ESDR-0201A
A Closed-Loop Control for Servovalves and More

Overview

HydraForce adds another useful and versatile member to the ExDR family of electronic valve drivers. The new ESDR-0201A was developed as a closed-loop control for the coming line of HydraForce Innercept™ digital proportional controls. The driver is built on the successful ExDR platform of coil-mounted integrated valve drivers. This version features two outputs for driving two-coil proportional valves, but can also be used with single-coil valves. It has a single 0-5 V analog input that forms the feedback leg of the PID control, along with a +5.5 V (200 mA) reference voltage to power a sensor or other input device, such as an LVDT (Linear Variable Differential Transformer) used with servovalves. It also includes an SAE J1939 CAN network interface that receives the PID setpoint, and can transmit diagnostic messages and status information back to the main vehicle controller.

A Better Proportional Control

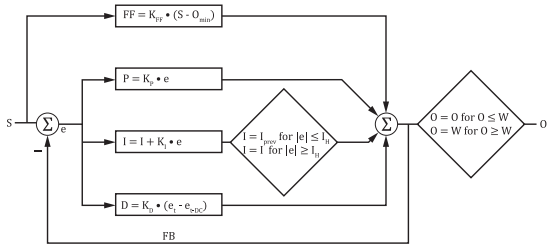
Using the ESDR simplifies control of hydraulic functions on the machine and greatly increases their accuracy, repeatability, and reliability. The ESDR uses a sophisticated closed-loop PID control that drives proportional hydraulic valves precisely while compensating for factors such as coil temperature, valve-to-valve manufacturing variation, hysteresis, and hydrodynamic forces.

Testing with HydraForce SP type proportional directional controls demonstrated a significant decrease in hysteresis over open-loop control using the same components. Also making notable increases were valve washout performance, and the control demonstrated near-perfect linearity across the control range from A coil to B coil.

What makes these advances possible is position feedback. The control is able to drive rapid small changes in the coil current to maintain the desired position at all times. Other forms of feedback are possible using many types of sensors such as pressure transducers, speed sensors, and position sensors like LVDT.

Distributed PID Control

Closing the loop locally (on the valve) relieves the main vehicle control from performing PID functions, and makes for faster and much more efficient control systems. The HydraForce ESDR is optimized for this. The control contains a full-featured set of PID tuning parameters including feed-forward for faster response.



HF-Impulse Configuration Software

To allow configuration, programming, tuning, and troubleshooting of our valve drivers and electronic control units, HydraForce provides HF-Impulse. This purpose-built software allows configuration of the communications parameters and those settings particular to each device type. It also facilitates programming control logic for ECDR style configurable drivers, and serves as a troubleshooting tool with real-time monitoring of I/O and diagnostic messaging parameters for CAN devices.

For detailed information and specifications, visit www.hydraforce.com or contact your local HydraForce representative at www.hydraforce.com/distribs/world.htm

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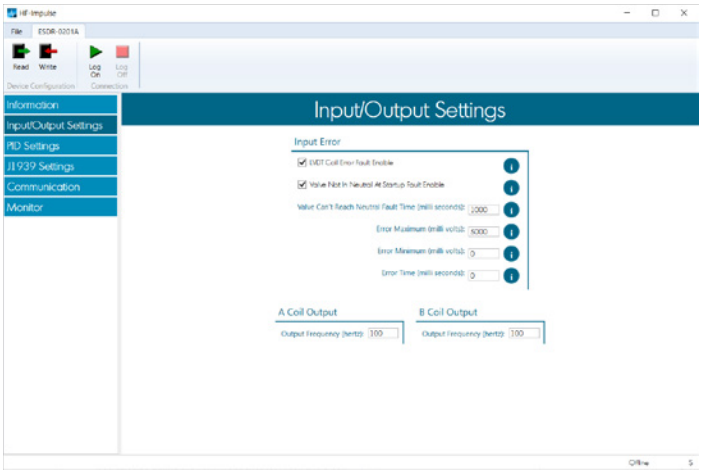
Input/Output Settings

For the ESDR, HF-Impulse lets you define parameters for certain input errors. When the device encounters these conditions with the input signal, it .raises a DM1 message on the CAN bus.



- LVDT coil error fault
- Valve not in neutral at startup
- Valve can't reach neutral fault time (ms)
- Error maximum (mV)
- Error minimum (mV)
- Error time (ms)

You can also define the PWM frequency for A coil and B coil outputs individually if necessary.

