Display Panel Standard

DPS

User Guide

⚠ Warning!

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Contents

Publication History

The following table provides an overview of the changes made to this document over the course of its publication history.

Revision	Description of Change
Rev. 001	First release of this document
Rev. 002	New template, minor edits 05/12/2017

Safety

Do not perform the procedures in this manual unless you are experienced in the handling of electronic equipment.

Contact the manufacturer if there is anything you are not sure about or if you have any questions regarding the product and its handling or maintenance.

The term "manufacturer" refers to Parker Hannifin Corporation.

Safety symbols

The following symbols are used in this document to indicate potentially hazardous situations:

Danger! Risk of death or injury.

Warning! Risk of damage to equipment or degradation of signal

When you see these symbols, follow the instructions carefully and proceed with caution.

General safety regulations

Work on the hydraulics control electronics may only be carried out by trained personnel who are well-acquainted with the control system, the machine, and its safety regulations.

> Follow the manufacturer's regulations when mounting, modifying, repairing, and maintaining equipment. The manufacturer assumes no responsibility for any accidents caused by incorrectly mounted or incorrectly maintained equipment. The manufacturer assumes no responsibility for the system being incorrectly applied, or the system being programmed in a manner that jeopardizes safety.

> ⚠ Do not use the product if electronic modules, cabling, or connectors are damaged or if the control system shows error functions.

> ⚠ Electronic control systems in an inappropriate installation and in combination with strong electromagnetic interference fields can, in extreme cases, cause an unintentional change of speed of the output function.

Welding after installation

Complete as much as possible of the welding work on the chassis before the installation of the system. If welding has to be done afterwards, proceed as follows:

> ⚠ Do not place the welding unit cables near the electrical wires of the control system.

1. Disconnect the electrical connections between the system and external equipment.

2. Disconnect the negative cable from the battery.

3. Disconnect the positive cable from the battery.

4. Connect the welder's ground wire as close as possible to the place of the welding.

Construction regulations

The vehicle must be equipped with an emergency stop which disconnects the supply voltage to the control system's electrical units. The emergency stop must be easily accessible to the operator. If possible, the machine must be built so that the supply voltage to the control system's electrical units is disconnected when the operator leaves the operator's station.

Safety during installation

> ⚠ Incorrectly positioned or mounted cabling can be influenced by radio signals, which can interfere with the functions of the system.

Safety during start-up

> ⊗ *Danger! Risk of death or injury.* Do not start the machine's engine before the control system is mounted and its electrical functions have been verified.
>
> Do not start the machine if anyone is near the machine.

Safety during maintenance and fault diagnosis

Before performing any work on the hydraulics control electronics, ensure that

- The machine cannot start moving.
- Functions are positioned safely.
- The machine is turned off.
- The hydraulic system is relieved from any pressure.
- Supply voltage to the control electronics is disconnected.

1. About the DPS

The Display Panel Standard (DPS) is an innovative user interface that makes complete vehicle information accessible in a single centralized location. The Display Panel Standard is a software-programmable, multiplexing, display panel that controls indicator LEDs, gauges, and a graphic LCD screen in a vehicle HMI. The DPS also monitors various dedicated input types, and activates solid-state switched outputs.

The DPS product family is a generic platform of features that can be implemented in many different instrument cluster shapes. The figure below shows a typical DPS layout.

Figure 1: DPS with 4 gauges

The DPS is controlled by software. You can write the software using the Vansco Display Software Developer's Kit (SDK) tool. Contact your Parker Vansco Account Representative for more details about the SDK.

The DPS has 26 LEDs that are used as telltales. There are 6 green, 12 amber, 7 red and 1 blue LED. The locations of these colors is fixed. The overlay can be configured by the customer, depending on volumes. Contact your Parker Vansco Account Representative for more details.

The DPS is available with 3, 4, or 5 gauges and a large (256x80) LCD.

The DPS has a buzzer that is intended to be used typically for a fault alarm, but could also be used for other noises.

The DPS can monitor up to 27 inputs:
- 5 analog inputs.
- 2 frequency inputs
- 20 digital inputs (4 are configured for wake-up/power control).

The DPS has up to 3 outputs, rated at 2.5 A maximum current:
- 1 high-side output (configured for alternator excitation and is limited to 80mA max).
- 2 low-side outputs (these outputs monitor current, and can be used for current feedback if a high-side output is used for pulse-width modulation).

The DPS can detect the following faults on the outputs:
- Short-circuit
- Overcurrent
- Open load
- Short-to-battery
- Short-to-ground

The DPS has 3 connectors:
- 2 x 20-pin Molex connectors that are used to interface with the inputs, outputs, and CAN.
- 1 x 4-pin Molex connector for USB interface, typically routed to a panel mounted USB port.

A separate cable is available to provide the interface from the 4-pin Molex connector to a USB, type B port.

This manual describes the hardware components of the DPS, but does not explain how to write or configure the software. For more information about software, refer to the appropriate software manual or contact your Parker Vansco Account Representative.

1.1. Diagram conventions

The following symbols are used in the schematic diagrams in this document:

Symbol	Meaning
	General input
	General output
	Frequency input
	Analog input
	Frequency sensor
	Pulse sensor
	Resistive sensor
	General sensor
	Application switch
	Load
	Pull-down resistor

Symbol	Meaning
	Pull-up resistor
	Battery
	Fuse
	Resistor
	Ground
	Chassis ground

2. Inputs

The DPS has digital, frequency, and analog inputs.

> ⚠ *Damage to equipment!* Do not connect inputs directly to unprotected inductive loads such as solenoids or relay coils, as these can produce high voltage spikes that may damage the DPS. If an inductive load must be connected to an input, use a protective diode or transorb.

2.1. Digital Inputs

The DPS has 20 digital inputs:

- INPUT1_D through INPUT20_D.

The digital inputs can be categorized into two groups called type 1 and type 2. Four of the digital inputs (INPUT1_D through INPUT4_D) are type 1, and the remaining digital inputs (INPUT5_D through INPUT20_D) are type 2.

The differences between the two types of digital inputs are the switching thresholds and the maximum processing speeds.

2.1.1. Digital Input Capabilities

Type 1

Type 1 digital inputs are processed quicker than type 2 digital inputs. All type 1 digital inputs have an option to be populated as either an active high input (with a pull-down resistor), or an active low input (with a pull-up resistor). The pull-up resistors are referenced to a switched battery supply, which is equivalent to the battery voltage when the unit is in normal operating power mode, but is disconnected when in inactive or disconnected power modes.

The type 1 digital inputs can be configured as wake-up inputs. When a high signal is applied to a digital input configured as a wake-up input when the unit is in inactive power mode, the unit will enter normal operating mode and begin to operate. A digital input that is configured as a wake-up input must also be configured as an active high input (pull-down resistor) to prevent the system from

continuously remaining powered up. All configuration is done using the Parker Vansco Display SDK.

