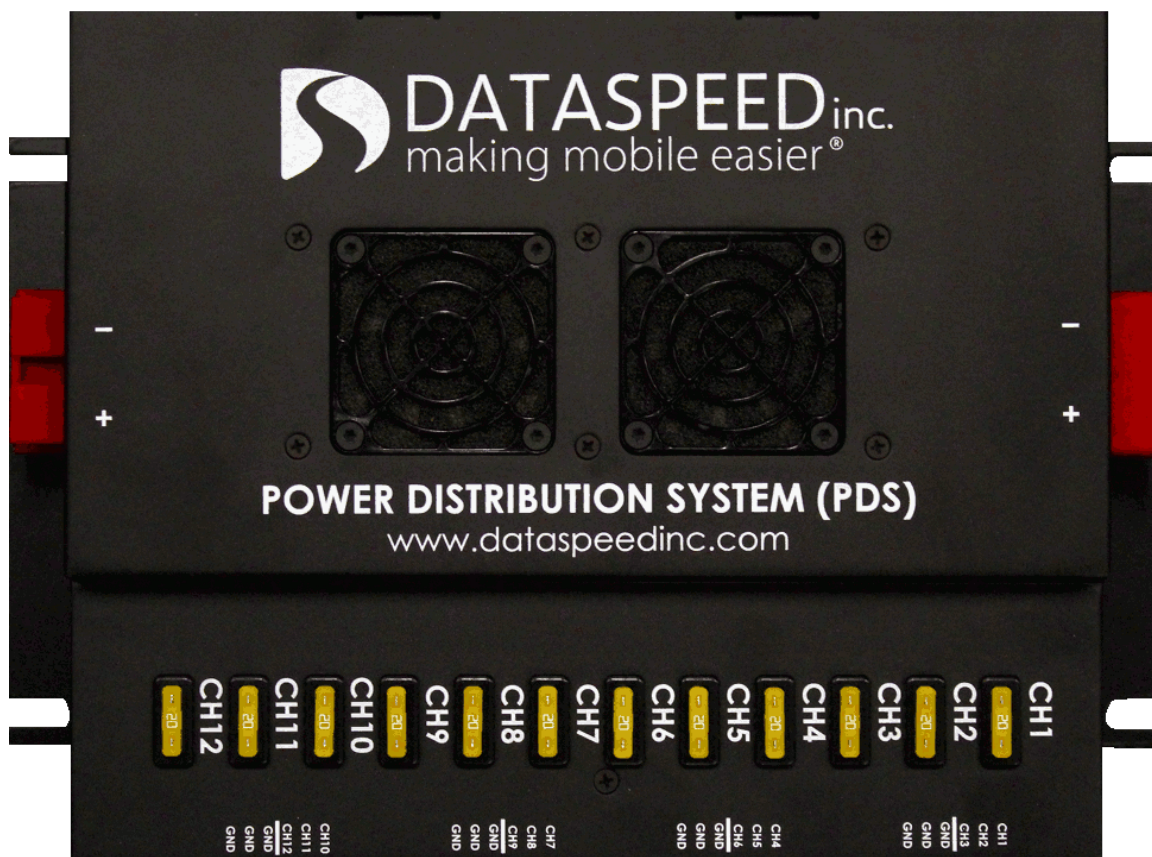
Features

- 12 channels at up to 15A each (12V V_{BAT}) or up to 10A each (24V V_{BAT})
- Programmable startup and shutdown scripts
- Over-current feedback and diagnostics
- External temperature sensor and fan support
- Switch panel or touchscreen control and status
- CAN, Ethernet, and USB communication
- Chain up to four units together for a maximum of 48 channels
- Inverter remote to control AC power (See supported inverters)

Description

The Dataspeed Inc. Intelligent Power Distribution System (iPDS) enables computer control of fused power channels and programmable startup and shutdown sequences. Control of channels as well as the status is available over communication interfaces including industry standard CAN, Ethernet, and USB. An iPDS Switch Panel or iPDS Touch Screen is also included with the system to allow control and show status.

Applications

- Driverless car research
- Advanced driver-assistance systems (ADAS)

Contents

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1 System Components

The Intelligent Power Distribution System consists of two components. The iPDS Panel, pictured on the title page is the main component. To interface to the iPDS Panel either an iPDS Switch Panel or an iPDS Touch Screen is provided. They both feature buttons to toggle channel power, visual feedback, script triggering and mode change, and the touch screen also shows each channel's current.

1.1 Switch Panel

The iPDS Switch Panel controls up to two iPDS Panels, 24 channels, with physical buttons and is conveniently hidden in the center console of Ford MKZ, Ford Fusion, and Chrysler Pacifica vehicles. LEDs in the buttons provide on/off/fault status of each channel. A startup and shutdown button are provided, as well as mode changing with a key. The function of each button can be configured in the GUI, see the Intelligent Power Distribution GUI documentation. The bottom-left button corresponds to channel 1, top-left to channel 6 and top-right to channel 24.

1.1.1 Status LEDs

The rear of the Switch Panel, near the power and CAN cable, features two status LEDs. The power LED (green) indicates that power and ignition have been applied. The status LED (red) blinks at a frequency of 1Hz to indicate normal operation.

1.1.2 Channel LEDs

The LEDs in the 4x6 grid indicate the status of the corresponding channels on the Power Distribution Panel.

Table 1: LED channel status enumeration

LED Status	Channel Status
Solid off	Channel off
Solid on	Channel on
1 blink	Relay failed to contact
2 blinks	Fuse is blown
3 blinks	Channel disabled due to over-current

1.1.3 Channel Buttons

Pressing the buttons in the 4x6 grid will send a CAN message command to the iPDS Panel to toggle the corresponding channel.

1.1.4 Script Buttons

The startup button LED will illuminate when the startup script is running and the shutdown button LED will illuminate when the shutdown script is running. Pressing the startup button will run or stop the startup script, and pressing the shutdown button will run or stop the shutdown script.

1.1.5 Mode Key

The mode can be selected by inserting and turning the key. When the key is turned, the 4x6 grid of buttons no longer corresponds to the channel statuses. The first three buttons select the mode. Normal operation returns after removing the key. See the Modes section for more information on the different modes.

1.2 Touch Screen

The iPDS Touch Screen controls up to four iPDS Panels, 48 channels, with touchscreen controls. The screen shows on/off/fault status of each channel as well as the current used by each channel. On-screen buttons are provided for running startup and shutdown scripts. Mode changes can be performed by entering a PIN. In addition the Power Distribution GUI allows configuration of the following:

- Channel names displayed on the Touch Screen

- Mode change PIN. The default PIN is 1234.

