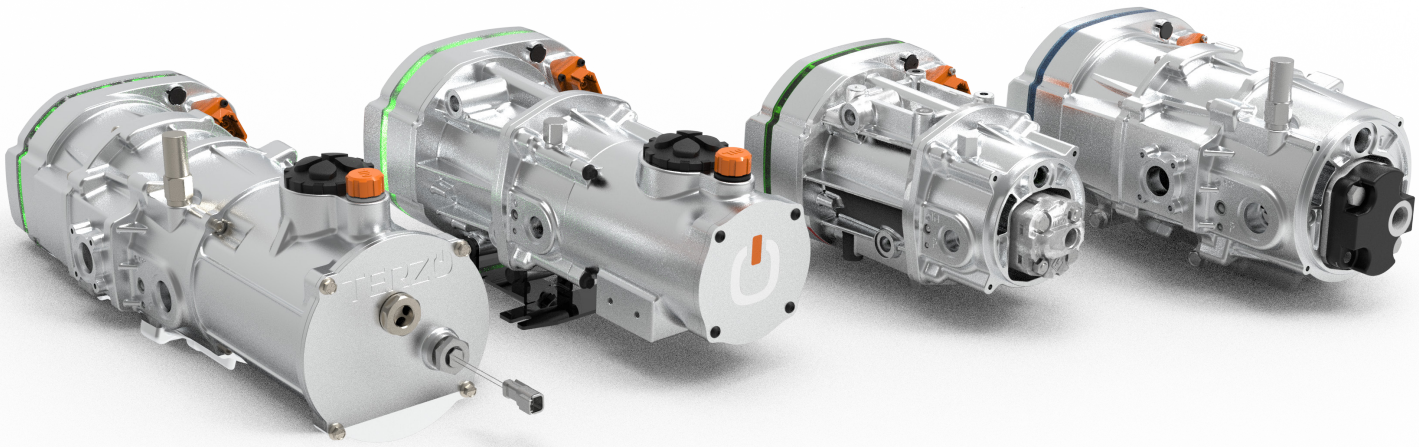
hydrapulse



02/2025
VERSION 1.5

hydrapulse®

USER MANUAL

OPERATION, INSTALLATION, & TROUBLESHOOTING

MODELS COVERED UNDER THIS MANUAL:

EHSU ELECTRO-HYDRAULIC STEERING UNIT
EHPU ELECTRO-HYDRAULIC POWER UNIT





TerzoPower.com | Info@TerzoPower.com | 916-245-9660

TERZO
POWER EVOLUTION

READING THIS DOCUMENT

This document is to be used as a reference tool to aid in design and integration of the Hydrapulse® products listed above. The user of this document should have a basic understanding of mechanical, electrical, and hydraulic equipment. Read this document before beginning the installation of the Hydrapulse.
Sections marked with a symbol in the left margin must be read and understood by everyone designing, installing, changing, or maintaining a Hydrapulse Unit. The different symbols used in this document are listed below.

WARNING!

SECTIONS LABELED WARNING WITH A SYMBOL IN THE LEFT MARGIN INDICATE A POTENTIALLY HAZARDOUS SITUATION MAY EXIST. THIS IS OF SPECIAL IMPORTANCE AND SHOULD BE UNDERSTOOD BY EVERYONE USING THE HYDRAPULSE. FAILURE TO COMPLY WITH THE RECOMMENDATIONS CAN CAUSE UNINTENTIONAL, AND UNEXPECTED BEHAVIOR OF THE CONTROL SYSTEM. THIS CAN POTENTIALLY CAUSE DEATH, SERIOUS INJURY OR PROPERTY DAMAGE.

NOTICE!

SECTIONS LABELED NOTICE WITH A SYMBOL IN THE LEFT MARGIN INDICATE IMPORTANT INFORMATION ABOUT THE HYDRAPULSE. IGNORING THIS COULD RESULT IN LESS THAN IDEAL OPERATING PARAMETERS OR DAMAGE TO THE PRODUCT.

PRECAUTIONS

Work to the hydraulic system or electrical system may only be done by a trained professional who understands the complications and dangers of such systems. The Hydrapulse units are designed to control high power hydraulics. This industry is inherently dangerous. Care must be taken when designing, testing, maintaining, and operating such systems. Failure to do so may result in property damage, personal injury, or death.

WARNING!

FAILURE OR IMPROPER SELECTION OR IMPROPER USE OF THE PRODUCTS AND/OR SYSTEMS DESCRIBED HEREIN OR RELATED ITEMS CAN CAUSE DEATH, PERSONAL INJURY AND PROPERTY DAMAGE.

This document and other information from Terzo Power Systems, its subsidiaries and authorized distributors provide product and/or system options for further investigation by users having technical expertise. It is important that all aspects of the application be analyzed, including consequences of any failure, and review the information concerning the product or system in the current product catalogue. Due to the variety of operating conditions and applications for these products or systems, the user, through his or her own analysis and testing, is solely responsible for making the final selection of the products and systems and assuring that all performance, safety and warning requirements of the application are met. The products described herein, including without limitation, product features, specifications, designs, availability and pricing, are subject to change by Terzo Power Systems, LLC and its subsidiaries at any time without notice.

WARNING!

THIS PRODUCT CAN EXPOSE YOU TO CHEMICALS INCLUDING LEAD, WHICH IS KNOWN TO THE STATE OF CALIFORNIA TO CAUSE CANCER. FOR MORE INFORMATION, VISIT WWW.P65WARNINGS.CA.GOV.

WARNING!

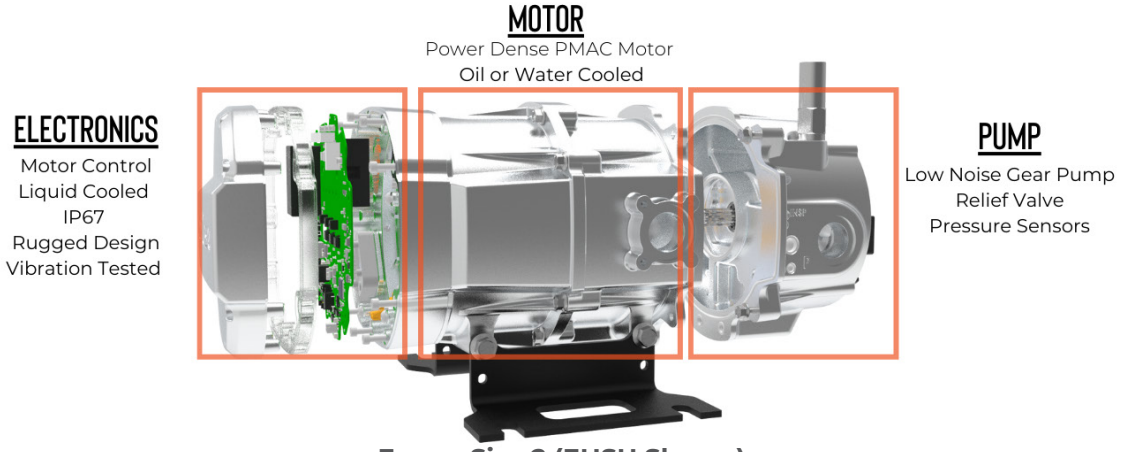
HIGH PRESSURE OIL CAN CAUSE SEVERE INJURY OR DEATH! DISCONNECT POWER AND RELIEVE PRESSURE PRIOR TO SERVICING THE HYDRAULIC EQUIPMENT.

DO NOT USE HANDS OR FINGERS TO FIND LEAKS. FLUID UNDER HIGH PRESSURE CAN BE INJECTED INTO SKIN CAUSING EXTREME INJURY AND SERIOUS INFECTION. USE A PIECE OF CARDBOARD TO LOCATE LEAKS. SMALL HIGH-PRESSURE JETS MAY BE HARD TO SEE. SPILLED HYDRAULIC OIL CAN CAUSE BURNS AND OTHER ACCIDENTS DUE TO SLIPPERY CONDITIONS AND CAN ALSO HARM THE ENVIRONMENT. TAKE CARE OF ALL SPILLED OIL AND HANDLE IT ACCORDING TO PROPER SAFETY AND ENVIRONMENTAL REGULATIONS. NEVER DISASSEMBLE HYDRAULIC COMPONENTS WHEN THE HYDRAULIC OIL IS HOT.

CONTENTS

1. PRODUCT OVERVIEW

All Hydrapulse product offerings (regardless of model) incorporate our integrated permanent magnet motor, motor drive control electronics (inverter), and controller software specifically designed for advanced hydraulic systems.



Frame Size 2 (EHSU Shown)

ELECTRONICS

Each Hydrapulse unit has a powerful suite of electronic features that enable digital control of the hydraulic flow and pressure and provides a "smart pump" for all types of hydraulic applications. A processor "closes the loop" with onboard pressure and current sensors to maintain pressure and flow setpoints. Other features include data logging, temperature sensing, LED indicators and a software-configurable CAN Termination Resistor to provide easier integration into systems.

MOTOR

Inside each unit is a permanent magnet, high efficiency synchronous motor that allows near instantaneous response to pressure and flowrate commands. Typical response time from zero to full flow or pressure is under 100ms. These motors are liquid cooled for peak performance and power density utilizing our innovative and proprietary lower pressure return oil cooling system that is internal to each Hydrapulse unit.

PUMP

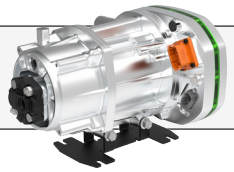
The pump section of each Hydrapulse can be numerous different types of pumps and drives. Each application may demand a different pump displacement and/or pump type so while we have several standard pumps, there is also the ability to customize this part of the Hydrapulse.