INPUT1_D through INPUT4_D are type 1 inputs. On the standard DPS configuration, type 1 inputs have 2.0K ohm pull-down resistors and are configured as wake-up inputs.

The following table provides specifications for the DPS's type 1 digital inputs:

Type 1 Digital Input Capabilities				
Item	Min	Nom	Max	Unit
Input voltage range	0	-	32	V
Pull-up / pull-down resistance	-	2		kΩ
Minimum negative going threshold	-	-	1.587	V
Maximum positive going threshold	4.013	-	-	V
Error in switching threshold due to circuit leakage current			13	mV
Cutoff frequency (3dB)	-	242	-	Hz
Input capacitance	-	50	-	nF
Overvoltage	-	-	36	V
Wetting current	-	12	-	mA
Amplifier gain	-	2	-	V/V

Type 2

All type 2 digital inputs have an option to be populated as either an active high input (with a pull-down resistor), or an active low input (with a pull-up resistor). The pull-up resistors are referenced to a switched battery supply, which is equivalent to the battery voltage when the unit is in normal operating power mode, but is disconnected when in inactive or disconnected power modes.

Some of the type 2 digital inputs can be configured as wake-up inputs. When a high signal is applied to a digital input configured as a wake-up input when the unit is in inactive power mode, the unit will enter normal operating mode and begin to operate. A digital input that is configured as a wake-up input must also be configured as an active high input (pull-down resistor) to prevent the system from continuously remaining powered up.

INPUT5_D through INPUT20_D are type 2 inputs. On the standard DPS configuration, type 2 inputs 9-12, 14, and 19 have 2.0K ohm pull down resistors. Type 2 inputs 5-8, 13, 15-18, and 20 have 2.0K ohm pull up resistors.

The following table provides specifications for the DPS's type 2 digital inputs:

Type 2 Digital Input Capabilities				
Item	Min	Nom	Max	Unit
Input voltage range	0	-	32	V
Pull-up / pull-down resistance	-	2		kΩ
Minimum negative going threshold	-	-	1.953	V
Maximum positive going threshold	4.668	-	-	V
Error in switching threshold due to circuit leakage current			47.5	mV
Cutoff frequency (3dB)	-	670	-	Hz
Input capacitance	-	50	-	nF
Overvoltage	-	-	36	V
Wetting current	-	12	-	mA
Amplifier gain	-	2	-	V/V

2.1.2. Active-High Digital Input Connections

A digital input is typically connected to a switch that is either open or closed.

- When an active-high switch is open, the pull-down resistor ensures that no voltage exists on the input signal, which will be interpreted by the DPS as inactive.

- When the switch is closed, the input is connected to battery voltage, which will be interpreted by the DPS as active.

For an input that is active-high

- It must be connected to battery power so that there is a battery connection when the state of the input changes.

- The power provided to the digital switch connected to the input must be provided through a fuse in the wire harness.

A typical active-high digital input connection is shown below:

Figure 2: Active high digital input

2.2. Analog Inputs

Analog inputs are typically used to read electrical signals that span a voltage range.

The DPS has 5 analog inputs:

- INPUT21_A through INPUT24_A (Analog 1 through Analog 4).
- A high-side output, OUTPUT2_HS has been configured as a 5th analog input in the standard DPS variants (Analog 5).

Three of the analog inputs, INPUT21_A, INPUT22_A and INPUT24_A are type 1, and INPUT23_A is type 3.

Analog inputs can be configured to function as programmable digital inputs.

2.2.1. Analog Input Capabilities

Type 1

Type 1 analog inputs have an option for a pull-up resistor referenced to a regulated +5V supply (through a diode, so actual reference will be about 4.4V), and options for pull-down resistors to provide a wider array of input range options. Type 1 analog inputs are well-suited to read resistive sensors or voltage sensors.

The standard DPS variants type 1 analog inputs are configured as follows:

- Analog 1 is configured for resistive loads and has an input range of 0-350Ω with a 150Ω pull-up.
- Analog 2 is configured for voltage loads and has an input range of 0-16V.
- Analog 4 is configured for voltage loads and has an input range of 0-6.6V.

Type 2

Type 2 analog inputs are well-suited to read voltage sensors, but are not recommended for resistive sensors, because they do not have a regulated pull-up reference (as the type 1 and type 3 inputs have).

The standard DPS variant high side output `OUTPUT2_HS` is configured to be used as an additional analog input. It is a type 2 analog input and is configured as follows:

- Analog 5 is configured for voltage loads and has an input range of 0-6.6V.

Type 3

The type 3 input is essentially the same as the type 1 inputs with the exception that it has a software selectable pull-up resistor. This software selectable pull-up resistors is intended to allow for an extended range when the input is configured for reading a resistive sensor. An extended range is often required for reading thermistors that operate over a large temperature range.

The standard DPS variants type 3 analog inputs are configured as follows:

- Analog 3 is configured for resistive loads and has a input range of 600-100KΩ.

2.2.2. Analog input connections

Analog inputs are susceptible to system noise, which can affect the accuracy of the signal. Signal accuracy can also be affected by ground level shift, which can cause inputs to activate when they shouldn't.

System noise

To prevent noise pickup on the sensors,

- Use the shortest possible wires when connecting analog inputs to sensors.

The following shows how to connect an analog input to reduce system noise:

Figure 3: Analog input system noise reduction

Ground level shift

To reduce ground level shift:

1. Dedicate one of the 2 system ground inputs (GND) to sensors that have dedicated ground wires, and connect all sensor grounds to this system ground input.

2. Splice the other system ground inputs together in the vehicle harness (close to the connector) to provide a better ground for the noisier low-side outputs and digital circuits.

3. Position the sensor's ground connection near the system ground connections to ensure that the signal remains within the digital activation range of the input.

Note 1: The system ground inputs are rated for low-current signals, which ensures the sensor's ground is very close in voltage potential to the system ground.

Note 2: Sensors that don't have a dedicated ground wire are typically grounded to the vehicle chassis through the sensor's body.
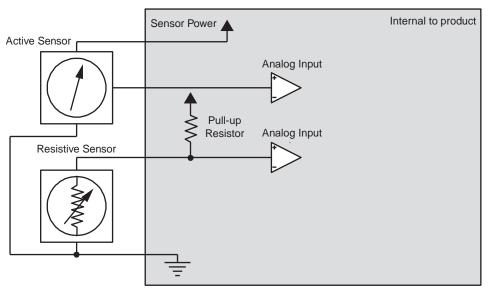

Figure 4: Analog input ground shift connection for sensors that have dedicated ground wires

2.3. Direct-Coupled Frequency Inputs

There is one type of frequency input in the DPS:

- Direct coupled frequency input

Direct coupled frequency inputs are typically used to read pulse signals.

The DPS has 2 direct coupled frequency inputs:

- INPUT25_F to INPUT26_F

2.3.1. DPS Direct Coupled Frequency Input Capabilities

Direct coupled frequency inputs allow you to read the frequency of external signals that have a ground reference and no DC offset. These inputs are ideal for use with hall-effect type sensors.