Figure 1: iPDS Interfacing Components

(a) iPDS Switch Panel

(b) iPDS Touch Screen
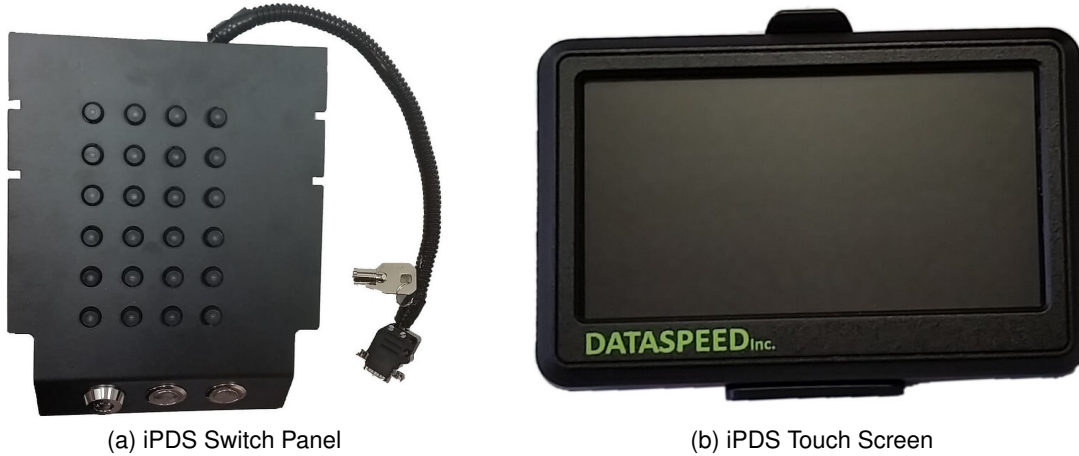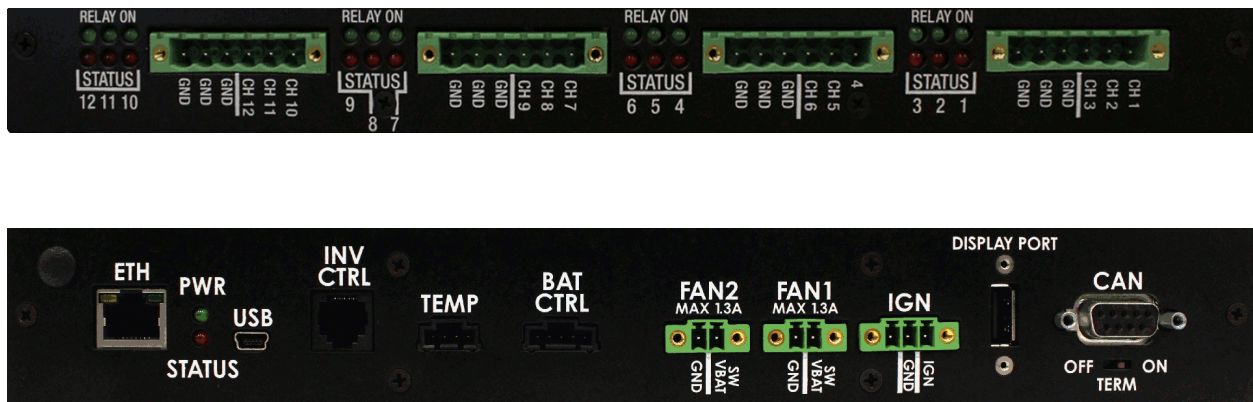
2 Connector Pin Descriptions

Table 2: Connector Description

Label	Manufacturer	Mating P/N	Description
POWER	Anderson	6810G3/1319G6	Power connector, V_{BAT} input
CH X/GND	Phoenix	1805343	Channel outputs[1]
CAN		DB9 Male	CAN and Ignition 1-2
Display Port		USB Type A	Input for Touch Screen
IGN	Phoenix	1827716	Ignition 3
FAN1 & FAN2	Phoenix	1827703	Fans
INV CTRL		RJ12	AC power inverter control interface
TEMP	Molex	50579404	External temperature sensor[2]
BAT CTRL	Molex	50579405	To be supported in future firmware
USB		USB Mini B	USB mini
ETH		RJ45	Ethernet
TERM			CAN termination resistance ON/OFF (120Ω)

[1] If the connectors are not fully seated additional resistance will cause excessive heat and potential damage to the unit

[2] Older revision A-F hardware uses a Type-K thermocouple for external temperature

2.1 CAN/DB9 Connector

The CAN/DB9 connector is used for CAN communication and to provide power output. Applying voltage to either ignition input will power the device on. The TERM switch below the CAN Connector (added in revision G) enables or disables the CAN termination resistance. See the Electrical Characteristics section for more information.

Figure 2: CAN/DB9 Connector

Pin	Symbol	Description
1	NC	No Connect
2	CANL	CAN Low
3	GND	Ground
4	IGN1	Ignition 1
5	GND	Ground
6	GND	Ground
7	CANH	CAN High
8	IGN2	Ignition 2
9	POUT	Power Out (Switched V_{BAT})
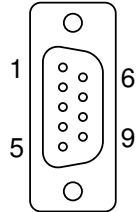
2.2 Display Port Connector

The Display Port connector is used to provide power and CAN communication to the Touch Screen. Note: This USB connector does not provide standard USB signals. Connecting a USB device may result in damage to your device.

Figure 3: Display Port Connector

Pin	Symbol	Description
1	POUT	Power Out (Switched V_{BAT})
2	CANL	CAN Low
3	CANH	CAN High
4	GND	Ground

2.3 Ignition Connector

The Power Distribution Panel draws less than 0.2mA with ignition off. Applying voltage to any of the 3 ignition pins will power the device on. The startup and shutdown scripts will execute automatically in auto mode. Additionally, for hardware revisions B and newer IGN3 is passed through to IGN1 through a diode. This allows ignition pass-through and output on IGN1 to other devices.