MODEL SIZES AND POWER LEVELS

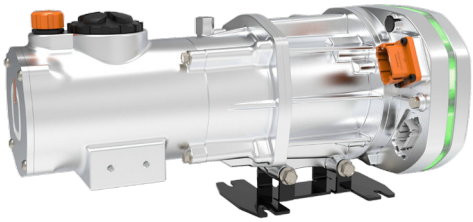
The Hydrapulse product family comes in three basic sizes: Frame Size 1, Frame Size 2, and Frame Size 3. A large number of power levels, voltages, and pump displacements are available from these three frames sizes. Please contact our engineering team if you need a particular power output that is not a standard item.

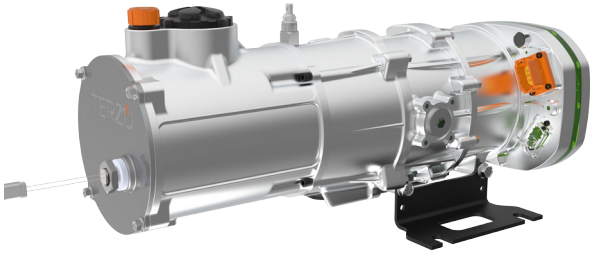
The table below shows the product matrix, power levels, and sizes available for our three frame sizes.

HYDRAPULSE PRODUCT FAMILY MATRIX

	EHSU Unidirectional Gear or Vane Pump ELECTRO-HYDRAULIC STEERING UNIT	**EHPU-U** Unidirectional Gear or Piston Pump ELECTRO-HYDRAULIC POWER UNIT	**EHPU-B** Bi-directional Gear Pump or Piston ELECTRO-HYDRAULIC POWER UNIT
FRAME SIZE 1 Up to Approx. 5kw			
FRAME SIZE 2 Approx. from 5 kw to 10kw			

Integrated Reservoirs





2. QUICKSTART GUIDE

QUICK START GUIDE OVERVIEW

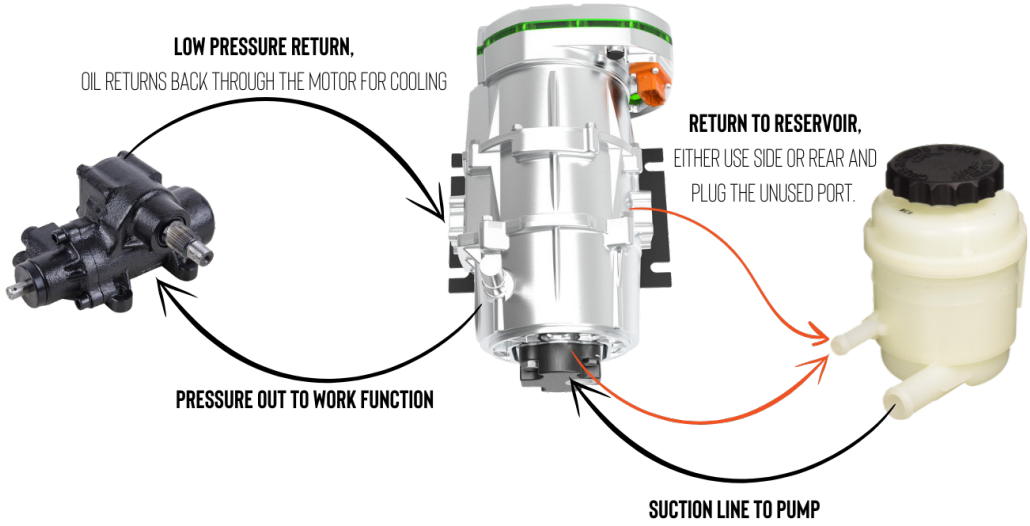
The following section describes how to quickly begin controlling both the EHPU and the EHSU models of the Hydrapulse.

WARNING!

OPERATION OF THIS DEVICE INVOLVES HIGH VOLTAGE. EXTREME CARE MUST BE TAKEN TO AVOID INJURY.

STEP 1 - Fix the Hydrapulse unit to a stable work surface.

STEP 2 - Connect the suction (S) port to your hydraulic reservoir. A flooded suction orientation is preferred to ensure adequate oil to the pump when initially operating the unit.



STEP 3 - Connect the Hydrapulse output pressure port (P) to the inlet of your desired hydraulic work function, such as a manifold, steering box, cylinder, or hydraulic motor.

STEP 4 - Connect the Hydrapulse return port to the return side of the hydraulic function.

STEP 5 - Connect the "return to tank" port of the Hydrapulse to the hydraulic reservoir.

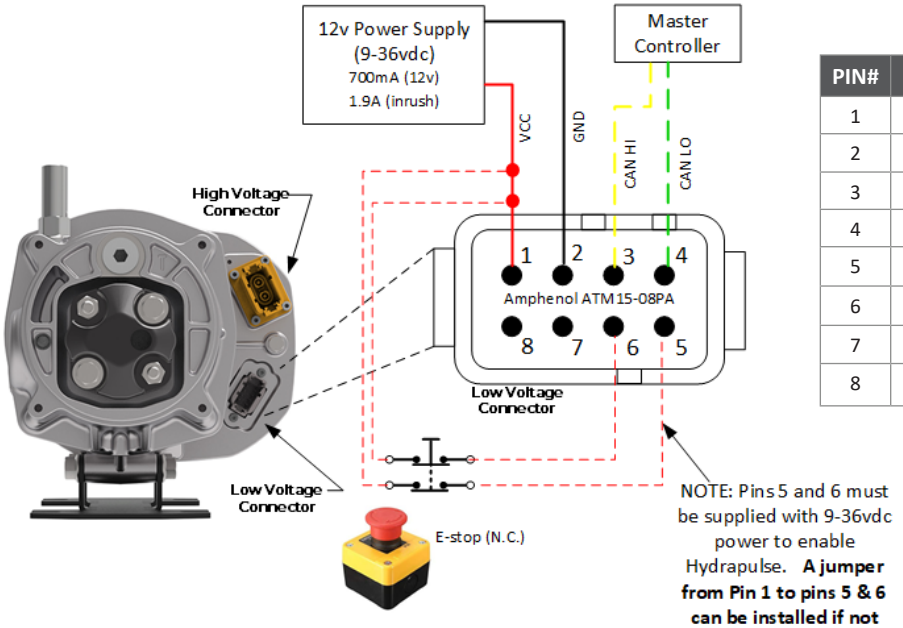
STEP 6 - Connect pin 1 of the low voltage connector to a 12v power supply, and pin 2 of the connector to ground. If E-STOP functionality is desired, connect pins 5 and 6 to the E-STOP circuit described in section 4. If E-STOP functionality is not necessary, the pins may be connected directly to the 12v power supply with pin 1.

STEP 7 - Connect the CAN HIGH (Pin 3) and CAN LOW (Pin 4) pins to the appropriate pins on your CANBUS controller.

STEP 8 - **<u>While the cable is not energized,</u>** connect the high voltage connector (ATHP062S25EL-S2) to a 200-800vdc high voltage power supply or battery with the pinout below.

STEP 9 - To turn on the Hydrapulse, power on the 12v power supply. The LEDs will begin to flash RED. On the CANBUS, the "Process Data" PGNS will broadcast from the unit in 100ms intervals from address 0x64.

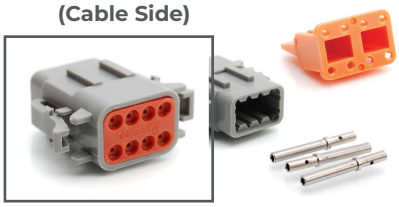
STEP 10 - The Hydrapulse will now be in the "disabled" state, and will have an undervoltage fault active on the fault PGN. Configuration parameter PGNs may be sent to change settings such as pressure/flow mode, max speed, and max pressure as described in Section 6 J1939 Communications. Configuration PGNs are only accepted when the device is disabled.



Amphenol ATM Connector Pinout (All Frame Sizes)

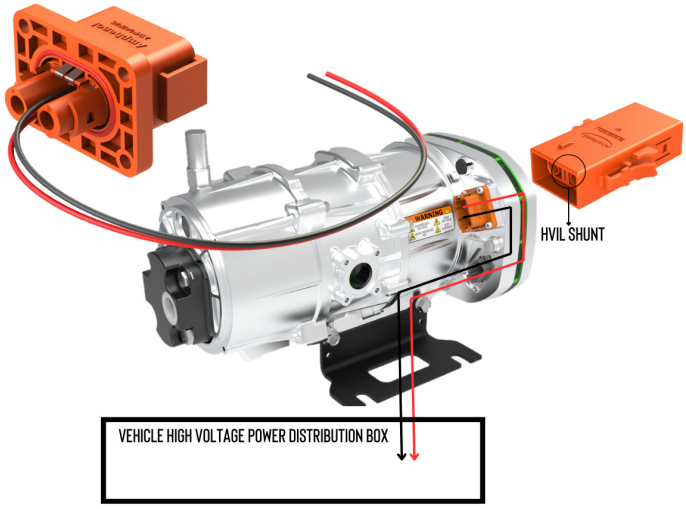
PIN#	NAME	DESCRIPTION
1	VCC	9-36vDC control power
2	GND	9-36vDC control ground
3	CAN-H	CAN High
4	CAN-L	CAN Low
5	STO-0 (E-STOP 0)	E-Stop 0
6	STO-1 (E-STOP 1)	E-Stop 1
7	HVIL-0	High Voltage Interlock Loop - 0
8	HVIL-1	High Voltage Interlock Loop - 1

Mating Connector (Cable Side)



ATM06-08SA Plug
(with wedge & contacts shown)

STEP 11 - Energize the high voltage cable through a **<u>current limited pre-charge process limited to 1 amp</u>** (refer to page 12 for additional information). Once the bus voltage rises above the undervoltage threshold, the undervoltage fault will automatically resolve itself and the LEDs will turn to a solid orange color.