Note: Quadrature and pulse counting is possible with direct coupled frequency inputs.

The following table provides specifications for the DPS's direct coupled frequency inputs:

Direct Coupled Frequency Input Capabilities				
Item	MIN	NOM	MAX	UNIT
Negative going switching threshold			.904	V
Positive going switching threshold	1.11			V
Input capacitance at pin		500		pF
Gain (Vcomp/Vpin)		1		V/V
Cut-off frequency (3dB)		6.4		kHz
Pull-up resistor		10		kΩ
Pull-up reference voltage		4.4		V

2.3.2. Direct-coupled frequency inputs connections

As with analog inputs, direct-coupled frequency inputs are also susceptible to system noise and ground shift.

To reduce system noise,

1. Connect direct-coupled frequency inputs to sensors that produce signals with no DC offset.

2. To prevent noise pickup on the sensors, use the shortest possible wires when connecting direct-coupled frequency inputs to sensors.

To reduce ground shift:

1. Dedicate one of the 2 system ground inputs (labeled GND) to sensors that have dedicated ground wires, and connect all sensor grounds to this system ground input.

2. Provide a better ground for the noisier low-side outputs and digital circuits by splicing the other system ground inputs together in the vehicle harness (close to the connector).

3. Locate the sensor's ground connection close to the system ground connections. This will help ensure the signal remains within the digital activation range of the input.

The DPS system ground inputs are rated for low-current signals, ensuring that the sensor's ground is close in voltage potential to the system ground.

Sensors that don't have a dedicated ground wire are typically grounded to the vehicle chassis through the sensor's body.

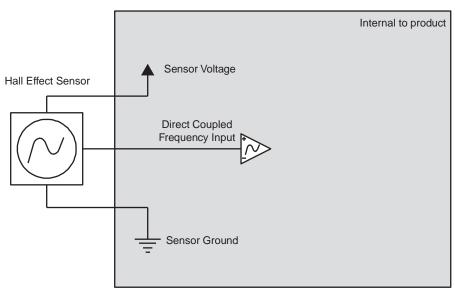The following shows a typical direct-coupled frequency input connection:

Figure 5: Direct coupled frequency input installation connections

3. DPS Outputs

The DPS has 3 solid-state FET technology outputs designed for low to medium current and high inrush inductive load switching. Output currents can range up to 2.5 A.

The DPS has 2 types of outputs:

- High-side outputs
- Low-side outputs with current sense

3.1. DPS High-Side Outputs

The DPS has 1 high-side output:

- OUTPUT1_HS (configured for 80 mA alternator excitation).

3.1.1. DPS High-Side Output Capabilities

High-side outputs are used for switching voltages to loads using either a pulse width modulated (PWM) signal, or an on/off signal. They can also test for various fault conditions, which can be used for software diagnostics (refer to *High-Side Output Diagnostics and Fault Protection* see "*High-Side Output Diagnostics and Fault Detection*" on page 15 for more details).

All high-side outputs come with internal flyback diodes that provide protection when driving inductive loads.

- When a high-side output is used as a PWM signal, a pulsed output signal is provided by the DPS, where the percentage of time that the output is on vs. off is determined by the duty cycle of the signal, and the duty cycle is determined by the application software.
- When a high-side output is used as an on/off signal, the output provides battery voltage when in the on state (the application software is responsible for switching high-side outputs on and off).

The following table provides specifications for the DPS high-side outputs:

High-Side Output Specifications				
Item	Min	Nom	Max	Unit
Operational voltage range	7	-	32	V
Overvoltage	-	-	36	V
Output current range	0	-	2	A
Load impedance @ 12 V	4	-	-	Ω
PWM frequency	5	-	500	Hz
PWM *resolution*[1]	-	0.1	-	%
Flyback diode *current*[2]	-	-	1	A
Short-circuit current limit (Tjunc = -40ºC to +150ºC)	9	15	23	A
Short-circuit trip time	-	2	-	ms
Thermal protection	-	150	-	ºC
Digital feedback negative threshold	1.5	-	-	V
Digital feedback positive threshold	-	-	3.58	V
Digital feedback cutoff frequency	-	322	-	Hz
Open-load detection – max detectable load @ 12 V	-	-	1.4 k	Ω
Open-load detection pull-up	9.8 k	-	10.2	kΩ
Current sensing	-	No	-	-
Analog feedback	-	No	-	-

3.1.1.1. High-Side Output Diagnostics and Fault Detection

Each high-side output has the ability to report many different fault conditions.

The types of faults that are reported are determined by the configuration of your high-side outputs, and this configuration must be considered when writing the application software.

3.1.2. DPS High-Side Output Installation Connections

You must be aware of the following when connecting the high-side output:

- The high-side output is connected to an internal bus bar, which can be connected to a +12 V or +24 V battery. The bus bar is connected to logic power (VBATT), and both share the same connector pins.

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[1] This is the typical value. Actual value is dependent on the base frequency, since the counter used for this operation has a finite number of steps.
[2] This is an average current value, meaning a worst case PWM current of 2 A at 50% duty cycle is possible with inductive loads.

- The high-side output can provide switched battery power to any load type in a vehicle.
- The high-side output can source up to 80mA in the alternator excitation configuration.
- The high-side output has an internal flyback diode, which is needed when driving an inductive load (the flyback diode absorbs electrical energy when the load is turned off).

Inductive loads will create an average current flow that moves out of the high-side output. When the output is on, the current flows through the output driver, and when the output is off, the current flows through the flyback diode. A duty cycle of 50% will produce the worst case average current flow through these two devices.

If large inductive loads are used, and the high-side output is providing a continuous PWM signal, then the PWM peak current must not be greater than the specified continuous current for the output (in continuous mode, the average current flow through the diode at 50% duty cycle is approximately equal to ½ the peak current).

When connecting high-side outputs, follow these best practices:
- High-side outputs should not be connected to loads that will draw currents greater than the maximum peak current, or maximum continuous current.
- The grounds for the loads should be connected physically close to the DPS power grounds.

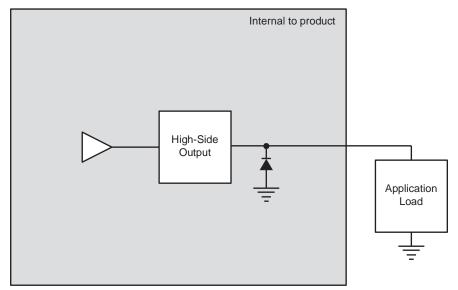The following shows a typical high-side output connection:

Figure 6: Typical high-side output installation connections

3.2. DPS Low-Side Outputs with Current Sense

The DPS has 2 low-side outputs:

- OUTPUT3_2A5_LS to OUTPUT4_0A7_LS

3.2.1. DPS Low-Side Outputs with Current Sense Capabilities

Low-side outputs with current sense are used for switching grounds to loads using either a pulse width modulated (PWM) signal, or an on/off signal. They also have the ability to sense current that is provided to loads, through an amplifier circuit.