Figure 4: Ignition Connector

Pin	Symbol	Description
1	IGN3	Ignition 3
2	GND	Ground
3	NC	No Connect

2.4 Fan Connectors

Figure 5: Fan Connector

Pin	Symbol	Description
1	SW VBAT	Switched V_{BAT}
2	GND	Ground

* Older revision A-F hardware uses a low side switch (V_{BAT} and switched ground)

2.5 Inverter Remote

The inverter remote is used to control a Samlex Pure Sine Wave Inverter from the list of supported models below. The inverter is mapped to channel index 48. If additional iPDS Panels are connected then channel 49, 50, and 51 are their respective indices for inverter control; each iPDS Panel can control one inverter. Additionally the startup and shutdown scripts can control the inverter(s) like any other channel. Unlike the 12 integrated channels, the inverter channel provides no current feedback. See the Status CAN message to see what feedback is available.

2.6 Battery Control

This connector is not presently used.

2.7 USB Connector

The USB connector is used to connect to a host PC. A USB connection is required for the configuration GUI and firmware upgrades.

2.8 Ethernet Connector

The Ethernet connector supports 10/100 Mbit/s communication. The Ethernet protocol is Lightweight Communications and Marshalling (LCM).

2.9 Switch Panel Connectors

The CAN/DB9 connector is used for power input and CAN communication. Applying voltage to the ignition input will power the device on. See the Electrical Characteristics section for more information.
The USB Mini connector can be used to perform firmware upgrades.

Table 3: Supported Samlex part numbers

Model	Wattage	Voltage DC	Voltage AC	Connector
PST-600-12	600W	12V	120VAC	RJ12
PST-1000-12	1000W	12V	120VAC	RJ12
PST-1500-12	1500W	12V	120VAC	RJ50[1]
PST-2000-12	2000W	12V	120VAC	RJ50[1]
PST-60S-12E	600W	12V	230VAC	RJ12
PST-100S-12E	1000W	12V	230VAC	RJ12
PST-150S-12E	1500W	12V	230VAC	RJ50[1]
PST-200S-12E	2000W	12V	230VAC	RJ50[1]
PST-600-24	600W	24V	120VAC	RJ12
PST-1000-24	1000W	24V	120VAC	RJ12
PST-1500-24	1500W	24V	120VAC	RJ50[1]
PST-2000-24	2000W	24V	120VAC	RJ50[1]
PST-60S-24E	600W	24V	230VAC	RJ12
PST-100S-24E	1000W	24V	230VAC	RJ12
PST-150S-24E	1500W	24V	230VAC	RJ50[1]
PST-200S-24E	2000W	24V	230VAC	RJ50[1]

[1] Requires adapter, contact Dataspeed for specifications

Figure 6: Switch Panel CAN/DB9 Connector

Pin	Symbol	Description
1	CAN2L	CAN 2 Low
2	CAN1L	CAN 1 Low
3	GND	Ground
4	IGN	Ignition
5	GND	Ground
6	GND	Ground
7	CAN1H	CAN 1 High
8	CAN2H	CAN 2 High
9	POWER	V_{BAT} input

2.10 Touch Screen Connectors
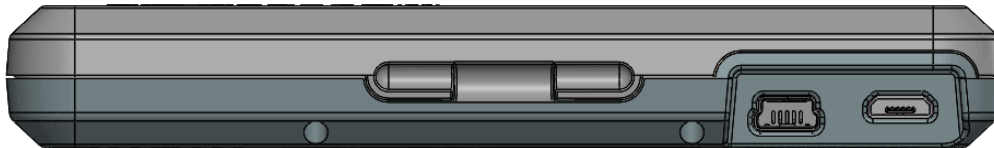
Figure 7: USB connectors, left: Mini, right: Micro

The USB Mini connector is used for power and CAN communication and should be connected to the iPDS Panel's Display Port. Note that the signals on this USB connector are not standard USB signals. Connecting a USB host such as a computer to the USB Mini connector is potentially dangerous.

The USB Micro connector is used for firmware updates. Note that the device cannot be powered by this connector.

Table 4: USB Mini Connector pin description.

Pin	Symbol	Description
1	POWER	V_{BAT} input
2	CANL	CAN Low
3	CANH	CAN High
4	GND	Ground

3 Electrical Characteristics

Table 5: Electrical Characteristics.

	Characteristic	Min	Typ	Max	Units	Conditions
	V_{IGN} ON[1]	9	12	28[2]	V	
	V_{IGN} OFF[1]	-0.3	0	2	V	
	V_{BAT}	9	12	28[2]	V	
	R_{CAN}		120		Ω	TERM=ON
	Temperature	-40		+85	$^\circ$C	
	I_{POUT}			1.5	A	Shared by CAN and Display Port
V_{BAT}=12V	$I_{CHANNEL}$			15	A	Continuous for each channel
	I_{TOTAL}			180	A	Total current (device and all channels)
	I_{BAT_PANEL}		1250		mA	V_{IGN}>9V, all channels on
	I_{BAT_PANEL}		250		mA	V_{IGN}>9V, all channels off
	I_{BAT_PANEL}			0.5	mA	V_{IGN}<2V
	$I_{BAT\_TOUCH\_SCREEN}$		150		mA	
	$I_{BAT\_SWITCH\_PANEL}$		200		mA	V_{IGN}>9V, all channels on
	$I_{BAT\_SWITCH\_PANEL}$		60		mA	V_{IGN}>9V, all channels off
	$I_{BAT\_SWITCH\_PANEL}$			0.5	mA	V_{IGN}<2V
V_{BAT}=24V	$I_{CHANNEL}$			10	A	Continuous for each channel
	I_{TOTAL}			90	A	Total current (device and all channels)
	I_{BAT_PANEL}		700		mA	V_{IGN}>9V, all channels on
	I_{BAT_PANEL}		100		mA	V_{IGN}>9V, all channels off
	I_{BAT_PANEL}			7.0	mA	V_{IGN}<2V
	$I_{BAT\_TOUCH\_SCREEN}$		75		mA	
	$I_{BAT\_SWITCH\_PANEL}$		100		mA	V_{IGN}>9V, all channels on
	$I_{BAT\_SWITCH\_PANEL}$		35		mA	V_{IGN}>9V, all channels off
	$I_{BAT\_SWITCH\_PANEL}$			1.0	mA	V_{IGN}<2V