Mating High Voltage Connector (Cable Side)

ATHP062S25EL-S2

PIN#	NAME	DESCRIPTION
A	BATT +	200-800 vdc input
B	BATT -	200-800 vdc negative

STEP 12 - Send a "1" to the first bit of the operational control command PGN. All other bits should be sent with a "0" (PGN 0x006400 by default). The device will enter the enabled state and the LEDs will change to a solid blue color. Note: The destination address needs to be included in the message, 0x006464

STEP 13 - While the unit is enabled, a new operational control PGN must be sent every 500ms to avoid triggering the heartbeat fault. The heartbeat fault can be disabled as described in Section 6 J1939 Communications.

STEP 14 - Change the start/stop bit to "1" and send the desired motor RPM to the command setpoint bytes of the operational control command PGN. By default, the command setpoint represents an RPM command. The setpoint may be changed to a pressure command by sending the respective message to the Pump Mode parameter in the configuration parameter #1 PGN.

The unit will update the internal command setpoint and begin accelerating towards the commanded speed or pressure. Listen for the pump to prime and purge the air from the system. Depending on reservoir size it may be necessary to stop the pump and fill the reservoir to avoid running the hydraulic pump dry.

If there are any unexpected noises, send a "0" to the enable bit, remove high voltage power, and inspect suction line for proper priming.

STEP 15 - The RPM and pressure feedback will be broadcast on the "process data 2" PGN

STEP 16 - Send a command setpoint of "0" to bring the pump to a stop, followed by sending a "0" to the enable bit after the pump has finished decelerating.

Operational Control Commands

PGN 0x006400 (RX)						
DESCRIPTION	LENGTH	BIT OFFSET	UNITS	SCALE	OFFSET	NOTES
DEVICE ENABLE	1	0	0: Disable Device 1: Enable Device			
START/STOP	1	1	0: Command Stop 1: Command Motion			
RESERVED	6	2	N/A			
COMMAND SETPOINT	16	8	RPM or PSI	1 RPM/bit or 1 PSI/bit	0	Signed 16 bit, little endian Pump Mode determines units. Constant Flow sets RPM/Constant Pressure sets PSI
RESERVED	40	24	N/A			

EXAMPLE MESSAGE

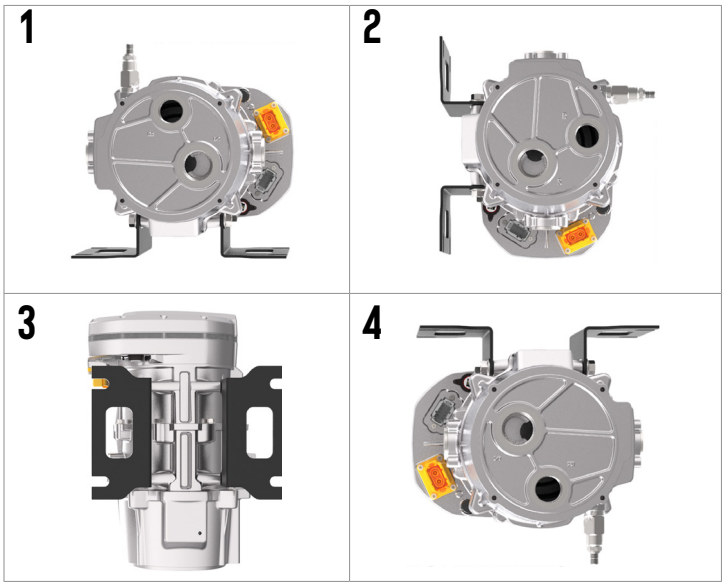
0C646401 8 03 D0 07 00 00 00 00 00

3. MECHANICAL INSTALLATION

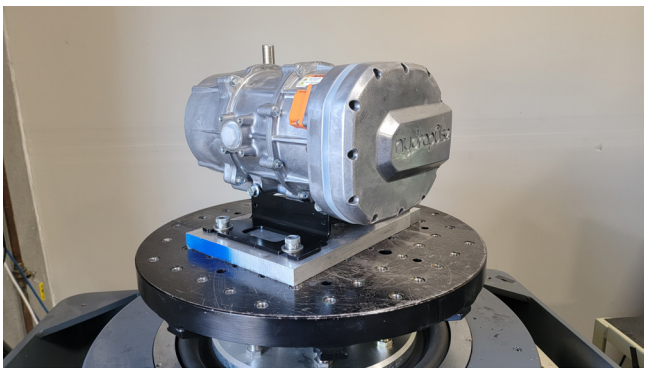
The following sections detail the mechanical installation requirements and connections for the Hydrapulse product line. Except where explicitly stated, all information applies to all EHPU and EHSU models.

MOUNTING ORIENTATION

All Hydrapulse units can be physically mounted in any orientation but depending on the pump type, reservoir location, other factors, it may be necessary to mount the unit in a specified position and/or direction. Orientation #1 shown below is the preferred mounting orientation, the EHSU 1 and 2 have been tested in this orientation to ISO16750 Shock and Vibe without isolators. If ISO16750 compliance is required for your application, orientation 2, 3, and 4 may require customer supplied mounting brackets. For mounting orientations that are not shown in each datasheet, please contact engineering prior to purchase with questions and application specifications.



ISO16750-3 Vibration Testing



Provided mounting brackets only rated for the shown orientation, other mounting orientations will require a customer provided mounting bracket.

FLOODED SUCTION

It is always best practice to have any hydraulic pump installed with a flooded suction. While there are many applications that allow a non-flooded suction, it's always best to check with our engineering support prior to system design or purchase.

4. WIRING INSTALLATION

The following sections detail the electrical requirements and connections available on the Hydrapulse product line. Except where explicitly stated, all information applies to all EHPU and EHSU models.

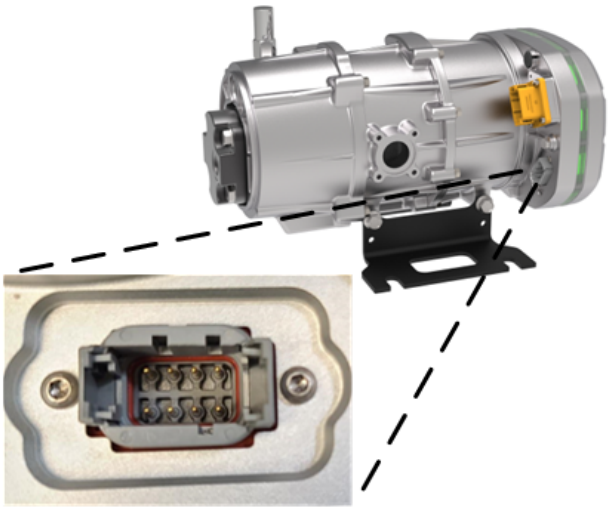
COMMUNICATIONS AND CONTROL WIRING

LOW VOLTAGE CONNECTOR - DEVICE SIDE

All Hydrapulse units use an Amphenol BoardLock ATM15-08PA-BM02 8 pin connector. This connector supplies low voltage power, CAN, E-stop, and the High Voltage Interlock loop (HVIL).

MATING LOW VOLTAGE CONNECTOR - CABLE SIDE

The cable side mating connector is an Amphenol ATM06-08SA connector kits are available for purchase under the Terzo Part Number 200-00118.



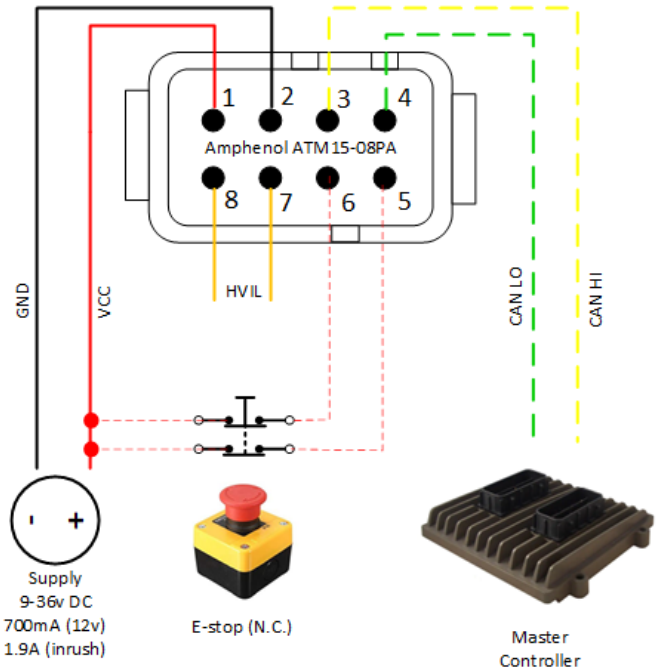
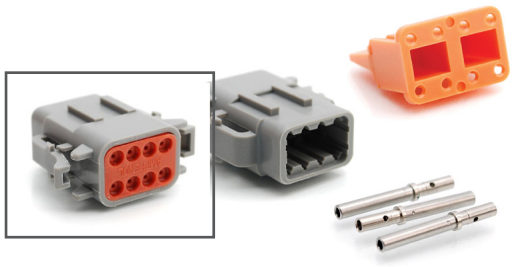


Table 4.1
Amphenol ATM Connector Pinout
(All Frame Sizes)

PIN#	NAME	DESCRIPTION
1	VCC	9-36vDC control power
2	GND	9-36vDC control ground
3	CAN-H	CAN High
4	CAN-L	CAN Low
5	STO-0 (E-STOP 0)	E-Stop 0
6	STO-1 (E-STOP 1)	E-Stop 1
7	HVIL-0	High Voltage Interlock Loop - 0
8	HVIL-1	High Voltage Interlock Loop - 1

Mating Connector
(Cable Side)



ATM06-08SA-KT01 Plug (with wedge & contacts shown)

Terzo Part Nuimber 200-00118

SIGNAL DESCRIPTIONS

The following provide descriptions and specifications for all controls/communication signals available in the ATM15 8-pin connector.