When a low-side output is used as a PWM signal, a pulsed output signal is provided by the DPS, where the percentage of time that the output is on vs. off is determined by the duty cycle of the signal, and the duty cycle is determined by the application software.

Current flow gets interrupted when using low-side outputs as a PWM signal, because the outputs are not on continuously. For this reason, the DPS can not support current feedback control systems if the output is being PWMed.

- When low-side outputs are used as an on/off signal, the output provides ground when in the on state (the application software is responsible for switching low-side outputs on and off).

- When low-side outputs are used to sense current, the application software will monitor the current flowing into the low-side output, and based on the amount of current, will turn the output either on or off.

  - The amplifier that measures the sensed current has an allowable voltage range of 0 V to 3 V. The application software will protect the circuit from an over-current or short-circuit event when the voltage from the amplifier reaches 2.9 V; therefore, the actual usable voltage range from the amplifier is only 0 V to 2.8 V.

The following table provides specifications for the DPS 2.5 A low-side output:

2.5 A Low-Side Output with Current Sense Configuration				
Item	Min	Nom	Max	Unit
Output voltage range	0	-	0.25	V
Output current	-	-	2.5	A
On resistance	-	45	100	mΩ
Maximum voltage applied to output pin	-	-	32	V
Current limit in short-to-battery condition	18	24	30	A
Maximum PWM frequency	-	500	-	Hz
PWM resolution	-	No	200	µs
Flyback diode continuous current			1	A
Flyback diode non-repetitive surge current	-	-	30	A
Output pull-down resistance	-	8.39	-	kΩ
Output pull-up resistance	-	10	-	kΩ
Feedback gain (Vmicro/Vpin)	-	1/11	-	V/V
Feedback max readable voltage	-	-	36.3	V
Feedback cut-off (3dB) frequency	-	322		Hz
Feedback worst case fixed error	-	-	±251	mV
Feedback worst case relative error	-	-	±2.8	%

The following table provides specifications for the DPS 0.7 A low-side output:

0.7 A Low-Side Output with Current Sense Configuration				
Item	Min	Nom	Max	Unit
Output voltage range	0	-	0.945	V
Output current	-	-	0.7	A
On resistance	-	550	1350	mΩ
Maximum voltage applied to output pin	-	-	32	V
Current limit in short-to-battery condition	1	1.5	1.9	A
Communication frequency	-	10.4	12.5	kHz
Output pull-down resistance	-	52.5	-	kΩ
Output pull-up resistance[3]	-	1	-	kΩ
Feedback cut-off frequency	-	31.8		kHz
Feedback low threshold[4]	0.4*VSW	-	0.53*VSW	V
Feedback high threshold	0.47*VSW	-	0.6*VSW	V
Feedback hysteresis	0	-	0.2*VSW	V

Low-side output PWM control methods		
High-side output	Preferred PWM control method	Secondary PWM control method
OUTPUT3_2A5_LS	Software PWM control	
OUTPUT4_0A7_LS	Software PWM control	

3.2.2. DPS Low-Side Outputs with Current Sense Installation Connections

You must be aware of the following when connecting low-side outputs:

- Low-side outputs are connected to a common internal ground point that is connected to the battery ground (GND).
- Low-side outputs provide switched ground to any load type in a vehicle.
- Low-side outputs can sink up to 2.5 A.
- When connecting a load to a low-side output, ensure the load will not drive currents greater than the maximum specified peak current, or maximum specified continuous current.

[3] Pull-up resistance is referenced to VSW (switched battery voltage).
[4] The switching thresholds are relative to VSW (switched battery voltage).

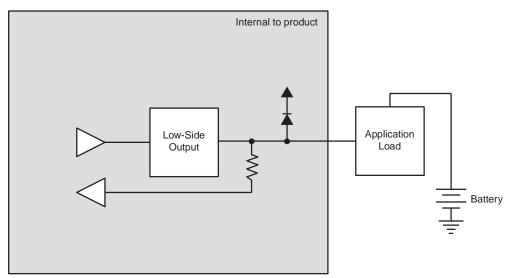The following shows a typical low-side output connection:

Figure 7: Low-side outputs with current sense installation connections

4. Power

The DPS is powered by the vehicle battery. The DPS can operate from 6 V up to 32 V with overvoltage protection at 42 V.

The various pins on the connectors are used for different types of power, as detailed in the following sections.

4.1. Logic and output power

The DPS has 1 pins, labeled VBATT, dedicated to providing power for logic and outputs, and 2 pins, labeled GND, dedicated to grounding the DPS.

Note: The power and ground connections are usually paralleled over several pins to minimize voltage drops on higher current applications.

4.1.1. Logic and output power connections

When connecting the DPS logic and output power, note that:

- Logic and output power connections are made using the VBATT and GND pins.

- When there are multiple output power pins, the number of wires needed to connect the DPS power depends on the amount of current required by the application.

  - It is recommended that you use the largest AWG wire allowed by your connector for the VBATT and GND pins, to meet the amount of expected output current; however, this is not always true and depends on your application.

- The DPS is protected against reverse-battery connections by an internal high-current conduction path that goes from ground to power. To protect the DPS from damage in a reverse-battery condition, place a fuse of 20 A or less in series with the power wires in the application harness.

Select fuse sizes by multiplying the maximum continuous current during normal operation by 1.333 (75% de-rating factor). Do not use slow-blow fuses for this application.

- All power connections to the DPS should be fused to protect the vehicle harness.

4.2. Sensor supply

The DPS has one pin, labeled SENSOR_SUPPLY, dedicated to providing power to external sensor.

> ⚠ *Warning!* Do not drive more than 50 mA of current through the SENSOR_SUPPLY pin. Doing so will cause the pin to protect itself by dropping the voltage, which will result in a lack of power to the sensors, causing unknown vehicle responses.

4.2.1. Sensor Power Capabilities

SENSOR_SUPPLY is a 5 V linear power supply. The voltage provided to the DPS must be 6.5 V or greater to ensure that the sensor supply can provide 5 V.

The following table provides specifications for the DPS sensor power:

Sensor Power Specifications				
Item	Min	Nom	Max	Unit
Output voltage range	4.8755	5.0	5.1255	V
Operational current output	-	-	50	mA
Short circuit voltage	0	-	32	V
Analog feedback voltage range	0	-	6.6	V
Analog feedback gain (Vmeasured/5V reference)	-	0.5	-	V/V
Analog feedback cut-off frequency	-	265	-	kHz
Analog feedback relative error	-	-	±2.0	%
Analog feedback fixed error (see note)	-	-	±50	mV
Note: Relative error calculated assuming that readings are adjusted using the 2.5 V reference voltage.				