[1] For the iPDS Panel, V_{IGN} is the maximum of V_{IGN1}, V_{IGN2}, and V_{IGN3}
[2] Older iPDS Panel revision A-H hardware only supports a maximum of 16 V
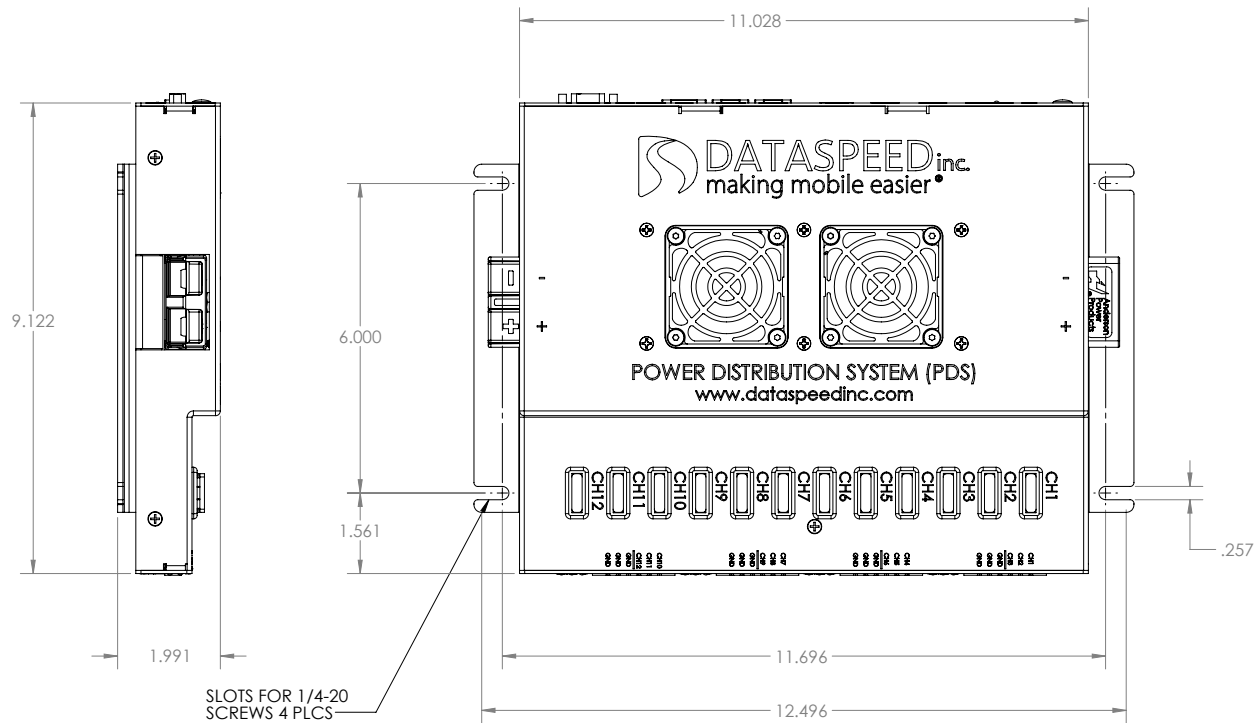
4 Mechanical Drawings

Figure 8: iPDS Panel Mechanical Drawing
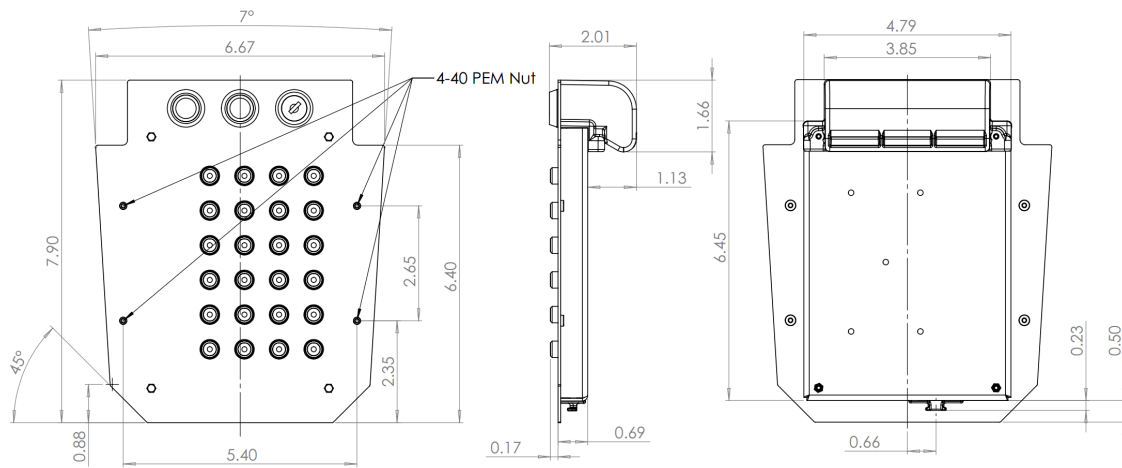
Figure 9: iPDS Switch Panel Mechanical Drawing for Lincoln MKZ

Figure 10: iPDS Switch Panel Mechanical Drawing for Ford Fusion

Figure 11: iPDS Switch Panel Mechanical Drawing for Ford Fusion
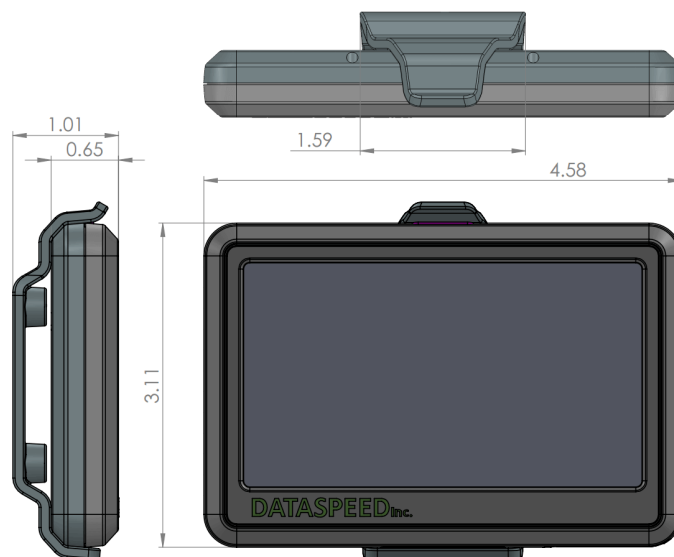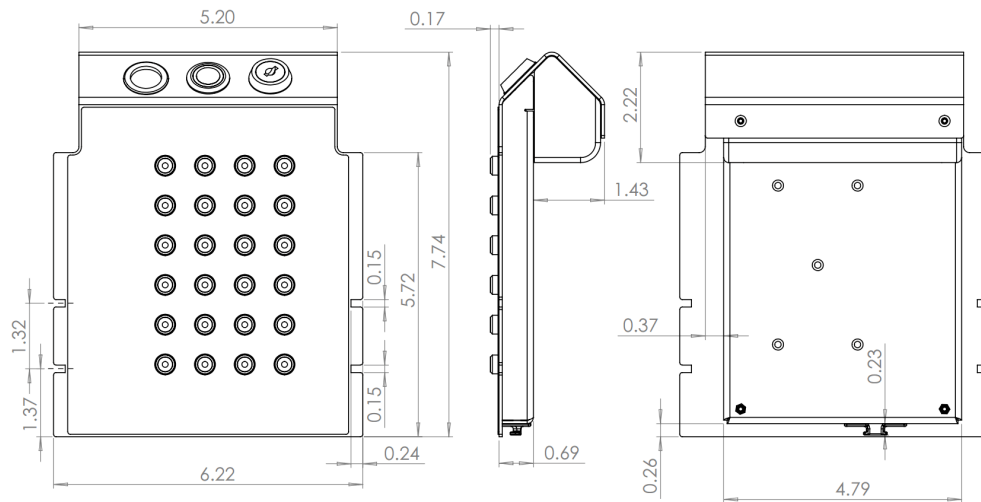
5 Active Cooling

