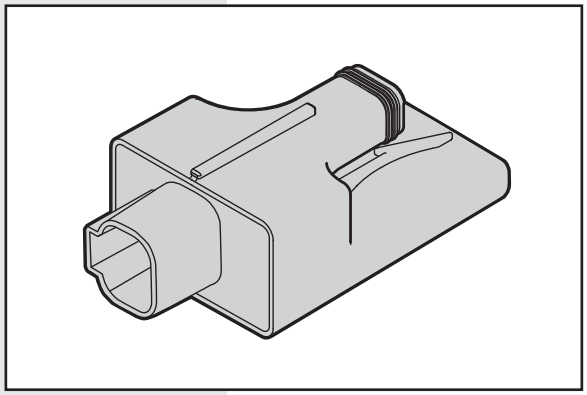
User Manual

ExDR-0101A

Valve Driver for Hydraulic Proportional Cartridge Valves



HydraForce®

7709108 • UM_ExDR-0101A • 08/17 •

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INTRODUCTION

Overview

This instruction details how to connect, configure, and monitor the ExDR-0101A valve driver using the HydraForce communication adapter and a Windows® computer.

Description

The ExDR-0101A is a compact plug-in style, microprocessor-based, valve driver designed for use in hydraulic proportional valve applications. It is configurable to drive a coil with voltage, current, resistance, or frequency signal. HF-Impulse, an easy-to-use, web accessible configuration tool, is available as a free download at www.hydraforce.com/electronics.

Operation

The controller accepts inputs from commonly available analog operator interface devices (joystick, potentiometer, sensors, master controller, etc.). The input signal drives the output current to the user-defined ramp rate, enabling accurate and proportional metering control of the hydraulic valve. You can configure the unit for direct valve operation.

Diagnostic Features

Built-in diagnostics detect defined errors. The driver output drops and holds at the inactive stand-by condition. After fault correction and a power cycle, the controller returns to standard operation. Recovery from supply voltage faults occurs two seconds after correction. The controller monitors input signal, supply voltage, and coil resistance for these conditions.

- Input signal below user-defined minimum
- Input signal above user-defined maximum
- Supply voltage below 8.5 volts
- Supply voltage above 33 volts
- Coil resistance below acceptable range
- Coil resistance above acceptable range

Tools/Materials You Need

You supply:

- ❑ Computer with Windows 7 or newer
- ❑ Power supply, 9–32 Vdc

HydraForce supplies:

Software

Download from www.hydraforce.com/electronics.

- ❑ *HF-Impulse*
- ❑ Drivers for USB/serial adapter

Hardware

- ❑ EVDR-0101A: 4204800
- ❑ USB/serial cable: 4000285
- ❑ Test cable: 4000286 (optional)

Documents

- ❑ UM-ExDR-0101A User Manual (this document)
- ❑ TR-ExDR-0101A Technical Reference

CONNECTING

Getting Set Up

1. Download *HF-Impulse* from the HydraForce electronics portal at www.hydraforce.com/electronics. This software communicates via serial communication with the ExDR-0101A.

Note: *www.hydraforce.com/electronics is a secure portal. Register if you do not already have a user ID and password. Registration is handled automatically if you use a company e-mail address.*

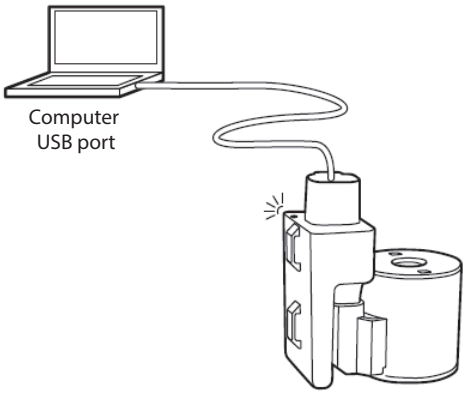
2. Unzip the file after downloading. Run *HfInpulse.Installer.msi* to install.
3. Download driver for USB/serial adapter from the electronics portal: *CMD21226_Setup.zip*.
4. Extract the content of the file and launch *CMD21226_Setup.exe*. Follow the installation prompts.

Note: *Installing this driver requires administrator privileges on the target device.*