5. Communication

The DPS can use two methods of communication with other modules on the vehicle or with a personal computer:

- CAN communication
- USB communication

5.1. Controller area network

The DPS has 1 Controller Area Network (CAN) communication port(s) available. The DPS hardware provides controller area network (CAN) communication according to the SAE J1939 specification, making the DPS compatible with any CAN-based protocol through software.

CAN communication is used to communicate the status of multiple modules that are connected together in the same network.

The DPS has two CAN buses, each of which can be terminated with a software-selectable 120 Ω terminating resistor.

CAN Bus Parameters				
Parameter	**Min**	**Nom**	**Max**	**Units**
Overvoltage	-		+/- 30	V
Baud rate (see note)	-	250	1000	kBd
Terminating resistor	-	120	-	Ω
Input capacitance (CANH or CANL)	-	90	-	pF
Slew rate (CANH or CANL)	-	15	-	V/µs
Note: Tested at 250 kBd. Speed of up to 1 MBd is theoretically possible, but not tested.				

5.2. USB communication

An optional USB connection allows you to connect temporarily to the unit for the purpose of retrieving logs, updating code, or configuring the unit.

Power to the USB connector is isolated from the vehicle power. Voltages are relative to USB ground on the 4-pin connector.

USB channel parameters				
Parameter	Min	Nom	Max	Unit
Max. voltage applied to USB Power	-0.5	-	6.0	V
USB power operating voltage	3.3	5	5.25	V
Operating supply current	-	15	-	mA
Max. voltage applied to data signals	-0.5	-	3.8	V
Data signal output voltage (high)	2.8	-	3.6	V
Data signal output voltage (low)	0	-	0.3	V
Driver output impedance	26	29	44	Ω
Communication speed	-	-	800	kBd

6. User Interface

The user interface of the DPS consists of the following:

- LCD color display
- gauges
- telltales
- buttons
- buzzer

6.1. LCD

The LCD that is supported in the DPS is:

- A large graphic LCD (256 x 80 pixels)

6.1.1. Backlight

The LCD is backlit with LED backlighting. The LEDs used for the LCD backlighting populated is tri-colour LEDs

The tri-colour backlighting LEDs allows the option of having the LCD change colours through software control. This may be required by certain customers to signal an error condition being displayed on the LCD, or it may be required to give users different options in the LCD backlighting colour.

The brightness control of the LCD is driven with a PWM signal, which means that variable brightness of the backlighting is possible. The tri-colour LED controls do not have PWM control, and are only on/off control signals. This means that the number of different colours possible for the LCD backlighting is limited to 7 when using tri-colour LEDs. The 7 possible colours that can be achieved with the tri-colour LEDs are:

- Red
- Green
- Blue

- ▪ Light Blue
- ▪ Purple
- ▪ Yellow
- ▪ White

The LED colours and brightness are configured by the user through the software tool.

6.1.2. LCD Heater

There is an LCD heater populated on the DPS. The LCD heater allows the graphic LCDs to operate in an ambient temperature below -20°C. With the use of the LCD heater the graphic LCD can operate down to -40°C. The LCD may take a few minutes to heat up to the point where it is visible at -40°C. When the LCD first starts up at -40°C, it will take the heater approximately 5 minutes to heat up the LCD to the point where the LCD is legible, about 10 minutes before the LCD is very clearly legible, and about 20 minutes before the response time of the LCD is less than 2 seconds.

The DPS cluster has an internal temperature sensor that is used to determine the ambient temperature so the LCD heater will only be turned on in cold conditions, and not when the ambient temperature is above freezing temperatures.

6.1.3. Large Graphic LCD

The large graphic LCD is the standard LCD for the DPS. The LCD is a monochrome FSTN (film super twisted nematic) transflective, positive image LCD, with a resolution of 256 x 80 pixels. It has been designed for use in both low and high ambient light conditions. The best viewable contrast is when viewed from above the horizontal plane of the LCD.

The LCD has an operating temperature of -20°C to +70°C. However, with the use of the heater the lower operating temperature can be extended to -40°C. The LCD will operate up to an ambient temperature of +85°C, however the contrast and viewing angle will degrade above +70 °C. This means that the LCD will not look as nice at +85°C, but it will still be legible.

6.2. Gauges

The DPS has a 3, 4 or 5 gauge configuration.

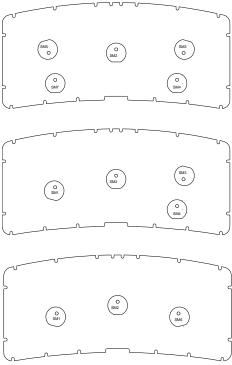The following diagrams shows the gauge positions.

Figure 8: DPS gauge locations

The DPS gauges are controlled by microstepping, except for the gauge on the bottom left side of the display, labeled SM7. Microstepping allows for finer resolution, when compared to partial stepping of the gauge, which is how SM7 is driven. This means that SM7 will look a little more coarse for small movements than the other gauges. This will not be noticeable for gauges that are representing vehicle parameters that do not change quickly, such as the fuel gauge, or temperature gauges. However, the SM7 location may not be suitable for gauges that represent faster moving vehicle parameters, such as RPM or speed. This should be considered when determining the function of SM7 in your application.

6.2.1. Gauge Backlighting

The DPS gauges are backlit with LED backlighting. The LEDs used for the gauge backlighting are tri-color LEDs. The tri-color backlighting LEDs allows for the option of the gauges to change colors through software control.

The brightness control of the gauges are driven with a PWM signal, which means that variable brightness of the backlighting is possible using the DPS configuration software. The tri-color LED controls are also driven by PWM control, which means that many different shades of color are possible for the gauge backlighting. If the gauge backlighting control signals are only used as

on/off in software, then there are 7 colors that are possible. The 7 possible colors that can be achieved with the tri-color LEDs in on/off control are:

- Red
- Green
- Blue
- Light Blue
- Purple
- Yellow
- White

There are also red LEDs that are used to light up the gauge pointers. The pointer backlighting cannot be dimmed, it is only on or off.

6.3. Status LEDs

There are 26 status LEDs on the DPS cluster. These are positioned as shown in the following figure.
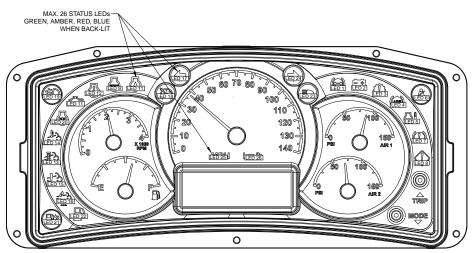
Figure 9: DPS status LEDs

Each of the status LEDs is a single color LED, and is one of the following colors:

- Green (LED 17, 18, 19, 24, 25, 26)
- Amber (LED 3, 4, 8, 11, 12, 13, 14, 15, 16, 20, 21, 22)
- Red (LED 1, 2, 5, 6, 7, 9, 10)
- Blue (LED 23)

The icons associated with each status LED is determined by the overlay, which can be customer specific.