CONTROL POWER

Control power will supply power to the on-board controller and all sensors. Configuration and some debugging can be done with only control power applied (i.e. no high-power input). It is recommended that firmware update occurs with only control power applied.

The table below lists the specifications.

Table 4.2

	SPECIFICATION	NOTES
Input Voltage Range	9-36 VDC	12v preferred, if running 24v or higher discuss with Terzo Engineering.
Current Draw	~700 mA	@ 12 VDC
In-Rush Current	~1.9 A	@ 12 VDC Only on power-up
	~2.6A	@ 24 VDC Only on power-up
Quiescent LV	0	Hydrapulse does not have a sleep mode, when power is applied the unit is on.
Quiescent HV		
Max Cont. Pin Current	3.5 A	Applicable for all input voltage levels

CAN COMMUNICATIONS

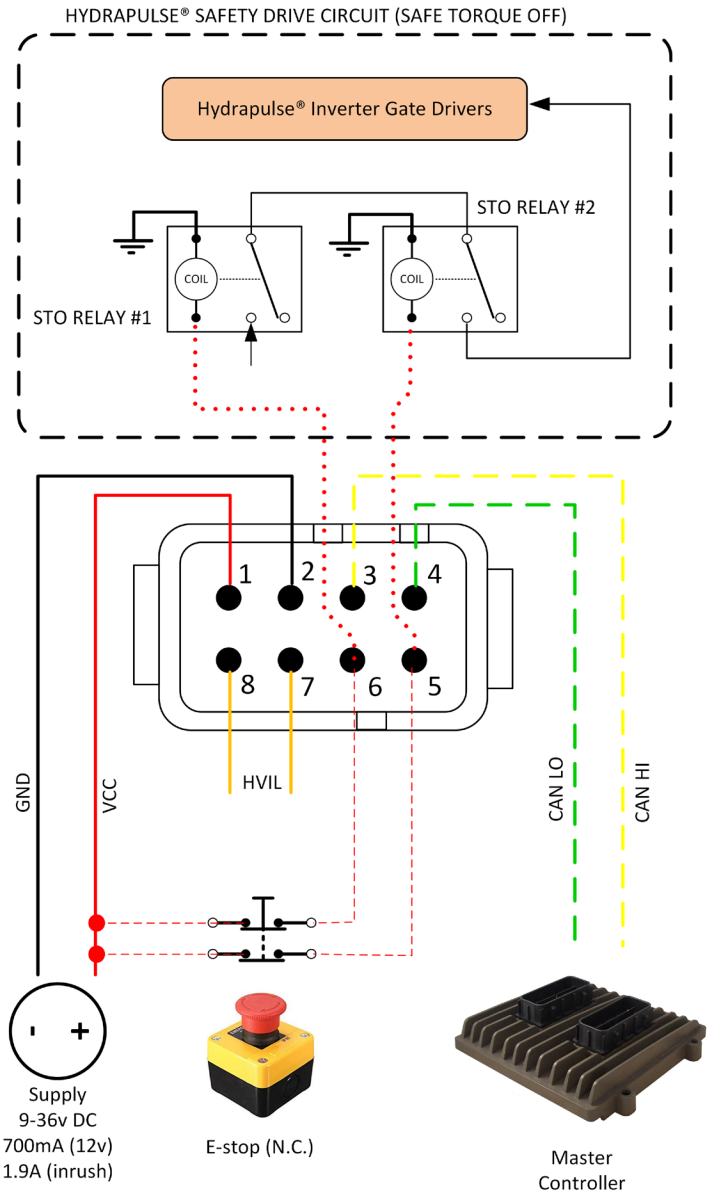
CAN-H and CAN-L connections follow the hardware requirements for CANbus. For network and communication specifications, refer to Section 6.

E-STOPS (SAFE TORQUE OFF)

Hydrapulse incorporates E-Stop functionality that is designed to adhere to the Safe Torque Off (STO) requirements found in many industrial machine safety protocols. While this can be useful in industrial applications these are typically bypassed when the hydrapulse units are used as a steering pump. When bypassing the STO functionality VCC power should be applied to both STO pins via jumper wire or other means.

STO-0 and STO-1 each control a normally-open safety relay to shut down the motor drive circuitry from a hardware level. Both relays are connected in series to provide redundancy. Power must be supplied to both STO pins in order to operate the Hydrapulse units. The input signals are referenced to GND (9-36VDC control ground). The input voltage range is 9-36VDC. A common method of connecting the STO signals is to use a dual channel, normally-closed E-Stop button shown in the figure below.
When an E-Stop is triggered, the following procedure should be done:

- Resolve the issue that led to an E-Stop
- Reset the STO-0 and STO-1 inputs
- Clear the SAFE TORQUE OFF fault with the CLEAR FAULT command. Refer to Section 6 and 7.



NOTICE!

TWO E-STOP SIGNALS ARE PROVIDED TO GIVE FLEXIBILITY FOR THE USER TO HAVE TWO SEPARATE AND INDEPENDENT E-STOP SWITCHES, BUT SHOULD THE USER WISH TO ONLY OPERATE A SINGLE E-STOP SWITCH THEN THE OTHER SIGNAL MAY BE TIED HIGH TO VCC. IT IS NOT RECOMMENDED TO BYPASS BOTH E-STOP SIGNALS IN THIS WAY.

GROUNDING

Correct grounding for the Hydrapulse is important for safety, proper operation of the Hydrapulse, and the operation of voltage sense systems.

CHASSIS REFERENCE GROUNDING (EV/HEV APPLICATIONS)

For vehicle applications, a clean bonding wire must be installed at the reference point shown below to ensure correct bonding of the Hydrapulse units to the vehicle chassis for voltage reference and safety systems.

EARTH GROUNDING (STATIONARY APPLICATIONS)

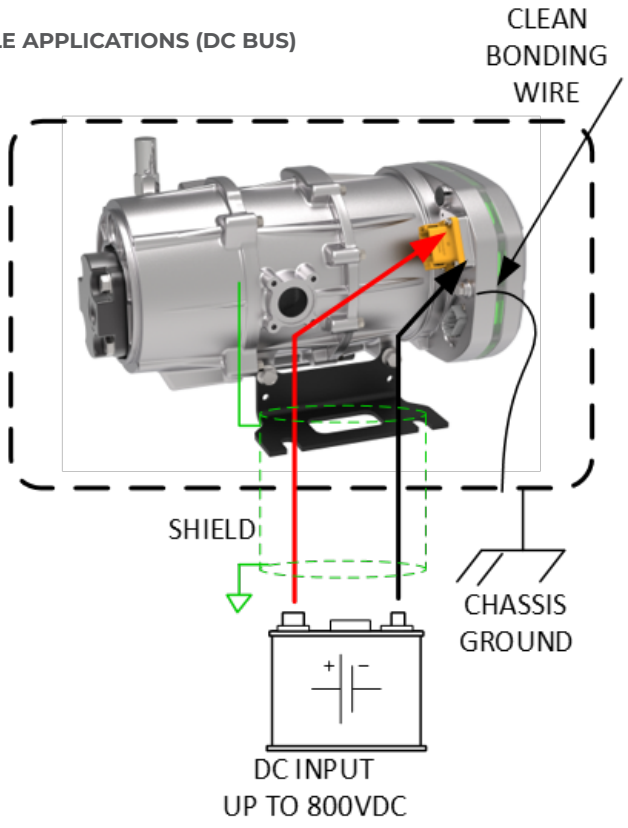
A grounding wire must be installed to earth ground (PE) in AC industrial or stationary applications. This ground circuit is connected to the earth ground in common with the AC to DC front end.

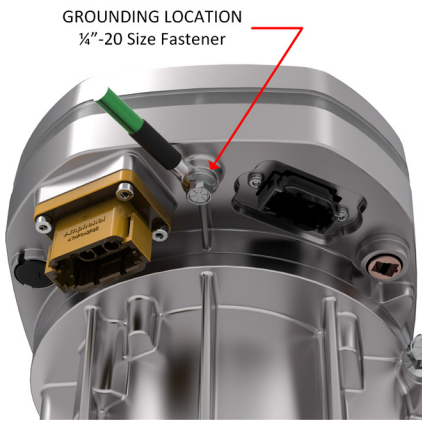
BUS VOLTAGE AND RATED SPEED

An important aspect regarding the physics of electric motors is the relationship between bus voltage and a motor's rated speed (i.e. flowrate). As the bus voltage decreases, the motor's rated speed also decreases. The Hydrapulse product line is designed so that the motor's rated speed is well above the maximum commanded speed, but this cannot be guaranteed in every case – especially for applications using the high voltage models at the lower end of the input range.

Refer to each model's flowrate versus voltage graphs to determine which model meets certain flow/speed requirements at specific voltages. Contact an Applications Engineer if a higher rated speed needs to be reached.

VEHICLE APPLICATIONS (DC BUS)





HIGH POWER INPUT

For all Hydrapulse models, the high power input is isolated from the 9-36VDC control power input. The high power input provides power to the motor drive circuitry.

The high power inputs for Hydrapulse models fall into one of two categories: low voltage (24-48 VDC) and high voltage (200-800 VDC).

LOW VOLTAGE MODELS (24-48VDC)

Coming Soon - check with our sales team on availability.

HIGH VOLTAGE MODELS (200-800VDC)

This section applies to all Hydrapulse models with input voltage ratings of 200-800 VDC.

FUSE SIZING

For high voltage models, there is no fuse internal to the device. A fuse must be added to the system. This can be done in two different ways:

PRE-CHARGE CAPACITANCE

When the Hydrapulse is the only component in the high voltage circuit, a pre-charge circuit is not required but it is recommended. The figure below shows a typical (and recommended) high-voltage, pre-charge circuit.