Two fans provide active cooling for the Power Distribution Panel to help extend the operating temperature in hot environments. If the internal temperature reaches 45 °C they will turn on automatically. When the internal temperature drops below 40 °C the fans will turn off. For proper operation make sure to not block the fan openings. The fan filters should also be checked regularly and cleaned of any dust buildup.

6 LEDs

6.1 Main

The power LED (green) indicates that power and ignition have been applied.
The status LED (red) blinks at a frequency of 1Hz to indicate normal operation.

6.2 Channels

Each channel has a green and red LED.
The green LED is driven with the relay. If this LED is on, the relay is on.
The red LED indicates a fault status:

Table 6: Red LED status

LED Status	Channel Status	Description
Solid off	NORMAL	On and load is above 150mA
Solid on	NO LOAD	On and load is below 100mA
1 blink	BAD RELAY	Relay failed to contact
2 blinks	BAD FUSE	Fuse is blown
3 blinks	OVER CURRENT	Channel disabled to protect fuse

7 Modes

Mode AUTO accepts commands over all communication interfaces and automatically executes the startup and shutdown scripts. Mode MANUAL accepts commands over all communication interfaces and automatically executes the shutdown script. Mode VALET only responds to USB commands. This is a lockout mode. Separate valet startup and shutdown scripts are executed.

Table 7: Mode Descriptions

Mode	Commands Accepted				Scripts Run			
	USB	CAN	Ethernet	Bluetooth	Startup	Shutdown	Valet Startup	Valet Shutdown
AUTO	X	X	X	X	X	X		
MANUAL	X	X	X	X		X		
VALET	X						X	X

8 CAN Messages

Table 8: CAN bus configuration.

Parameter	Value	Units
BitRate	500	kbit/s
t_q	200	ns
SyncSeg	1	t_q
PropSeg	3	t_q
PhaseSeg1	3	t_q
PhaseSeg2	3	t_q
SyncJumpWidth	2	t_q

CAN bus termination of 120 Ω is only present on the iPDS Panel. In Panel revisions G and newer the TERM switch must be set to on for termination.

8.1 Request

Message ID: 0x410
Rate: On Event
Transmitted by: iPDS Switch Panel, iPDS Touch Screen

Table 9: Request CAN Message Description.

Byte	Bits	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	7:0	INDEX							
1	15:8	REQUEST							

bit 0-7   **INDEX:** Channel Index
    0 = Channel 1
    1 = Channel 2
    2 = Channel 3
    ...
    47 = Channel 48
    —
    48 = Inverter 1
    49 = Inverter 2
    50 = Inverter 3
    51 = Inverter 4

bit 8-15   **REQUEST:** Relay Request
    0 = Off
    1 = On
    2 = Toggle

Note: In Valet Mode the iPDS Panel will ignore Request CAN messages.

8.2 Mode

Message ID: 0x411
Rate: On Event
Transmitted by: iPDS Switch Panel, iPDS Touch Screen

Table 10: Mode CAN Message Description.

Byte	Bits	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	7:0	MODE							

bit 0-7   **MODE:** Mode Request
               0 = Auto
               1 = Manual
               2 = Valet

8.3 Script

Message ID: 0x412
Rate: On Event
Transmitted by: iPDS Switch Panel, iPDS Touch Screen

Table 11: Script CAN Message Description.

Byte	Bits	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	7:0	SCRIPT							

bit 0-7   **SCRIPT:** Script Request
               0 = None
               1 = Startup
               2 = Shutdown

Note: In Valet Mode the iPDS Panel will ignore Script CAN messages.

8.4 Reserved

Message ID: 0x413
Rate: On Event
Transmitted by: iPDS Touch Screen

8.5 Status

Message ID: 0x420, 0x421, 0x422, 0x423
Rate: 50ms
Transmitted by: iPDS Panel

Table 12: Status CAN Message Description.

Byte	Bits	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	7:0	INVERTER[1,2,3,4] BITS				RESERVED			
1	15:8	SCRIPT				MODE			
2	23:16	STATUS[2,14,26,38]				STATUS[1,13,25,37]			
3	31:24	STATUS[4,16,28,40]				STATUS[3,15,27,39]			
4	39:32	STATUS[6,18,30,42]				STATUS[5,17,29,41]			
5	47:40	STATUS[8,20,32,44]				STATUS[7,19,31,43]			
6	55:48	STATUS[10,22,34,46]				STATUS[9,21,33,45]			
7	63:56	STATUS[12,24,36,48]				STATUS[11,23,35,47]			