6.4. Buttons

There are two buttons on the DPS that are used for the user to interface to the unit. These buttons use rubber button caps over metal switch domes that, when pushed, close the switches electrically.

The switch domes have a trip force of 700 grams +/- 40 grams. The rated life of the dome is 1,000,000 cycles.
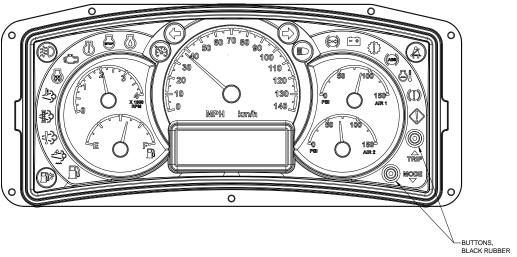
Figure 10: DPS button locations

6.4.1. Wake-up Feature

The buttons can be configured to wake-up the DPS when they are pressed. The wake-up feature allows information to be displayed on the LCD when the button is pressed, even if the ignition is inactive. The wake-up feature is application controlled.

6.5. Buzzer

The DPS has a buzzer that is intended to be used for a fault alarm, but it has also been used for other noises (e.g., to create a relay clicking noise) in some applications.
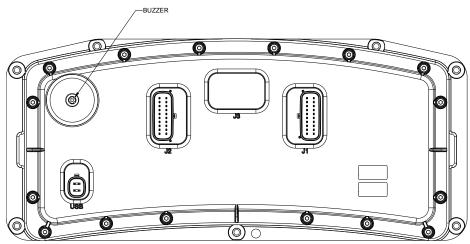
Figure 11: DPS buzzer location

There is a hole in the back cover of the enclosure to allow the sound to exit the DPS. A buzzer gasket is placed between the buzzer housing and the back cover, which prevents water and dust from entering the unit. This gasket also acts as a tunnel for the sound coming from the buzzer. The buzzer is significantly louder with the gasket installed.

7. Installation

Because every system is different, it is not feasible to provide detailed installation instructions that will be suitable for every assembly. This chapter therefore provides only high-level guidelines on installing the DPS.

> The vehicle manufacturer is responsible for creating procedures for mounting the DPS in a vehicle during production assembly.

7.1. Mechanical requirements

When mounting the DPS, ensure that

- the DPS is oriented to the operator's viewing angle
- the wire harness connects easily to the connectors and that the bend radius is adequate
- the harness is shielded from harsh impact
- the buzzer hole is not blocked

7.1.1. Mounting the DPS to a Vehicle

It is up to the original equipment manufacturer (OEM) to ensure the product is securely mounted to the vehicle.

The following guidelines are related to physically attaching the DPS to a vehicle:

- The DPS should be secured with **screws in all 7 screw holes** using #10-32 screws.
- The screws should be tightened according to the fastener manufacturer's tightening torque specifications.
- A trim ring is recommended (to be supplied by the OEM).

7.1.2. DPS Dimensions

The following shows the dimensions of the DPS in millimeters [inches]:
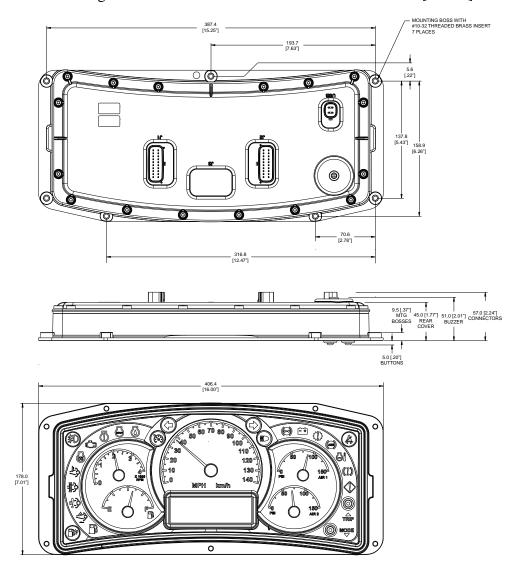
Figure 12: DPS dimensions

7.2. Environmental requirements

The DPS is intended to be mounted in a panel or dashboard in vehicles such as agricultural equipment or construction equipment, which may be subject to extreme temperatures and other unusual environmental conditions.

The DPS warranty does not cover damage caused by exposure of the product to environmental conditions that exceed its design limitations.

1. Mount the DPS in an environment that is within its ambient temperature range of –40 °C to +85 °C.

2. Mount the DPS in an environment that is within its ingress rating. The sealing standard for the DPS is EP455 level 1 (IPX6) from the front.

7.3. Electrical Requirements

The DPS is powered with a direct battery connection (+VBATT) on connector pin J1-10, and a ground connection on connector pins J1-9, and J1-15. The direct battery connection does not cause the cluster to power up in normal operating mode by itself. All functions are switched on and off with power up sources (wake-up digital inputs, buttons). The direct battery input is protected against vehicle transients such as load dump, inductive load switching, etc. It is also protected against reverse battery voltage of -42V by creating a high current path that will cause the external fuse (required) to blow.

The following table provides the electrical requirements of the DPS:

DPS Electrical Specifications				
ITEM	Min	Nom	Max	Units
Input voltage for normal operation when configured for both 12V and 24V system	8	12	32	Volts
Minimum voltage during cranking	5.5			Volts
Over Voltage Protection (DC)			42	Volts
Over Voltage Shutdown Voltage	33	34		Volts
Reverse Battery Protection			-42	Volts
Maximum Continuous Current			12.6	Amps
Off-State Current when configured for either 12V system only or 24V system only			1	mA
Off-State Current when configured for 12V and 24V system			2	mA
Maximum Current Rating of External Fuse			20	Amps

8. Connectors and pinouts

Three Molex MX150 sealed connector shells are molded into the rear cover of the standard unit. Connectors J1 and J2 have 20 pins; the J4 USB connector has four.

Parameter	Terminal
Current rating	15A with 18-gauge wire
Voltage rating	500 VDC maximum
Sealing	IP67
Wire gauge	14 – 22 AWG
Contact resistance	10 mΩ maximum
Mating cycles	100
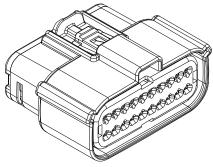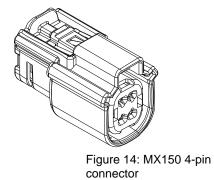
Figure 13: MX150 20-pin connector

Figure 14: MX150 4-pin connector

Mating Connector Part Numbers		
Connector	Molex part no. with locking clip	Molex part no. without locking clip
J1 connector (gray), 20-pin, key option B	33472-2007	33472-2002
J2 connector (black), 20-pin, key option A	33472-2006	33472-2001
J4 USB connector (black), 4-pin, key option A	33472-0406	33472-0401

8.1. DPS Connector Pinouts

Connector pins connect to inputs, outputs, and communication channels. They provide the interface between the vehicle harness and the internal circuitry of the DPS.