Table 4.3

Model Number	Max Current Draw	FUSE AMPERAGE	Recommended Fuse
EHxU-1-56-350	15a	30a	Littelfuse 10EV030.ZXBDP
EHxU-1-56-650	8a	15a	Littelfuse EXM10-15-1P
EHxU-1-75-650	14a	25a	Littelfuse EXM10-25-1P
EHxU-2-105-350	31a	40a	Littelfuse 10EV040.ZXBDP
EHxU-2-105-650	17a	25a	Littelfuse EXM10-25-1P
EHxU-3-xxx-650	72a	100a	Bel 0ALBBK100-BB
F3-66-350			
F3-66-650			

Typical high-voltage pre-charge circuit

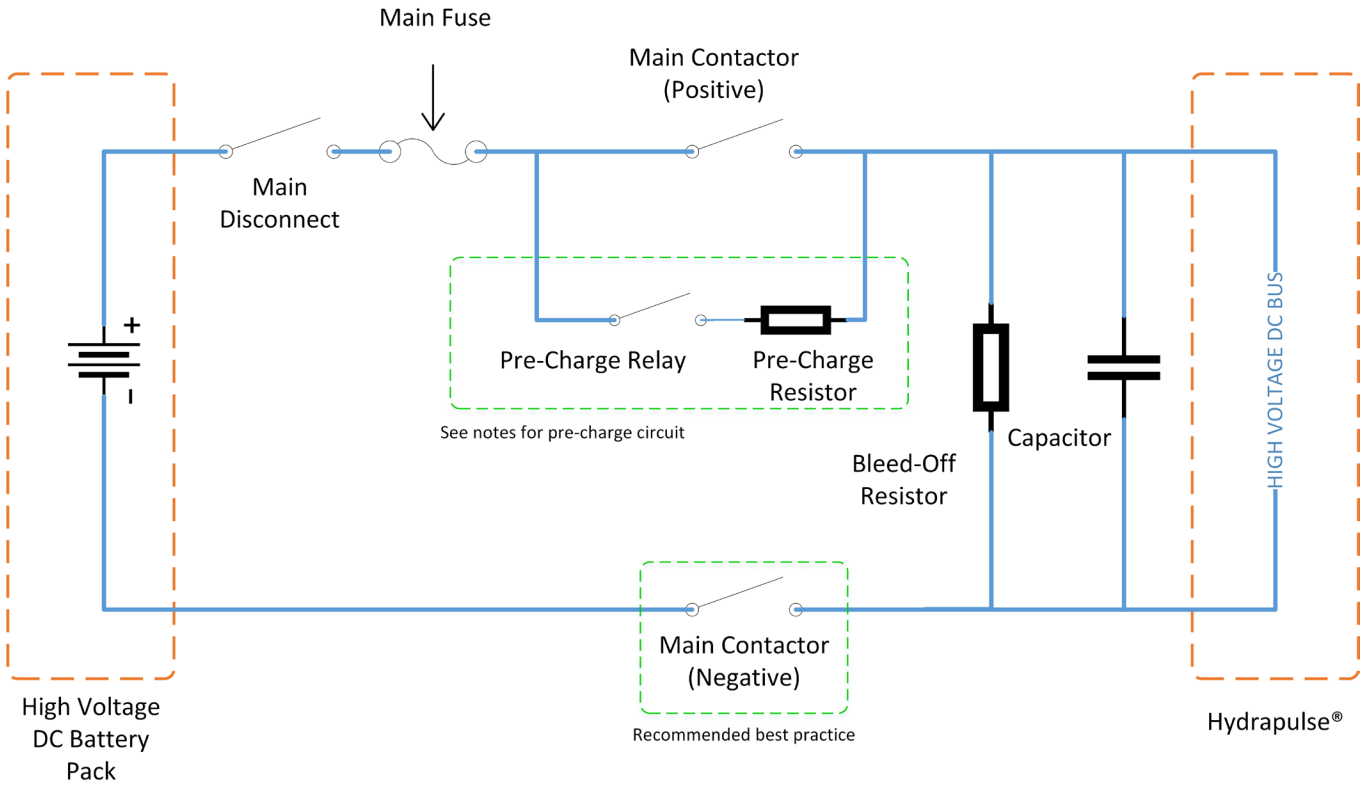
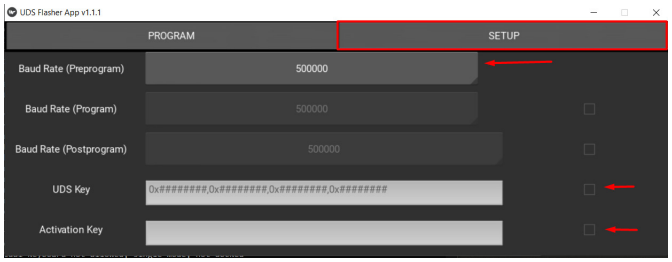


Table 4.4 Input Bus Capacitance

Model Number	Internal DC Link Capacitance (uF)	X-Capacitance (pF)
EHxU-1	20	1300
EHxU-2	20	1300
EHxU-3	99	
F3-66	400	

5. CONTROLS

TERZO UDS FIRMWARE FLASHING PROCEDURE



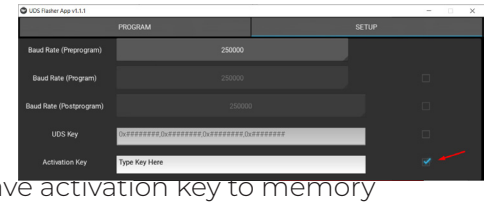
INSTALLATION

Download and install driver for PCAN device
Download and install UDS flasher

INITIAL UDS FLASHER SETUP

The Terzo UDS Firmware Flasher must be configured with a customer specific activation key to activate the tool, as well as a UDS key to unlock the EHSU being re-programmed.

1. Launch UDS flasher
2. Click Setup tab
3. Change the “baud rate (preprogram)” box to the baud rate of the unit being updated (500000 for units that operate at a 500k baud rate)
4. Click the box checkbox to the right of “activation key”

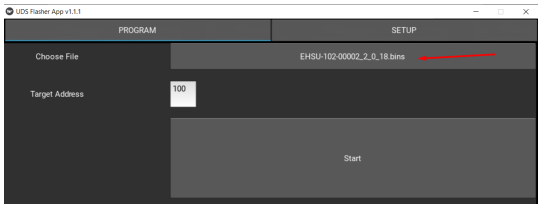


5. Paste activation key provided by Terzo into the “activation key” text box
6. Click checkbox to the right of “activation key” to send activation key to save activation key to memory
7. Perform the same steps as above for the UDS key field, using the UDS key provided by Terzo

PROGRAMMING AN EHSU WITH THE TERZO UDS FLASHER APP

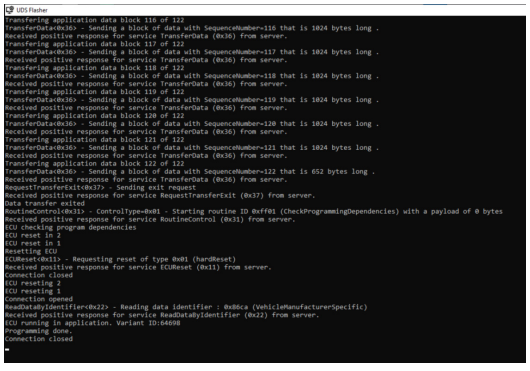
The following steps demonstrate how to install a firmware file onto an EHSU.

1. Launch UDS flasher
2. Click Setup tab
3. Change the “baud rate (preprogram)” box to the baud rate of the unit being updated (500000 for units that operate at a 500k baud rate)
4. Click Program tab
5. Click on “no file selected” box, which will open a file browser. Navigate to the desired EHSU firmware (.bins format) and select it



6. Change Target Address to address of EHSU (100 by default)
7. Power EHSU with 9-36vdc on the VCC connection of the low voltage header.
8. Connect PCAN USB adapter to CAN H and CAN L pins of the low voltage header with external termination resistor if necessary. Make sure to properly ground the PCAN CAN grounding wires.
9. Click “start” button
10. LED lights on EHSU will begin to flash a purple color, followed by a flashing white while the program is being uploaded. The terminal window will show the status of the upload procedure
11. When the programming is complete the unit will boot back into the main application, which should lead to a flashing red LED as the undervoltage fault is registered.
12. The terminal interface will state that the programming is done

    or if the process failed



DEVICE STATES

The figure below shows the different states of the Hydrapulse.
The Hydrapulse powers up in the Disabled state and all configuration must be done in this state. To operate the device it must be moved to the Enabled state. In the Enabled state, only Operational Control Parameters from Table 5.2 are valid. Table 5.1 below lists the device states and summarizes the transitions between the states.

Note: Disabled and Enabled states refer to the motor drive controller. Enabled means that motor position is regulated (even if no motion is commanded). There may or may not be holding torque applied when stopped, depending on the inputs to the system. In many cases, Disabled is the preferred state when no motion is required, especially if energy conservation is valued.

CONTROL PARAMETERS

Operational Control Parameters allow the device to transition between states and control the output of the Hydrapulse when in operation. All Operational Control Parameters are listed below. Refer to Section 6 for J1939 details.

MODES OF OPERATION - CONSTANT FLOW MODE

Table 5.1 Hydrapulse State Descriptions

STATE	STATE TRANSITIONS	FEEDBACK	VALID COMMUNICATIONS	NOTES
DISABLED	to/from *Enabled* by setting DEVICE ENABLE	ENABLE STATE	All communication valid	
FAULT	To *DISABLED* by resolving fault from *ENABLED* when fault is detected	ANY FAULT	All communication valid	Must resolve fault before moving device to *Enabled* state. See faults section.
ENABLED	to/from *DISABLED by setting* DEVICE ENABLE	ENABLE STATE	Only Operational Control Commands	
IN MOTION	to *STOPPING by setting* START/STOP to stop from *ENABLED* by setting START/STOP to start and setting a non-zero COMMAND SETPOINT	IN MOTION	Only Operational Control Commands	
STOPPING	to *ENABLED* by waiting for device to stop from *IN MOTION* by setting START/STOP to stop	STOPPING	Only Operational Control Commands	

Table 5.2 Operational Control Parameters

PARAMETER	TYPE	NOTES
DEVICE ENABLE	Boolean	Disables / Enables device
START/STOP	Boolean	Commands motion / stops motion
COMMAND SETPOINT	Signed Value	Updates output reference. Either flowrate or pressure base on PUMP MODE

When PUMP MODE is configured for constant flow, the COMMAND SETPOINT parameter sets the speed of the motor and therefore the *flowrate* of the Hydrapulse. The flowrate (speed) will continuously adjust to maintain the flowrate setpoint.