5. Connect the USB/serial adapter to your computer.

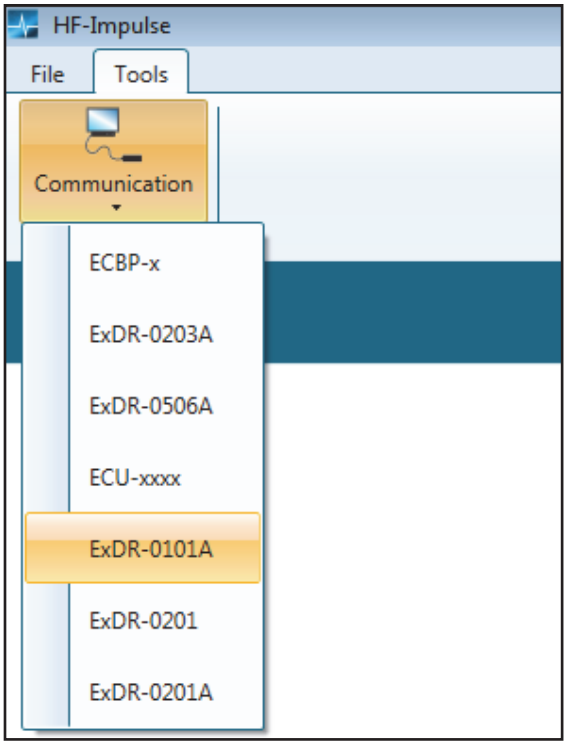
Communication Connections

Connect the USB/serial cable to the ExDR 0101A. Connect the cable to the appropriate USB port on your computer. The USB port powers the controller during configuration. When the cable is connected, the red LED on the ExDR-0101A blinks once per second.

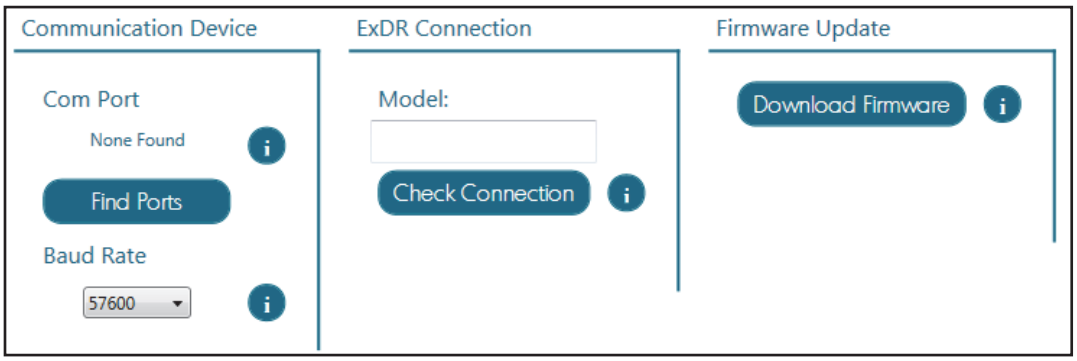


Establishing Communications

1. Start HF-Impulse software.
2. Select **`Communication`** to establish a connection with the ExDR-0101A.



3. If the USB/serial adapter is connected correctly, the *Com Port* selection lists the COM port in use. If the selection is blank, the drivers are not properly installed or the USB/serial adapter is not connected. The baud rate defaults to 57600.
4. When *None Found* appears under *Com Port*, click **`Find Ports`** to search for the USB device on your computer.
5. Click **`Check Connection`**. A pop up message reports the ExDR connection status.



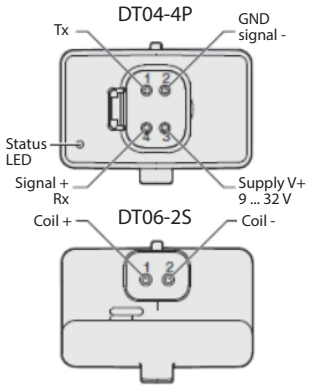
Operational Connections

The ExDR-0101A plugs directly into a coil. You can mount it remotely, and you can purchase DT04 plugs to wire from the ExDR-0101A output to a coil.