The following tables show the pinouts for each connector:

J1 (Gray) Connector Pinout		
Pin	**Name**	**Function**
1	INPUT2_D	Digital input
2	INPUT1_D	Digital input
3	CAN2_SHLD	CAN 2 shield
4	CAN2_LO	CAN 2 Low
5	CAN2_HI	CAN 2 High
6	CAN1_SHLD	CAN 1 shield
7	CAN1_LO	CAN 1 Low
8	CAN1_HI	CAN 1 High
9	GND	Ground
10	+VBATT	Power
11	INPUT3_D	Digital input
12	INPUT4_D	Digital input
13	INPUT5_D	Digital input
14	INPUT6_D	Digital input
15	GND	Ground
16	INPUT21_A	Analog input
17	INPUT22_A	Analog input
18	INPUT25_F	Frequency input
19	OUTPUT1_HS	High-side output
20	OUTPUT4_0A7_LS	0.7A Low-side output

J2 (Black) Connector Pinout		
Pin	**Name**	**Function**
1	INPUT17_D	Digital input
2	INPUT16_D	Digital input
3	INPUT15_D	Digital input
4	INPUT14_D	Digital input
5	INPUT13_D	Digital input
6	INPUT12_D	Digital input
7	INPUT11_D	Digital input
8	INPUT10_D	Digital input
9	INPUT9_D	Digital input
10	INPUT8_D	Digital input
11	INPUT23_A	Analog input
12	INPUT24_A	Analog input
13	INPUT26_F	Frequency input
14	OUTPUT3_2A5_LS	2.5A Low-side output
15	OUTPUT2_HS/INPUT27_A	High-side output/Analog input
16	INPUT18_D	Digital input
17	INPUT19_D	Digital input
18	INPUT20_D	Digital input
19	INPUT7_D	Digital input
20	SENSOR_SUPPLY	+5V sensor power

J4 (Black) USB Connector Pinout		
Pin	**Name**	**Function**
1	USB_D-	USB data low
2	USB_VCC	USB power (5V from Host)
3	USB_D+	USB data high
4	USB_GND	USB ground (0V from Host)

9. Startup

> ⊗ *Danger! Risk of injury.* If the control system is not fitted properly, the machine could move uncontrollably. Do not start the machine's engine before the control system is completely fitted and its signals are verified.

In addition to the measures described below, the machine must also meet the machine directives of the country in question.

Starting the control system

Start the control system as follows:

1. Ensure that all modules and cables are fitted correctly.

2. Ensure that the correct fuses are installed.

3. Ensure that for supply voltage and return lines in the cable's conductor joint are connected correctly.

4. Verify that the emergency stop works by ensuring that it does either of the following:

   ♦ disconnects the supply voltage to all modules

   ♦ shuts off the diesel engine or a dump valve, thereby depressurizing the hydraulic system
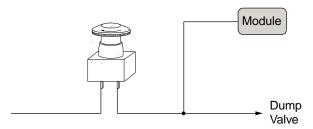
Figure 15: Emergency stop

Prepare for system start

> ⊗ *Danger! Risk of injury.* Make sure no one is in dangerous proximity to the vehicle.

Prepare for the initial system start as follows:

1. Ensure that the engine for the hydraulic system's pump is in the off position.

2. Ensure that all connectors are properly connected.

3. Turn on the control system.

4. Ensure that voltage is being supplied to all modules.

5. Ensure that the emergency stop is functioning properly.

Start the system

After the above inspections have been completed, start the system as follows:

1. Start the engine for the hydraulic system's pump.

2. Calibrate and adjust input and output signals, and carefully check every output function.

10. Tests

The following table lists the results for verification tests that were performed for the DPS:

DPS Technical Specifications		
Test	**Test Specification**	**Notes**
High Temperature Soak	Vansco Spec 5.1.1	96h soak at +85°C
Low Temperature Soak	Vansco Spec 5.1.2	96h soak at -40°C
Temperature Cycle	EP455 (Feb 2003) Section 5.1.1 – Level 2	
Temperature Shock	J1455 (Jun 2006) Section 4.1.3.2	
Handling Shock	J1455 (Jun 2006) Section 4.11.3.1	
Installation Shock	EP455 (Feb 2003) Section 5.14.2.1	
Operational Shock	EP455 (Feb 2003) Section 5.14.1	
Random Vibration	J1455 (Jun 2006) Section 4.10.4.2	
Particle Impact (Lenses/Display Glass)	Vansco Spec 5.2.7	Drop a 50g steel sphere onto the display lens
Altitude (Storage)	EP455 (Feb 2003) Section 5.2.2	
Dust Ingress	IEC 60529 (Feb 2001) Sections 13.4 and 13.5 – IP5X Rating	
Water Ingress	IEC 60529 (Feb 2001) Section 14.2.6 – IPX6 Rating from the front	
Humidity Soak	EP455 (Feb 2003) Section 5.13.2	
Humidity and Temperature Cycle	EP455 (Feb 2003) Section 5.13.1	
Salt Spray	IEC 68-2-11 Part 2 (1981)	
Readability	EP455 (Feb 2003) Section 5.4.2 – Level 2	
Solar Radiation, UV Effects	IEC 68-2-5:1975 Part: Test S Procedure C	
Chemical Exposure	J1455 (Jun 2006) Section 4.4 EP455 (Feb 2003) Section 5.8.2	
Electrical Steady State (Operating Voltages)	EP455 (Feb 2003) Section 5.10.1	
Electrical Steady State (Overvoltage)	EP455 (Feb 2003) Section 5.10.2 – Level 2	
Electrical Steady State (Reverse Polarity)	EP455 9Feb 2003) Section 5.10.3	

DPS Technical Specifications		
Test	**Test Specification**	**Notes**
Electrical Steady State (Short Circuit)	EP455 (Feb 2003) Section 5.10.4	
Electrical Steady State (Power Up Operational Requirements)	EP455 (Feb 2003) Section 5.10.7	
Electrical Transients (Inductive Load Switching – Power Lines)	ISO 7637-2 (Jun 1990) Section 4.6.1 J1113/11 (Jan 2006)	
Electrical Transients (Alternator Field Decay)	EP455 (Feb 2003) Section 5.11.2	
Electrical Transients (DC Motor Field Decay)	ISO 7637-2 (Jun 1990) Section 4.6.2	
Electrical Transients (Mutual Coupling – Power Lines)	ISO 7637-2 (Jun 1990) Section 4.6.3 J1113/11 (Jan 2006)	
Electrical Transients (Mutual Coupling – Signal Lines)	ISO 7637-3 (Jul 1995) Section 4.5 J1113/11 (Jan 2006)	
Electrical Transients (Cranking)	ISO 7637-2 (Jun 1990) Section 4.6.4 J1113/11 (Jan 2006)	
Electrical Transients (Load Dump)	ISO 7637-2 (Jun 1990) Section 4.6.5 J1113/11 (Jan 2006)	
Accessory Noise	EP455 (Feb 2003) Section 5.11.1	
Batteryless Operation	EP455 (Feb 2003) Section 5.11.3	
Electrostatic Discharge - Surface	EP455 (Feb 2003) Section 5.12	
Electrostatic Discharge - Connectors	ISO 10605 2001(E) Section 5 test level 4	
Electromagnetic Compatibility (Susceptibility) – Safety Critical Applications	ISO 11452 Part 2 (Dec 1995) J1113/21 (Oct 2006)	100 V/m
Electromagnetic Compatibility (Susceptibility) – Non-Safety Critical Applications	ISO 11452 Part 2 (Dec 1995) J1113/21 (Oct 2006)	50 V/m
Electromagnetic Compatibility (Emissions)	ISO 14982 (Jul 1998) Section 6.4 and 6.5 J1113-41 (May 2000) Level 3	