Acceleration & Deceleration Slew Rates

The Configuration Parameters, ACCELERATION and DECELERATION will set the slew rate for the commanded flowrate (speed) of the motor. They apply every time the COMMAND SETPOINT is updated.

Pressure Limiting

The motor will adjust the output to maintain flow (speed), unless the pressure reading reaches the MAX PRESSURE setpoint. In this case, the motor will scale back its output to maintain that pressure so as not to exceed the setting.

The PRESSURE/FLOW LIMITING warning indicates if the device is pressure limited (i.e., has reached the max pressure setpoint).

MODES OF OPERATION - CONSTANT PRESSURE MODE

When PUMP MODE is configured for constant pressure, the COMMAND SETPOINT parameter sets the target pressure of the Hydrapulse. The output of the pump will continuously adjust to maintain the pressure setpoint.

Flow Limiting

The motor will adjust the output to maintain pressure, unless the speed reading reaches the MAX SPEED setpoint. In this case, the motor will scale back its output to maintain that speed so as not to exceed the setting.

Table 5.3 Process Data List and Description

NAME	TYPE	DESCRIPTION	NOTES
Device Operational State			
ENABLE STATE	Boolean	Device disabled/enabled	
IN MOTION	Boolean	Device in motion/stopped	
STOPPING	Boolean	Device decelerating/not decelerating	
Operational Settings			
PUMP MODE	Boolean	Constant Flow/Constant Pressure	Reads configuration set by user
COMMAND SETPOINT	Signed Value	Target setpoint in flowrate or pressure	Reads operational parameter set by user
Measured Value			
FLOWRATE	Signed Value	Measured flowrate (speed) of device motor	
PRESSURE A	Unsigned Value	Measured pressure of pressure port A	
PRESSURE B	Unsigned Value	Measured pressure of pressure port B	
DC BUS VOLTAGE	Unsigned Value	Measured Bus voltage	
DEVICE TEMPERATURE	Unsigned Value	Measured internal temperature of device hardware	
FLUID TEMPERATURE	Unsigned Value	Measured temperature of hydraulic fluid	

PROCESS DATA (FEEDBACK TO USER VIA BROADCAST MESSAGES)

All device states, operational settings, and measured values are fed back to the user as Process Data. CAN SCHEDULING configures if Process Data is broadcasted automatically and the frequency at which it is broadcasted at. The Table below lists all data that is fed back to the user. Refer to the Section 6 for specific data format and J1939 PGN information.

Table 5.4 Configuration Parameters

NAME	TYPE	DESCRIPTION	NOTES
PUMP MODE	2 bit	Selects constant pressure or constant flow	Refer to Pump mode section
INVERT DIRECTION	Boolean	Sets direction of rotation for motor. Reference is looking down on pump side	
INVERT PRESSURE SENSE	Boolean	Sets the high pressure port	
UNIDIRECTIONAL MODE	Boolean	Disables/enables bi-directionality	
HEARTBEAT DISABLE	Boolean	Disables/enables heartbeat functionality	Refer to Heartbeat section
CAN SCHEDULING	Lookup table	Sets frequency of Process Data messages	Refer to CAN section
TUNING PARAMETERS	Lookup table	Selects the tuning for constant flow and constant pressure response	Select appropriate output response.
MAX SPEED	Unsigned Value	Sets the maximum output speed of the motor	Two parameters are available for both directions
ACCELERATION	Unsigned Value	Sets the acceleration slew rate for constant flow	Two parameters are available for both directions
DECELERATION	Unsigned Value	Sets the deceleration slew rate for constant flow	Two parameters are available for both directions
MAX PRESSURE	Unsigned Value	Sets the maximum pressure output for constant flow mode	Two parameters are available for both directions
MAX FAULT PRESSURE	Unsigned Value	Sets the pressure threshold where the device would fault	Expressed as a percentage above MAX PRESSURE

CONFIGURATION PARAMETERS

Table 5.4 lists all configuration parameters available to the user. Configuration is valid only while the device is disabled.

READ DEVICE CONFIGURATION

The current device configuration can be read by requesting particular J1939 PGNs. The specific PGNs are listed in Section 6 J1939 Communications.

Additionally, the device ID can be read to indicate product type, firmware version, and serial number of the drive side. Refer to Section 6 J1939 Communications.

BURN TO EEPROM AND FACTORY RESET

To save the current device configuration on power cycle, the configuration parameters can be burned into EEPROM. This action burns all parameter settings into EEPROM. Additionally, all parameters can be reset to factory default settings. This also performs a burn function which will overwrite any previously burned settings. Refer to Section 6 for specifics.

FAULTS AND WARNINGS OVERVIEW

The Hydrapulse uses a multitude of sensors to monitor the operation and environment of the device. To ensure safe operation, there are multiple faults and warnings that can occur. A fault will disable the device, while a warning will continue operation with reduced power output or performance. A complete list of faults and warnings can be found in Table 6.17.

Clear Fault Command - Many faults require the host controller to issue the CLEAR FAULT command. Refer to Table 6.11 - Auxillary Command PGNs.

NOTICE!

IT IS THE RESPONSIBILITY OF THE USER TO ENSURE THE CAUSE OF THE FAULT IS RESOLVED BEFORE CLEARING. FAILURE TO DO SO MAY LEAD TO DEVICE OR SYSTEM FAILURES.

TORQUE OUTPUT LIMITING

The maximum output of the motor is internally fixed based on the cooling requirement of the device. If the pump side is loaded such that the maximum output is reached, the device will remain operating at this max output. The TORQUE OUTPUT LIMITING warning indicates if the device maximum output is reached.

HEARTBEAT MODE

When heartbeat is enabled (default), an Operational Control PGN must be sent at a frequency of 1 Hz (once per second) or greater when the device is enabled. If an Operational Control PGN is not received within 1 second, the device will stop motion and enter an error state.

Heartbeat can be disabled through the HEARTBEAT DISABLE parameter.

L.E.D. STATUS INDICATION

The Hydrapulse Smart Pump has an LED light ring status indicator visible during operation. This is used to visually indicate status of the Hydrapulse. For further status details such as fault codes, the user interface can give all information needed for troubleshooting and correcting issues. The table below lists the LED pattern and description.

FAULT | DISABLED | ENABLED | IN MOTION | FIRMWARE UPDATE STARTING | FIRMWARE UPDATE IN PROCESS

6. J1939 COMMUNICATIONS

The Hydrapulse device follows the J1939 communication standard. Reference SAE J1939 documents for more details regarding the communication standard.

NETWORK CONFIGURATION

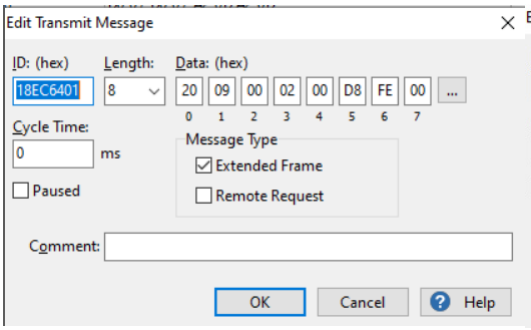
Network Requirements
Baud Rate: 250 kb/s or 500 kb/s
Termination Resistor: External Required, no internal termination resistor option.

Device Address
Upon device start-up, each device will perform an auto-assign routine to claim an available address. The device will attempt to claim address 100 (0x64). If already taken, the device will increment the address by 1 and reattempt.

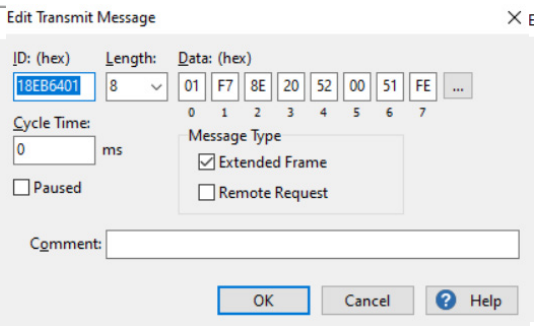
J1939 Commanded Address Instructions

1. Open PCAN View and Connect to EHSU
2. Power on EHSU with 12/24v and take note of the address claim message (0x0CEEFFxx) where xx is the current address example with address 64: 0x0CEEFF64 data F7 8E 20 52 00 51 FE 80
3. Right click in the TRANSMIT window and select "new message"
4. Create the message shown with ID 0x18ECXX01, where XX is the current address of the unit,and the Data is exactly as is shown. Example 0x18EC6401 data: 20 09 00 02 00 D8 FE 00
5. Create the message shown with ID 0x18EBxx01, where xx is the current address, and the data is the following Data: 01 bb cc dd.... Where: byte 0 is 01 byte 1-7 are copied from byte 0-6 of the Name block in the message 0x0CEEFFxx on page 1 of this document. Example 0x18EB6401 data 01 F7 8E 20 52 00 51 FE
6. Create the message shown with ID 0x18EBxx01, where xx is the current address, and the data is the following Data: 01 bb cc dd.... Where: byte 0 is 02 byte 1 is copied from byte 7 of the Name block in the message 0x0CEEFFxx on page 1 of this document. byte 2 is the desired address in hex
7. Byte 3-7 are 00 example 0x18EB6401 data 02 80 65 00 00 00 00 00
8. Send the 3 messages in order by double clicking the ID, and observe the “count” increment from 0 to 1 note that it is critical to send the messages in the order shown to the left.
9. Power Cycle the pump by removing and re-applying the LV 12/24v input
10. Confirm address has updated successfully by observing the address claim message address as 0x0CEEFFXX, where xx is the pumps address note that this message will only appear after the power cycle listed above.