bit 0-3   **RESERVED:**
bit 4   **INV-REQUEST[1,2,3,4]:** Inverter 1,2,3,4 request: 0 = Off, 1 = On
bit 5   **INV-STATUS[1,2,3,4]:** Inverter 1,2,3,4 status: 0 = Off, 1 = On
bit 6   **INV-OVERLOAD[1,2,3,4]:** Inverter 1,2,3,4 over-load: 0 = No Fault, 1 = Fault
bit 7   **INV-OVERTEMP[1,2,3,4]:** Inverter 1,2,3,4 over-temperature: 0 = No Fault, 1 = Fault
bit 8-11   **MODE:** Current mode
                     0 = Auto
                     1 = Manual
                     2 = Valet
bit 15-12   **SCRIPT:** Running script
                     0 = None
                     1 = Startup
                     2 = Shutdown
bit 19-16   **STATUS[1,13,25,37]:** Channel 1,13,25,37 status
                     0 = Off
                     1 = On
                     2 = No Load
                     3 = Bad Relay
                     4 = Bad Fuse
                     5 = Over Current
bit 23-20   **STATUS[2,14,26,38]:** Channel 2,14,26,38 status (same as 1)
bit 27-24   **STATUS[3,15,27,39]:** Channel 3,15,27,39 status (same as 1)
bit 31-28   **STATUS[4,16,28,40]:** Channel 4,16,28,40 status (same as 1)
bit 35-32   **STATUS[5,17,29,41]:** Channel 5,17,29,41 status (same as 1)
bit 39-36   **STATUS[6,18,30,42]:** Channel 6,18,30,42 status (same as 1)
bit 43-40   **STATUS[7,19,31,43]:** Channel 7,19,31,43 status (same as 1)
bit 47-44   **STATUS[8,20,32,44]:** Channel 8,20,32,44 status (same as 1)
bit 51-48   **STATUS[9,21,33,45]:** Channel 9,21,33,45 status (same as 1)
bit 55-52   **STATUS[10,22,34,46]:** Channel 10,22,34,46 status (same as 1)
bit 59-56   **STATUS[11,23,35,47]:** Channel 11,23,35,47 status (same as 1)
bit 64-60   **STATUS[12,24,36,48]:** Channel 12,24,36,48 status (same as 1)

8.6 Current 1

Message ID: 0x424, 0x425, 0x426, 0x427
Rate: 50ms
Transmitted by: iPDS Panel

Table 13: Current 1 CAN Message Description.

Byte	Bits	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	7:0	CURRENT[1,13,25,37]<7:0>							
1	15:8	CURRENT[1,13,25,37]<15:8>							
2	23:16	CURRENT[2,14,26,38]<7:0>							
3	31:24	CURRENT[2,14,26,38]<15:8>							
4	39:32	CURRENT[3,15,27,39]<7:0>							
5	47:40	CURRENT[3,15,27,39]<15:8>							
6	55:48	CURRENT[4,16,28,40]<7:0>							
7	63:56	CURRENT[4,16,28,40]<15:8>							

bit 0-15   **CURRENT[1,13,25,37]:** Channel 1,13,25,37 current
               0x8000 = -32.768A
               0xFFFF = -0.001A
               0x0000 = 0.000A
               0x0001 = 0.001A
               0x7FFF = 32.767A
bit 31-16   **CURRENT[2,14,26,38]:** Channel 2,14,26,38 current (same as 1)
bit 47-32   **CURRENT[3,15,27,39]:** Channel 3,15,27,39 current (same as 1)
bit 63-48   **CURRENT[4,16,28,40]:** Channel 4,16,28,40 current (same as 1)

8.7 Current 2

Message ID: 0x428, 0x429, 0x42A, 0x42B
Rate: 50ms
Transmitted By: iPDS Panel

Table 14: Current 2 CAN Message Description.

Byte	Bits	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	7:0	CURRENT[5,17,29,41]<7:0>							
1	15:8	CURRENT[5,17,29,41]<15:8>							
2	23:16	CURRENT[6,18,30,42]<7:0>							
3	31:24	CURRENT[6,18,30,42]<15:8>							
4	39:32	CURRENT[7,19,31,43]<7:0>							
5	47:40	CURRENT[7,19,31,43]<15:8>							
6	55:48	CURRENT[8,20,32,44]<7:0>							
7	63:56	CURRENT[8,20,32,44]<15:8>							

bit 0-15   **CURRENT[5,17,29,41]:** Channel 5,17,29,41 current
               0x8000 = -32.768A
               0xFFFF = -0.001A
               0x0000 = 0.000A
               0x0001 = 0.001A
               0x7FFF = 32.767A
bit 31-16   **CURRENT[6,18,30,42]:** Channel 6,18,30,42 current (same as 5)
bit 47-32   **CURRENT[7,19,31,43]:** Channel 7,19,31,43 current (same as 5)
bit 63-48   **CURRENT[8,20,32,44]:** Channel 8,20,32,44 current (same as 5)

8.8 Current 3

Message ID: 0x42C, 0x42D, 0x42E, 0x42F
Rate: 50ms
Transmitted By: iPDS Panel

Table 15: Current 3 CAN Message Description.

Byte	Bits	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	7:0	CURRENT[9,21,33,45]<7:0>							
1	15:8	CURRENT[9,21,33,45]<15:8>							
2	23:16	CURRENT[10,22,34,46]<7:0>							
3	31:24	CURRENT[10,22,34,46]<15:8>							
4	39:32	CURRENT[11,23,35,47]<7:0>							
5	47:40	CURRENT[11,23,35,47]<15:8>							
6	55:48	CURRENT[12,24,36,48]<7:0>							
7	63:56	CURRENT[12,24,36,48]<15:8>							

bit 0-15   **CURRENT[9,21,33,45]:** Channel 9,21,33,45 current
              0x8000 = -32.768A
              0xFFFF = -0.001A
              0x0000 = 0.000A
              0x0001 = 0.001A
              0x7FFF = 32.767A
bit 31-16   **CURRENT[10,22,34,46]:** Channel 10,22,34,46 current (same as 9)
bit 47-32   **CURRENT[11,23,35,47]:** Channel 11,23,35,47 current (same as 9)
bit 63-48   **CURRENT[12,24,36,48]:** Channel 12,24,36,48 current (same as 9)

8.9 Reserved

Message ID: 0x430
Rate: 200ms
Transmitted by: iPDS Panel

8.10 Reserved

Message ID: 0x431
Rate: On Event
Transmitted by: iPDS Panel

8.11 Reserved

Message ID: 0x432
Rate: 200ms
Transmitted by: iPDS Panel

8.12 Status2

Message ID: 0x43C, 0x43D, 0x43E, 0x43F
Rate: 50ms
Transmitted by: iPDS Panel

Table 16: Status2 CAN Message Description.