11. Glossary

active high

Input type that is on when it reads a battery voltage level, and off when it is floating or grounded.

active low

Input type that is on when it reads a ground voltage level, and off when it is floating or connected to battery voltage.

analog input

An input that allows a voltage level to be read and converted to discrete digital values within a microprocessor.

application software

A level of software that makes a product (hardware) perform desired functions for the end user.

bus bar

A strip or bar of copper, brass, or aluminum that conducts electricity.

CAN bus

See *controller area network (CAN) bus*.

CAN high

The positive wire in a shielded twisted-pair cable, which, when connected with a CAN low, provides a complete CAN differential signal.

CAN low

The negative wire in a shielded twisted-pair cable, which, when connected with a CAN high, provides a complete CAN differential signal.

CAN shield

The shielding that wraps around the CAN high and CAN low wires in a shielded twisted-pair cable.

controller area network (CAN) bus

A communications network bus that permits data from sensors and other equipment within a motor vehicle to communicate with each other and, through telltales and other diagnostic tools, with the operator.

current feedback

A circuit that allows software to measure the amount of current provided by the outputs. This circuit is typically connected to an analog input that is connected to the microprocessor. Also known as current sense or current sensing.

current sensor

A device that detects electrical current in a wire and generates a signal proportional to it.

DC-coupled

DC coupling passes the full spectrum of frequencies including direct current. The signal being read by this circuit must fall within the detection threshold range specified for the input.

digital input

An input that is typically controlled by an external switch that makes the input either active (on), or inactive (off).

duty cycle

The time that a device spends in an active or operative state, expressed as a fraction or percentage of the total cycle time (start, operate, stop).

electromagnetic compatibility (EMC)

The ability of a component within a system to function correctly despite electromagnetic interference propagated by other components in the system.

electromagnetic susceptibility

The ease with which a device, component, circuit, etc., suffers a degradation of performance when subjected to electromagnetic energy.

EMC

See *electromagnetic compatibility*.

FET

See *field effect transistor*.

field-effect transistor (FET)

     A transistor whose flow of charge carriers is controlled by an external electric field.

flyback

     A voltage spike seen across an inductive load when its supply voltage is suddenly reduced or removed.

frequency input

     An input that allows a frequency value to be read from an oscillating input signal.

gain

     To increase the voltage level of an input signal to maximize the resolution of an input.

ground level shift

     An undesirable condition in which the ground level elevates. This condition can cause inputs to activate when they shouldn't.

high-side output

     An output that provides switched battery voltage to an external load.

inductive load

     A load that produces a magnetic field when energized. Inductors are electrical components that store energy and are characterized by the following equation:

$$E_{\text{stored}} = \tfrac{1}{2}LI^2$$

inrush current

     The peak instantaneous input current drawn by an electrical device when first turned on.

load

     Any component that draws current from a module and is typically switched on and off with outputs. Examples include bulbs, solenoids, motors, etc.

load dump

     A surge in the power line caused by the disconnection of a vehicle battery from the alternator while the battery is being charged. The peak voltage of this surge may be as high as 120 V and may, unless precautions are taken, affect other loads connected to the alternator.

low-side output

>An output that provides a switched ground voltage to an external load.

open load

>The disconnection of a load from an output, often because of a broken or worn wire or connector pin.

overcurrent

>A fault state that occurs when a load draws more current than specified for an output, which results in the output shutting down to protect the circuitry of the product.

overvoltage

>A situation in which the voltage in a circuit rises above its upper design limit.

pull-down resistor

>A resistor that connects an input to a ground reference so that an open circuit can be recognized by the microprocessor, which is typically used on active-high digital inputs or analog inputs.

pull-up resistor

>A resistor that connects an input to a voltage reference so that an open circuit can be recognized by the microprocessor, which is typically used on active-low digital inputs or analog inputs.

pulse counter

>A device that detects and counts pulses occurring on a frequency input for a given period of time.

pulse-width modulation (PWM)

>A digital logic circuit programmed to produce a pulse having any desired period or duty cycle. It is a means of controlling variable speed motors. See also duty cycle.

PWM

>See *pulse-width modulation*.

sensor power

>A regulated voltage output that provides a set voltage level for analog sensors attached to the product.

short-to-battery

> A fault state that occurs when an input or output pin is connected to battery power, potentially resulting in high current flow.

short-to-ground

> A fault state that occurs when an input or output pin is connected to system ground, potentially resulting in high current flow.

slew rate

> 1. The maximum rate at which an output voltage can swing across its full dynamic range.
>
> 2. The maximum rate at which a control system can react to an adjustment or change.

steady state

> In a circuit or network, a state of equilibrium undisturbed by transients. Compare *transient*.

switching threshold current

> The minimum amount of current required in an input before its associated telltale illuminates.

system noise

> Electrical interference generated from external devices that affect the behavior of inputs, outputs, and sensors. System noise can be generated from things like the vehicle alternator, engine, transmission, etc.

telltale

> An optical signal that, when illuminated, indicates the status of a system within a motor vehicle.

terminating resistor

> A resistor placed at the end of a wire to absorb signals and prevent them from reflecting back into the line and causing interference.

TFT LCD

> See *thin-film transistor liquid-crystal display*.

thin-film transistor liquid crystal display (TFT LCD)

> A liquid crystal display in which each pixel of the screen is powered separately by a transistor.

transflective liquid crystal display

A liquid crystal display that reflects and transmits light, permitting readability in varying light conditions.

transient

A short-lived burst of energy caused by a sudden change of state. Compare *steady state*.

transient voltage suppressor

A Zener diode engineered for high-power current switching. See also *Zener diode*.

transorb

See transient voltage suppressor.

wetting current

The minimum current needed to flow through a mechanical switch to break through any film of oxidation that may be on the switch contacts.

Zener diode

A diode that allows current to flow in the reverse direction when voltage is above a certain value.

12. Index

Display Panel Standard
DPS User Guide
HY33-5012-IB/US