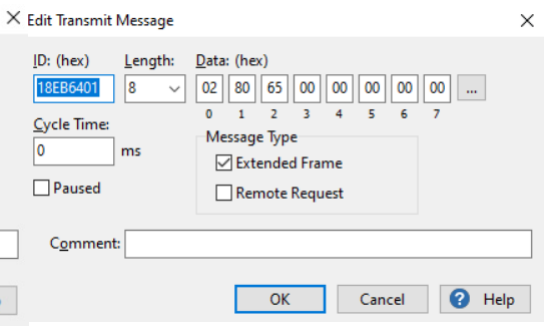
STEP 4



STEP 5



STEP 6



PGN MAPPING

The following sections detail the specific PGNs and their data fields transmitted and received by the Hydrapulse device.

CONFIGURATION COMMAND PGNS

There are eight configuration PGNs associated with the device: four transmit (TX) and four receive (RX). The data fields in the four transmit PGNs match those in the receive PGNs. The receive PGNs are used to configure the device while the transmit PGNs are used to report back current device configuration.

Each time the device receives a configuration PGN it will respond with the associated transmitted configuration PGN. This allows the user to confirm whether configuration was successful. The device may not accept or may modify received configuration parameters if they are invalid or out of range. For example, if a MAX SPEED+ parameter is greater than 4,000 RPM, the device will cap it at 4,000 (or the maximum speed of your model). The transmit configuration PGNs can additionally be requested at any time following the J1939 protocol. Refer to the "Request Specific PGNs" at the end of this section for more information.

Table below summarizes the configuration PGNs available on the device.

Table 6.3

	RX PGN	TX PGN	DATA
Configuration #1	0x006600	0x00F2C0	Table 6.4
Configuration #2	0x006700	0x00F2D0	Table 6.5
Configuration #3	0x006800	0x00F2E0	Table 6.6
Configuration #4	0x006900	0x00F2F0	Reserved for Future Use

Table 6.4 Configuration Commands #1

PGN 0x006600 (RX) / 0x00F2C0 (TX)						
DESCRIPTION	LENGTH	BIT OFFSET	UNITS	SCALE	OFFSET	NOTES
PUMP MODE	2	0	00: Constant Flow (default) 01: Constant Pressure 10 & 11: Reserved			Constant Flow mode is RPM control, Constant Pressure is PID control based on pressure sensor input and commanded pressure.
INVERT DIRECTION	1	2	0: CCW is positive direction (default) 1: CW is positive direction			Invert direction locked on steering units and -U versions.
INVERT PRESSURE SENSE	1	3	0: Port A is HIGH-SIDE PRESSURE(default) 1: Port B is HIGH-SIDE PRESSURE			Invert pressure locked on steering units and -U versions.
UNIDIRECTIONAL MODE	1	4	0: Bidirectional mode 1: Unidirectional mode (default)			When set, unidirectional mode only allows motion in the + direction, Bidirectional mode locked on Steering units and -U versions.
RESERVED	2	5	N/A			
HEARTBEAT DISABLE	1	7	0: Heartbeat mode is enabled (default) 1: Heartbeat mode is disabled			Refer to "Heartbeat Mode" in Section 5
RESERVED	16	8	N/A			
CAN SCHEDULING	4	24	Refer to Table 6.3 Below			All Process Data PGNs and *Fault/Warning* PGN are sent at this frequency
RESERVED	4	28	N/A			
RESERVED	28	36	N/A			

Table 6.5 Configuration Commands #2

PGN 0x006700 (RX) / 0x00F2D0 (TX)						
DESCRIPTION	LENGTH	BIT OFFSET	UNITS	SCALE	OFFSET	NOTES
ACCELERATION+	8	0	RPM/msec	1 RPM-msec/bit	0	Acceleration slew rate for + speeds. Refer to Table 6.9 below
ACCELERATION-	8	8	RPM/msec	1 RPM-msec/bit	0	Acceleration slew rate for – speeds. Refer to Table 6.9 below, Negative parameters do not exist on steering units.
DECELERATION+	8	16	RPM/msec	1 RPM-msec/bit	0	Deceleration slew rate for + speeds. Refer to Table 6.9
DECELERATION-	8	24	RPM/msec	1 RPM-msec/bit	0	Deceleration slew rate for – speeds. Refer to Table 6.9 below, Negative parameters do not exist on steering units.
MAX FAULT PRESSURE	8	32	%	1 %/bit	100%	Sets pressure fault point. Based on MAX PRESSURE+ and MAX PRESSURE- Refer to Refer to Table 6.9 below
RESERVED	24	40	N/A			

Table 6.6 Configuration Commands #3

PGN 0x006800 (RX) / 0x00F2E0 (TX)						
DESCRIPTION	LENGTH	BIT OFFSET	UNITS	SCALE	OFFSET	NOTES
MAX SPEED+	16	0	RPM	1 RPM/BIT	0	AMax speed in + direction. Unsigned 16 bit, little endian Example: 0x07D0 sets max speed of 2000 RPM. Refer to Table 6.9
MAX SPEED-	16	16	RPM	1 RPM/BIT	0	Max speed in - direction. Unsigned 16 bit, little endian. Refer to Table 6.9 (Negative parameters locked on Steering units)
MAX PRESSURE+	16	32	PSI	1 PSI/BIT	0	Max pressure in + direction. Unsigned 16 bit, little endian Example: 0x03E8 sets max pressure of 1000 PSI. Refer to Table 6.9
MAX PRESSURE-	16	48	PSI	1 PSI/BIT	0	Max pressure in - direction. Unsigned 16 bit, little endian. Refer to Table 6.9 (Negative parameters locked on Steering units)

Table 6.7 CAN Scheduling Options

DATA BITS (HEX)	DESCRIPTION
0x0, 0xF	N/A Setting. No function when part of RX PGN
0x1	All scheduled PGNs transmitted at 100 msec intervals
0x2	Transmitted at 200 msec intervals
0x3	Transmitted at 300 msec intervals
0x4	Transmitted at 400 msec intervals
0x5	Transmitted at 500 msec intervals (default)
0x6	Transmitted at 600 msec intervals
0x7	Transmitted at 700 msec intervals
0x8	Transmitted at 800 msec intervals
0x9	Transmitted at 900 msec intervals
0xA	Transmitted at 1 sec intervals
0xB	Transmitted at 1100 msec intervals
0xC	Transmitted at 1200 msec intervals
0xD	Transmitted at 1300msec intervals
0xE	PGNs only available on request

Table 6.9 Valid Range and Default Values for Parameters

PARAMETER	MIN	MAX	DEFAULT	EXAMPLE
ACCELERATION+	1	50	20	
ACCELERATION-	1	50	20	
DECELERATION+	1	50	20	
DECELERATION-	1	50	20	
MAX FAULT PRESSURE	20	100	50	
MAX SPEED+	500	4000/3500* /3000**	4000/3500* /3000**	
MAX SPEED-	500	4000/3500*/3000**	4000/3500*/3000**	
MAX PRESSURE+	200	4000	3000	
MAX PRESSURE-	200	4000	3000	

NOTES

* Models with Frame Size 2 have max speed of 3500 RPM

** Models with Frame Size 3 have max speed of 3000 RPM

OPERATIONAL CONTROL PGNS

There are two receive (RX) Operational Control PGNs associated with the device. The table below summarizes the Operational Control PGNs available on the device.

	RX PGN	DATA
Operational Control #1	0x006400	Table 6.10 Below
Operational Control #2	0x006500	Reserved for Future Use

Table 6.10 Operational Control Commands

PGN 0x006400 (RX)						
DESCRIPTION	LENGTH	BIT OFFSET	UNITS	SCALE	OFFSET	NOTES
DEVICE ENABLE	1	0	0: Disable Device 1: Enable Device			
START/STOP	1	1	0: Command Stop 1: Command Motion			
RESERVED	6	2	N/A			
COMMAND SETPOINT	16	8	RPM or PSI	1 RPM/bit or 1 PSI/bit	0	Signed 16 bit, little endian Pump Mode determines units. Constant Flow sets RPM/Constant Pressure sets PSI
RESERVED	40	24	N/A			

AUXILLARY COMMAND PGNS

There is one receive (RX) Auxiliary Command PGN associated with the device. The data field is broken into Groups, where a particular group value will perform a specific operation, such as Clear Faults.

Table 6.11 Auxillary Commands

PGN 0x006A00			
DESCRIPTION	LENGTH	BIT OFFSET	NOTES
RESERVED	56	0	N/A
GROUP 1	4	56	0000: No Function 0001: Clear Faults
GROUP 2	4	60	0000: No Function 0001: Burn to EEPROM 0010: Reset Factory Default Parameters

PROCESS DATA PGNS

There are five transmit (TX) Process Data PGNs associated with the device. The Process Data is used to give live feedback regarding the state of operation and sensor values. They are automatically transmitted at the frequency set by the CAN SCHEDULING parameter in Table 6.7, or can be transmitted by request by the host controller. The table below summarizes the Process Data PGNs available on the device.