Tuning Parameters

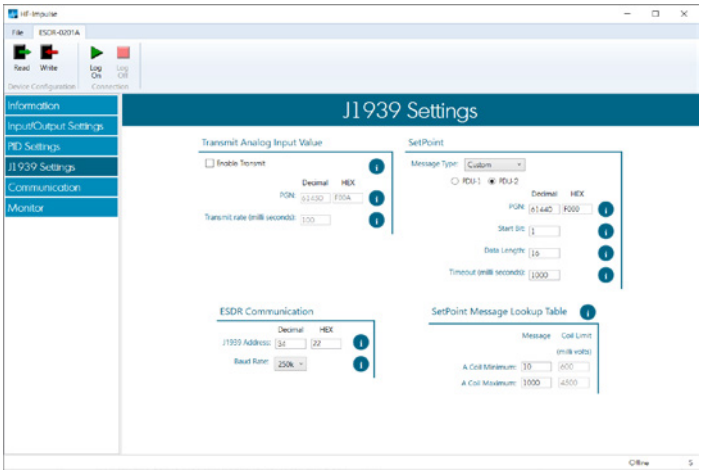
Specifically for the ESDR, HF-Impulse provides the following PID tuning parameters:

- Proportional gain
  - The output is proportional to the error
- Derivative gain
  - The output is proportional to the previous error
- Integral gain
  - The output is proportional to the rate off change of the error
- Feed forward gain
  - The output is proportional to the desired setpoint
- Windup guard (output limit)
  - The output is limited to protect against derivative windup
- Derivative cycles
  - The derivative term is averaged over this number of cycles to dampen it and prevent overshoot
- Integral hold
  - The integral term is limited for error greater than the hold value
- Duty cycle minimum
  - The output cannot fall below this minimum value

J1939 Settings

You can specify CAN network parameters such as:

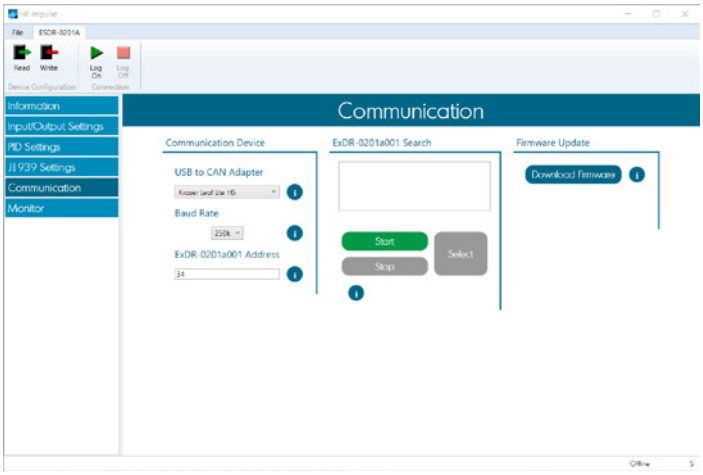
- Transmit analog input value (enable)
- Set point message parameters
  - Select basic or extended joystick presets or choose custom for full control
- ESDR Communication
  - CAN address and baud rate
- Set point message lookup table
  - Define the minimum/maximum message values and output limits.
  - Because the ESDR is designed as a closed-loop control, output scaling is not necessary and therefore perfectly linear between minimum and maximum values.



Communication

You can define parameters for how HF-Impulse will communicate with the device. This requires a USB to CAN adapter and three types are supported. You can also search the connected network for your device, and perform firmware updates.

- Communication device
  - Kvasser Leaf Lite HS
  - PEAK PCAN/USB
  - ECAN-1
- ExDR-0201 search
- Firmware update

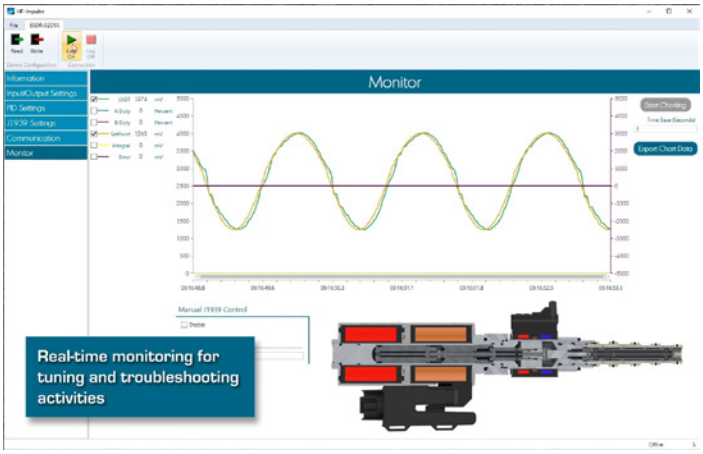


Monitoring

HF-Impulse will chart operating telemetry in real time for monitoring/tuning/troubleshooting activities. You can also export the data in CSV format for analysis.