Byte	Bits	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	7:0	BOARDTEMP[0,1,2,3]							
1	15:8	THERMOCOUPLE[0,1,2,3]							
2	23:16	VOLTAGE[0,1,2,3]<7:0>							
3	31:24	—	—	—	—	VOLTAGE[0,1,2,3]<11:8>			

bit 0-7   **BOARDTEMP[0,1,2,3]:** Internal board temperature of unit 0,1,2,3
             0x80 = -20.0°C
             0xA8 = 0.0°C
             0xA9 = 0.5°C
             0x00 = 44.0°C
             0x01 = 44.5°C
             0x7F = 107.5°C
bit 8-15   **THERMOCOUPLE[0,1,2,3]:** External thermocouple reading of unit 0,1,2,3
             0x80 = -20.0°C
             0xA8 = 0.0°C
             0xA9 = 0.5°C
             0x00 = 44.0°C
             0x01 = 44.5°C
             0x7F = 107.5°C
bit 16-27   **VOLTAGE[0,1,2,3]:** Input voltage of unit 0,1,2,3
             0x000 = 0.00V
             0x001 = 0.01V
             0x3FF = 40.95V
bit 28-31   **Unimplemented:** Set to '0'

Note: The master iPDS Panel is unit 0 and slaves 1-3 are units 1-3.

9 Bluetooth

Bluetooth is available to control and receive the status of the iPDS. By default Bluetooth is disabled, and can be enabled through the iPDS GUI. Once Bluetooth is enabled, a PIN is required to pair. The PIN is the same used for changing the mode.

9.1 Android

An Android app, "Dataspeed iPDS" is available on the Google Play Store. The app connects over Bluetooth and is similar in design to the Touch Screen. Channel control and status, mode changes, running or stopping scripts, and diagnostic information is available.

9.2 Communication Specification

The communication protocol is loosely based around HDLC or ISO 13239. Table 17 outlines the Bluetooth message format used by the iPDS. The start and end of frame flags are always 0x7E. The length field is the number of bytes of the message field plus command field. The CRC is calculated over the

length, command, and message fields. The CRC is a CRC16-CITT initialized with 0xFFFF. An online calculator that provides the same CRC calculation is available at http://www.lammertbies.nl/comm/info/crc-calculation.html. The CRC of the length, command, message, and CRC fields of a valid message should result in 0x0000. Since 0x7E is reserved as a frame flag, if it needs to occur anywhere else in the

Table 17: General Bluetooth Message Structure

Start Flag	Length	Command	Message	CRC	End Flag
1 byte	1 byte	1 byte	0+ bytes	2 bytes	1 byte

transmitted data it needs to be escaped with the character 0x7D. If either the frame flag or escape character occur in the data to be transmitted, they are preceded with the escape character, 0x7D. The length field and CRC should be calculated after any escape characters are added. Three control commands can currently be sent to the iPDS: Relay Channel Request, Script Request, and Mode Change Request. The Relay Channel Request tells a channel to turn on, off, or to toggle. The Script Request tells the iPDS to begin execution of one of four stored scripts, or to stop execution of all scripts. The Mode Change Request changes which mode the iPDS unit is operating in: Auto, Manual, or Valet. Table 18 shows the available commands. The Length given assumes no escape characters are required.

Table 18: Command Definitions

Command	Length	ID	Message Byte 1	Message Byte 2(+)
Relay Request	3	0	Channel [0-51]	RELAY_REQUEST
Script Request	2	1	SCRIPT_TYPE	
Mode Request	6	2	MODE	PIN (4 bytes)
Status Message	115	3	[See example]	
Get Name	2	4	Channel [0-51]	
Set Name	4-63	4	Channel [0-51]	Null-terminated string
Name Response	4-63	4	Channel [0-51]	Null-terminated string

9.2.1 Requests

The three request types currently supported are Relay, Script, and Mode. The possible RELAY_REQUEST, SCRIPT_TYPE, and MODE values are given in Table 19.

Table 19: Request Values

Value	Relay	Script	Mode
0x00	Channel off	Stop a running script	Auto
0x01	Channel on	Run startup script	Manual
0x02	Toggle channel	Run shutdown script	Valet

9.2.2 Status

A status message is sent every 100 ms. Table 20 shows an example status message. The start and end frame flags are left out to save space. In a multi-unit setup each iPDS Panel is currently individually connectable via Bluetooth and will send their own status, but in a future release the master will send all of the information for all the units and any slaves will have their Bluetooth transceivers disabled.

9.2.3 Channel Names

A Command ID of 4 is used for requesting the name of a channel or setting a new channel name. To request a channel name, send a message with ID 4, length 2, and a channel number as the only message byte.

Table 20: Example Status Message

Field	Datatype	Raw Hex	Value	Notes
Length	Uint8	0x73	115 bytes	Longer if escapes required
Command	Uint8	0x03	STATUS	
Voltage	Float32	0x41709BA7	15.038 V	Input (battery) voltage
Ignition 1	Float32	0x4167020D	14.438 V	
Ignition 2	Float32	0x00000000	0.0 V	
Ignition 3	Float32	0x4171A5E4	15.103 V	
Board Temp 1	Float32	0x420B2EF1	34.796 C	
Board Temp 2	Float32	0x4225330B	41.300 C	NaN in RevG hardware and older
Board Temp 3	Float32	0x42305C96	44.090 C	NaN in RevG hardware and older
External Temp 1	Float32	0x41C20000	24.250 C	NaN if not present
External Temp 2	Float32	0xFFC00000	NaN	Will be supported in future firmware
External Temp 3	Float32	0xFFC00000	NaN	Will be supported in future firmware
External Temp 4	Float32	0xFFC00000	NaN	Will be supported in future firmware
Total Current	Float32	0x40021CAC	2.033 A	Total iPDS current draw
Current 1	Float32	0x3BA3D70B	0.005 A	Channel 1 current draw
Current 2	Float32	0x3A83126F	0.001 A	Channel 2 current draw
Current 3	Float32	0x00000000	0.000 A	Channel 3 current draw
Current 4	Float32	0x00000000	0.000 A	Channel 4 current draw
Current 5	Float32	0x3CF5C290	0.030 A	Channel 5 current draw
Current 6	Float32	0x3A83126F	0.001 A	Channel 6 current draw
Current 7	Float32	0x00000000	0.000 A	Channel 7 current draw
Current 8	Float32	0x3CA3D70B	0.020 A	Channel 8 current draw
Current 9	Float32	0x00000000	0.000 A	Channel 9 current draw
Current 10	Float32	0x00000000	0.000 A	Channel 10 current draw
Current 11	Float32	0x00000000	0.000 A	Channel 11 current draw
Current 12	Float32	0x3B03126F	0.002 A	Channel 12 current draw
Mode	Uint8	0x00	AUTO	Auto = 0, Manual = 1, Valet = 2
Script Status	Uint8	0x00	NONE	Script status[1]
Channel Status 1	Uint8	0x2F	NO LOAD[2]	Channel status:
Channel Status 2	Uint8	0x2F	NO LOAD	Bit 0: requested state. 0=off, 1=on
Channel Status 3	Uint8	0x2F	NO LOAD	Bit 1: relay. 0=open, 1=closed
Channel Status 4	Uint8	0x2F	NO LOAD	Bit 2: fuse. 0=blown/missing, 1=ok
Channel Status 5	Uint8	0x2F	NO LOAD	Bit 3: red led. 0=off, 1=on
Channel Status 6	Uint8	0x2F	NO LOAD	Bits 4-7: status[2]
Channel Status 7	Uint8	0x2F	NO LOAD	
Channel Status 8	Uint8	0x2F	NO LOAD	
Channel Status 9	Uint8	0x2F	NO LOAD	
Channel Status 10	Uint8	0x2F	NO LOAD	
Channel Status 11	Uint8	0x2F	NO LOAD	
Channel Status 12	Uint8	0x2F	NO LOAD	
Inverter Status	Uint8	0x01	NO LOAD	Inverter status[3]
Bluetooth Status	Uint8	0x07	NO LOAD	Bluetooth status[4]
Internal Fan Status	Uint8	0x00	Both OFF	Bit 0 = fan 1, bit 1 = fan2
Unit ID	Uint8	0x00	MASTER	Master = 0, Slave X = X
CRC	Int16	0x4A9D		