	TX PGN	DATA
Process Data #1	0x00F250	Table 6.12 Below
Process Data #2	0x00F260	Table 6.13 Below
Process Data #3	0x00F270	Table 6.14 Below
Process Data #4	0x00F280	Table 6.15 Below
Process Data #5	0x00F290	Reserved for Future Use

Table 6.12 Process Data #1

PGN 0x00F250 (TX)						
DESCRIPTION	LENGTH	BIT OFFSET	UNITS	SCALE	OFFSET	NOTES
TIME	8	0	msec	100 msec/ bit	0	Time at which data was sampled. Allows proper syncing of all transmitted data.
PUMP MODE	2	8	00: Constant RPM 01: Constant Pressure 10 & 11: Reserved			
ENABLE STATE	1	10	0: Device Disabled 1: Device Enabled			
IN MOTION	1	11	0: Device not in motion 1: Device in motion			
STOPPING	1	12	0: Device not decelerating 1: Device decelerating			
RESERVED	18	13	N/A			
COMMAND SETPOINT	16	32	RPM or PSI	1 RPM/bit or 1 PSI/bit	0	Signed 16 bit, little endian
RESERVED	16	48	N/A			

Table 6.13 Process Data #2

PGN 0x00F260 (TX)						
DESCRIPTION	LENGTH	BIT OFFSET	UNITS	SCALE	OFFSET	NOTES
TIME	8	0	msec	100 msec/bit	0	Time at which data was sampled. Allows proper syncing of all transmitted data.
RESERVED	8	8	N/A			
MOTOR SPEED	16	16	RPM	1 RPM/bit	0	Signed 16 bit, little endian
PRESSURE SENSOR A	16	32	PSI	1 PSI/bit	0	Unsigned 16 bit, little endian Pressure sensor A and B will read the same for steering units and -U Versions.
PRESSURE SENSOR B	16	48	PSI	1 PSI/bit	0	Unsigned 16 bit, little endian Pressure sensor A and B will read the same for steering units.

PGN 0x00F270 (TX)						
DESCRIPTION	LENGTH	BIT OFFSET	UNITS	SCALE	OFFSET	NOTES
TIME	8	0	msec	100 msec/ bit	0	Time at which data was sampled. Allows proper syncing of all transmitted data.
RESERVED	8	8	N/A			
POSITION	16	16	revolutions	4 revs/bit	0	Signed 16 bit, little endian
RESERVED	32	32	N/A			

Table 6.15 Process Data #4

PGN 0x00F280 (TX)						
DESCRIPTION	LENGTH	BIT OFFSET	UNITS	SCALE	OFFSET	NOTES
TIME	8	0	msec	100 msec/ bit	0	Time at which data was sampled. Allows proper syncing of all transmitted data.
DEVICE TEMPERATURE	8	8	°C	1 °C/bit	0	Temp measured from Heatsink of Power module
FLUID TEMPERATURE	8	16	°C	1 °C/bit	0	
RESERVED	24	24	N/A			
DC BUS VOLTAGE	16	48	Volts	1 V/bit	0	
MOTOR TEMPERATURE			°C			
MCU TEMPERATURE			°C			

SYSTEM DATA PGN

There is one transmit (TX) System Data PGN. It is transmitted upon request from the host controller.

Table 6.16 System Data

PGN 0x00F2B0 (TX)						
DESCRIPTION	LENGTH	BIT OFFSET	UNITS	SCALE	OFFSET	NOTES
TIME SINCE LAST BURN	16	0	msec	100 msec/ bit	0	Time at which last 'Burn to EEPROM' command was completed. Refer to Table 6.11.
RESERVED	48	16	N/A			

FAULTS AND WARNINGS PGN

There is one transmit (TX) Faults and Warnings PGN associated with the device. It is automatically transmitted at the frequency set by the CAN SCHEDULING parameter in Table 6.7, or can be transmitted by request by the host controller

PGN 0x00F240 (TX)					
DESCRIPTION	LENGTH	BIT OFFSET	STATE	CLEAR	NOTES
TIME	8	0			100 msec/bit
OVER VOLTAGE FAULT	1	8	0: No Fault 1: Fault occurred	CAN	>900 Volts for 1s (10 consecutive 100ms samples)
UNDER VOLTAGE FAULT	1	9	0: No Fault 1: Fault occurred	AUTO	Varies based on product specifications, reach out to Terzo Engineering for details.
OVER TEMPERATURE FAULT	1	10	0: No Fault 1: Fault occurred	CAN	"> 100 MCU single 100ms sample > 150 Stator (135 A2) if 5 of last 16 100ms samples, LPF/10ms > 110 Heatsink for 3s (30 consecutive 100ms samples, LPF/10ms)"
FLUID OVER TEMPERATURE FAULT	1	11	0: No Fault 1: Fault occurred	CAN	This setting varies between products, reach out to Terzo Engineering for details.
OVER PRESSURE FAULT	1	12	0: No Fault 1: Fault occurred	CAN	>4000psi or [Max pressure setting * fault pressure %) for 1s (10 consecutive 100ms samples)
RESERVED	1	16	0: No Fault 1: Fault occurred	CAN	
HEARTBEAT NOT DETECTED	1	17	0: No Fault 1: Fault occurred	CAN	Motor enabled without receiving CAN command for 10 consecutive 100ms checks
STO 1	1	18	0: No Fault 1: Fault occurred	CAN	Input state of STO 1 for 100ms (10 consecutive 10ms samples)
STO 2	1	19	0: No Fault 1: Fault occurred	CAN	Input state of STO 2 for 100ms (10 consecutive 10ms samples)
RESERVED	4	20			
ANY INVERTER FAULT	1	24	0: No Fault 1: Fault occurred	CAN	"any of inverter faults are high"
HARDWARE	1	25	0: No Fault 1: Fault occurred	CAN	"No Pressure sensor Invalid Board Address"
RESERVED	1	26	0: No Fault 1: Fault occurred	CAN	Not Currently enabled
INVERTER WRONG DIRECTION	1	27	0: No Fault 1: Fault occurred	CAN	Opposite speed feedback for 200ms (20 consecutive 10ms samples)
INVERTER FAULT - NO CURRENT	1	28	0: No Fault 1: Fault occurred	CAN	Feedback current has more than 90% error from command
PRESSURE / FLOW LIMITING WARNING	1	40	0: No Fault 1: Fault occurred		Pressure loop output at max psi < flow command
TORQUE LIMIT WARNING	1	41	0: No Fault 1: Fault occurred	AUTO	Reference current command being clamped at the limit
ANY INVERTER ALARM	1	42	0: No Fault 1: Fault occurred	AUTO	Any of bit 43-45 are high
INVERTER ALARM / CURRENT TRACKING	1	43	0: No Fault 1: Fault occurred	AUTO	More than 30% motor phase current error detected (normally reserved)
INVERTER ALARM / TEMPERATURE DERATE	1	44	0: No Fault 1: Fault occurred	AUTO	Current output limit reduced to derate level setting when MCU, oil, heatsink or stator temperature > derate temperature setting for 3s (30 consecutive 100ms samples, LPF/10ms) NOT ENABLED ON ALL MODELS
INVERTER ALARM - SPEED DEVIATION	1	45	0: No Fault 1: Fault occurred	AUTO	Feedback 250RPM over or under command for 8s
RESERVED	17	46			
ANY WARNING	1	62	0: No Fault 1: Fault occurred	AUTO	any warning has occurred (not faults)
ANY FAULT	1	63	0: No Fault 1: Fault occurred	AUTO	any fault has occurred (not warnings)

IT IS THE RESPONSIBILITY OF THE USER TO ENSURE THE CAUSE OF THE FAULT IS RESOLVED BEFORE CLEARING. FAILURE TO DO SO MAY LEAD TO DEVICE OR SYSTEM FAILURES.

DEVICE ID PGN

There is one transmit (TX) Device ID PGN. It is transmitted upon request from the host controller. Send a message to 0x18EA64xx (where xx is the source address of the controller sending the message) that is 8 bytes long with the payload of A0 F2 00 00 00 00 00 00

An EHSU with serial number ending in 1000 running firmware version 2.0.20 would respond with pgn 0x0CF2A064 with the following payload 00 02 00 14 E8 03 00 00 0x02, 0x00, 0x14 represent firmware version 2.0.20, and 0x03E8 represents serial number 1000.

Table 6.18 Device ID

PGN 0x00F2A0 (TX)			
DESCRIPTION	LENGTH	BIT OFFSET	NOTES
Device ID	8	0	0x00: HP-015-001
Firmware Version	24	8	Divided into 3 byte unsigned values. Example: 0x010001 is Version 1.0.1
Device Serial Number	16	32	Unsigned integer. Represents last 5 digits of device serial number. Example: 0x01D8 is serial number 472
RESERVED	16	48	N/A

REQUEST SPECIFIC PGNS

Some transmit (TX) PGNs on the Hydrapulse are available by request. This request is received through a reserved PGN. PGN 0x00EA00 is the request message PGN with 3 bytes of data, corresponding to the transmit PGN (TX) the host controller wishes to receive from the Hydrapulse.

PGN 0x00EA00 should be sent by the host controller with priority 6 and the three data bytes should be the requested PGN in little-endian.

hydrapulse

ENVIRONMENTAL PROTECTION

CLIMATE

SAE J1455-4.1.3 Temperature Cycle
SAE J1455-4.1.3 Thermal Shock
SAE J1455-4.1.3 Thermal Stress
SAE J1455-4.2 Humidity

MECHANICAL VIBRATION

SAE J1455-4.10 Swept Sine Vibration
SAE J1455-4.10.4 Random Vibration
SAE J1455-4.11 Mechanical Shock
SAE J1455-4.11 Operational Shock / Harness Shock
SAE J1455-4.12 Combined Environmental
ISO 16750-3 Shock and Vibration

ELECTRICAL

SAE J1455-4.13 Heavy-Duty Truck Electrical Environment

EMI/EMC

EIC 61000-6-4 Radiated Emissions
IEC 61000-6-2 Industrial Immunity
FCC Part 15B Class A
CISPR 25
ISO 11452-2 RI
ISO 11452-4 BCI
ISO 10605 ESD
ISO 7637-2 3rd Edition transients (on 12vdc)

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