- LVDT (0 to 5 V input value)
- A Duty (A coil duty cycle)
- B Duty (B coil duty cycle)
- Set point
- Integral term
- Error

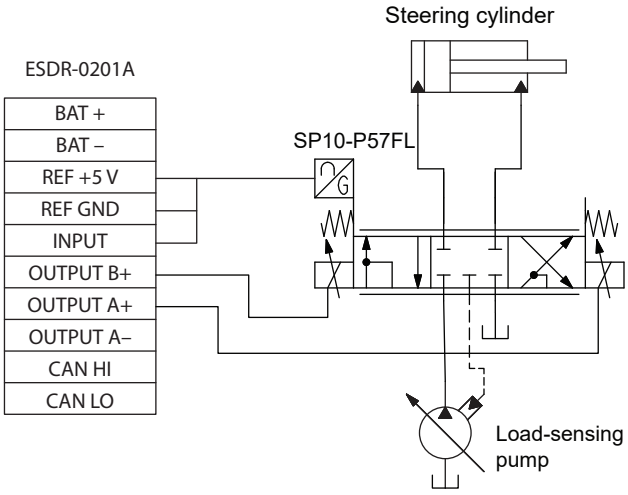
All of the data is plotted on a scale 0 to 5000 mV so the relationships of the values can be easily understood.



Application Suggestions

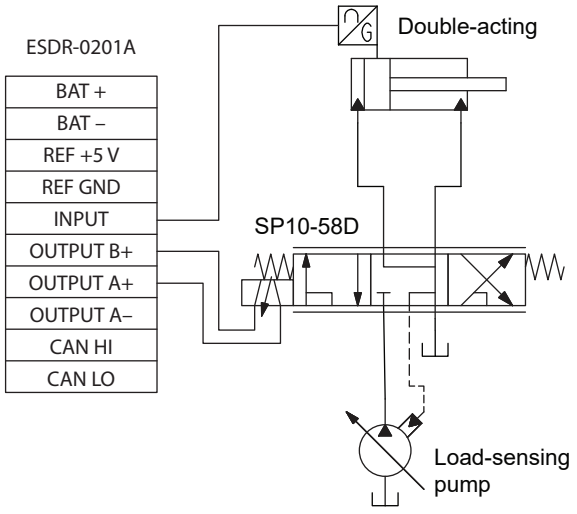
The ESDR-0201A has a lot of potential as a closed-loop CAN control in a distributed control network. The main benefits are controlling a device by CAN message, and distributing the closed-loop control to lighten the load on the main vehicle control, forming a faster and more responsive system overall. Here are some potentially useful applications.

Flow Control with LVDT Sensor



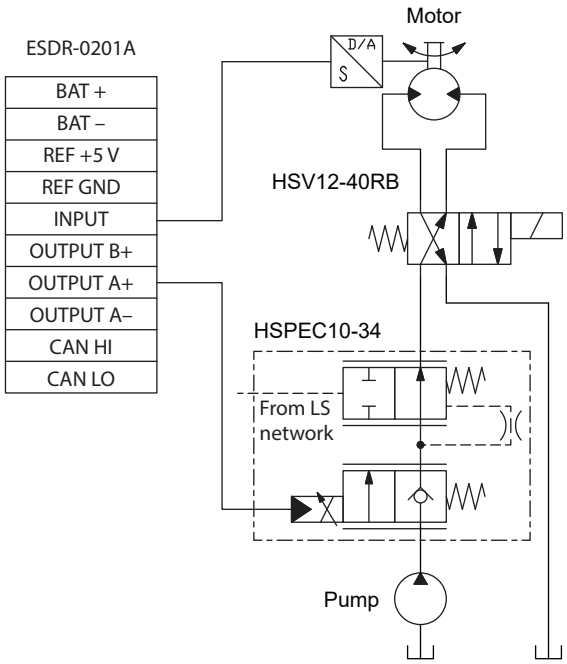
For applications such as auto-steering where precise and repeatable flow control is needed, you can use the ESDR with an LVDT position sensor that feeds the spool position back to the 0-5 V input. In this simplified example, the SP10-P57FL (patent pending) controls flow to the double-acting steering cylinder while providing an isolated load-sense signal back to the pump.