[1] No scripts running = 0, startup = 1, shutdown = 2, valet startup = 3, valet shutdown = 4
[2] See the STATUS field of the Status CAN Message Description.
[3] Bit 0 = request, bit 1 = status, bit 2 = overload, bit 3 = overtemp.
[4] Bit 0 = hardware present, bit 1 = connected, bit 2 = enabled, bit 3 = searching

The iPDS unit will respond with a message also with an ID of 4 and the channel number, but also with the channel name in the message field. The channel name is a null-terminated string. To set a channel name, send a message with ID 4 and length greater than 3. The message field contains the channel number and null-terminated new channel name. A length field greater than 3 is required since the ID, channel number, and null terminator all take one byte, and a zero-length channel name is not allowed. The maximum name length is 62 characters, but most devices will not be able to display a name that long. The channel name that is used after reception of the set name command will be echoed back. If the channel name was set successfully the exact same message will be echoed back. If not, the name in the response message will indicate which name is currently in use.

9.2.4 Example Messages

Start and end flags of 0x7E are not shown.

Table 21: Example Bluetooth Commands

Description	Length	ID	Message bytes				CRC1	CRC2
Toggle channel 1	0x03	0x00	0x00	0x02			0x3F	0xFE
Run startup script	0x02	0x01	0x01				0x81	0xEC
Set mode to Manual	0x06	0x02	0x01	0x31	0x32	0x33 0x34	0xA6	0x73
Get channel 1's name	0x02	0x04	0x00				0x6E	0x38
Get name response	0x05	0x04	0x00	0x30	0x31	0x00	0x37	0x16
Set channel 1's name	0x05	0x04	0x00	0x30	0x31	0x00	0x37	0x16

10 Updating

The latest documentation and firmware releases are available at
https://www.dataspeedinc.com/release-packages/.
Check the firmware CHANGELOG to see which components have updates. Update the firmware of required modules with DataspeedBootloader.exe. This process is documented in DataspeedBootloader.pdf.

11 Troubleshooting

- There are no messages on the CAN bus

  - Check that your CAN tool is configured for 500 kbit/s.
  - Check that the CANH and CANL signals wires are terminated at both ends of the bus. If the CAN TERM switch is set to ON the iPDS panel will internally provide one of the required 120 Ω termination resistors.

- Unable to turn channels on/off via CAN/Touchscreen/Switches

  - Check that the mode is AUTO or MANUAL, but not VALET. Valet mode prevents commands on all interfaces except USB.
  - Check that the CAN TERM switch is set to ON.

- The thermocouple on the iPDS Panel is reporting wild values

  - iPDS Panel hardware revisions A-F have thermocouple sensors. There is a known hardware issue with the thermocouple sensor where the value is prone to noise from nearby equipment such as the inverter remote cable. It is not recommended to trust the temperature reading from the thermocouple sensor. Hardware revision G and newer changed to a different digital temperature sensor to address this issue.

- Something else is not working

  - Check that all modules have the latest firmware with DataspeedBootloader.exe and a USB cable.
  - If the issue still persists, contact Dataspeed.

APPENDIX A: REVISION HISTORY

Revision A-00 (July 2015)

1. Initial release of this document.

Revision A-01 (September 2015)

1. Added CAN messages for multiple units to achieve 24 channels.
2. Added description for each mode.
3. Added section describing LED status codes.

Revision A-02 (October 2015)

1. Changed all CAN IDs to 0x4XX.

Revision A-03 (December 2015)

1. Added inverter to messages.

Revision A-04 (May 2016)

1. Added mechanical drawing.
2. Added connector pictures and part numbers.
3. Changed RESERVED pins on CAN/DB9 connector to ignition pins.

Revision A-05 (August 2016)

1. Updated LED table.
2. Added power usage to electrical specs.
3. Added Status2 CAN message

Revision A-06 (August 2017)

1. Fixed main LED color (power/status).
2. Fixed CAN bus termination value.
3. Added reserved CAN messages.
4. Added connector descriptions for inverter remote and battery control.
5. Added electrical characteristics for each channel

Revision A-07 (October 2017)

1. Split inverter status into 4 individual bits.

Revision A-08 (January 2018)

1. Updated mechanical drawing
2. Added note about multiple ignition voltages

Revision A-09 (May 2018)

1. Updated for changes in revision 'G' hardware

2. Changed IGN connector from 2-pin to 3-pin

3. Changed temperature sensor connector

Revision A-10 (April 2020)

1. Combined iPDS Panel, Switch Panel, and Touch Screen datasheets into this document

2. Updated for changes in iPDS Panel revision 'I' hardware

3. Updated product pictures

4. Updated connector description table

5. Updated electrical characteristics for 24V operation

6. Updated mechanical drawing

7. Added active cooling section

8. Added 4-Panel system support for up to 48 channels

Revision 11 (November 2020)

1. Added inverter control and feedback information

2. Added Bluetooth section

3. Added updating section

4. Added troubleshooting section

5. Added USB and Phoenix connector drawings

6. Improved Switch Panel documentation

7. Updated current characteristics for both 12V and 24V operation

8. Removed 'A' from documentation revisions since only the number is meaningful