Position Control



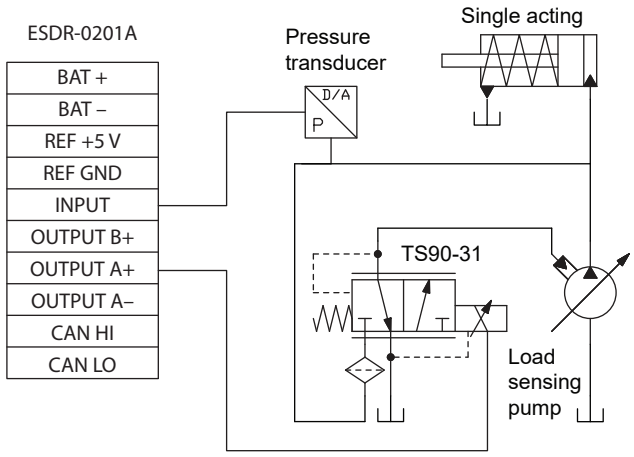
When used with a position sensor integrated to the cylinder, the ESDR can control its position. The PID loop can be tuned to match the desired response. For example it can be optimized for speed, or to minimize overshoot/overcorrection. The simplified circuit shows an SP10-58D proportional directional valve with motor spool. An isolated load sense signal communicates the load pressure to the load-sensing pump. A stroke sensor with analog output forms the feedback leg of the PID control.

Speed Control



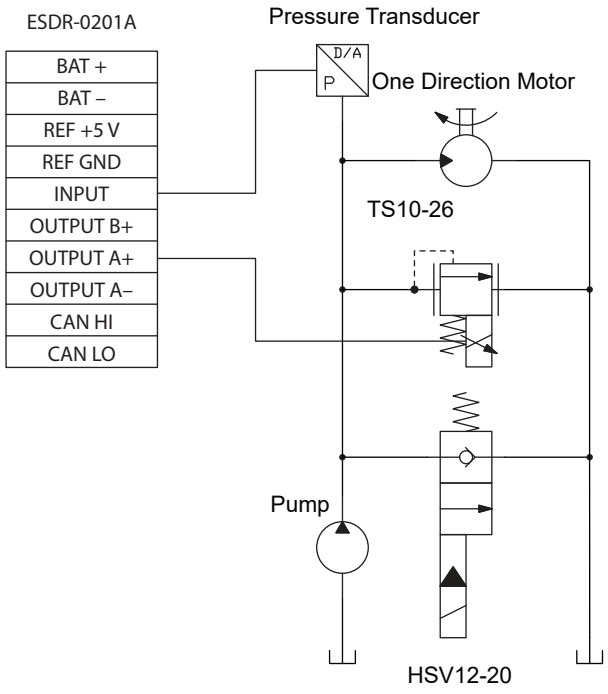
The ESDR can provide closed-loop motor speed control when used with a speed pickup that provides an analog output. In the example an HSPEC10-34 provides pressure compensated flow control and an HSV12-40RB can reverse the direction of rotation as needed possibly to clear the radiator in a fan drive application. The main vehicle control can close the loop on engine temperature. This example can also drive a conveyor or auger to provide closed-loop control of product feed rate.

Force Control



You can control the force of a press, grapple, or other clamping device using a proportional relief valve with a pressure sensor to communicate the load to the ESDR. In the example, the ESDR regulates a load-sensing pump using a TS90-31 to control the load-sensing pressure. This achieves force control of the single-acting cylinder.

Torque Control



In another variation of force control, you can easily control the torque of a hydraulic motor with a proportional relief valve, using a pressure sensor for feedback. In the example, the ESDR controls a TS10-26 proportional relief valve. An HSV12-20 is available as a dump valve/function enable. This configuration is useful for applications like stump grinders and boring machines.

Coming Soon

INNERCEPT™

DIGITAL PROPORTIONAL CONTROL

Hydraforce is finalizing the design of the Innercept™ digital proportional control. This patent-pending innovation will provide game-changing servovalve performance to HydraForce SP and PE valves using an integrated LVDT position sensor.

- Closed-loop control with ESDR-0201A
- Near zero hysteresis
- Hydrodynamic flow force correction
- Compensate for manufacturing variation

Innercept provides the speed, accuracy, and repeatability needed to meet the increasing demand for autonomous applications in today's mobile hydraulics marketplace.