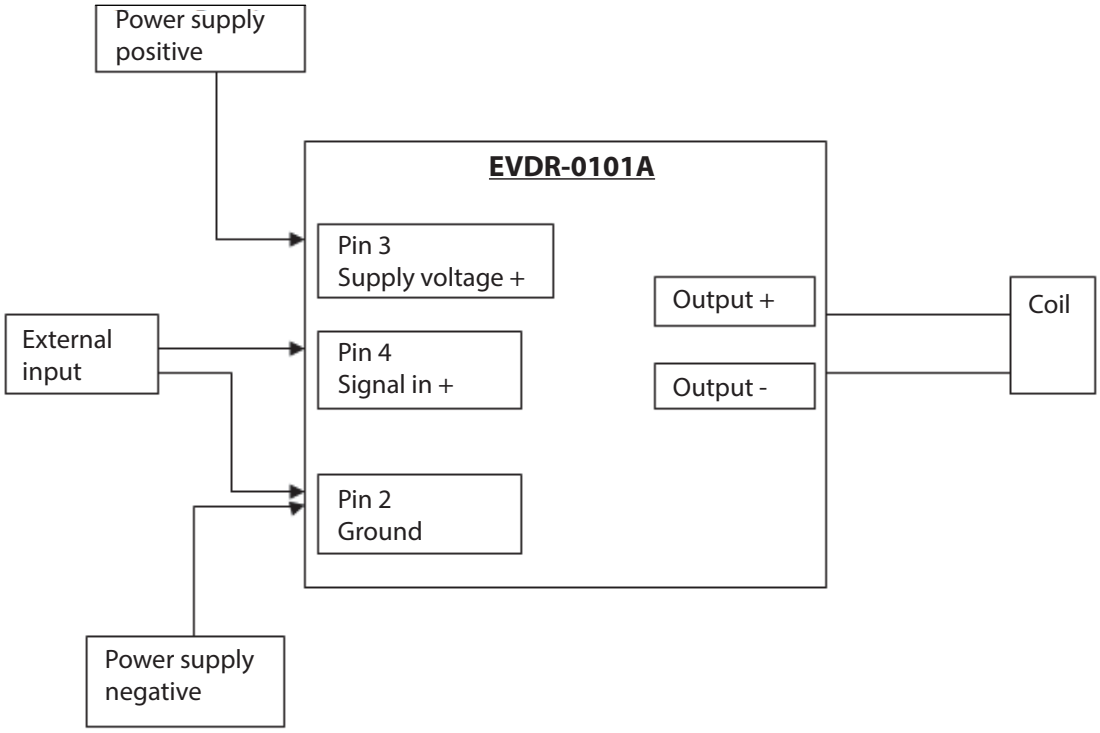
Electrical Connections

Description	Interface	Pin	Mating connector
Battery, 9 – 32 V	Power+ Power–	3 2	DT06-4S
Serial TTL and voltage/current, resistance input	Serial in	4	DT06-4S
Serial TTL (for configuration only)	Serial out	1	DT06-4S
Solenoid	Sol A+ Sol A–	1 2	DT04-2P

Wiring Diagram



Connect the ExDR-0101A as shown below. Use two wires on the *Pin 2 ground*. This prevents amperage from the power supply ground from interfering with the signal.



HF-IMPULSE COMMON FEATURES

Overview

This section details the features of HF-Impulse software common to all ExDR valve drivers. The EVDR-0101A, ETDR-0101A, and EGDR-0101A sections discuss settings particular to each firmware personality.

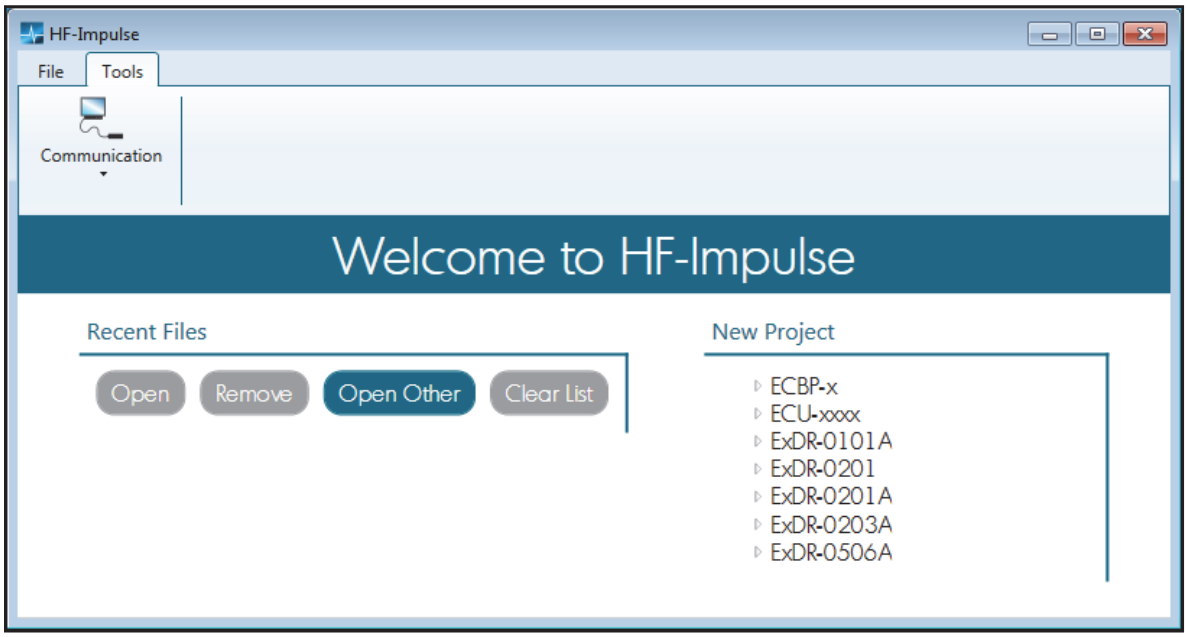
Information Icons

HF-Impulse contains information icons.

Click on these to open a window with useful information.

Welcome Screen

The *Welcome to HF-Impulse* screen allows you to choose recent projects or start new projects.



Recent Files is a record of paths from previously opened projects. The file path is displayed here. To choose one of the paths, select it and then click **`Open`**. To browse the computer to locate a project file, click **`Open Other`**. All HF-Impulse files have the *.icf file extension.

New Project is grouped by hardware type and then by firmware type. For example, one hardware type is ExDR-0101A and EVDR-0101A is a firmware (personality) type.

The *Welcome to HF-Impulse* screen also lets the user directly access communication for the hardware. It is not necessary to open a project to check communication. The communication screen in this link is the same screen seen in the project named Communication.

Information Screen

The *Information* screen shows the project name, model, and firmware.

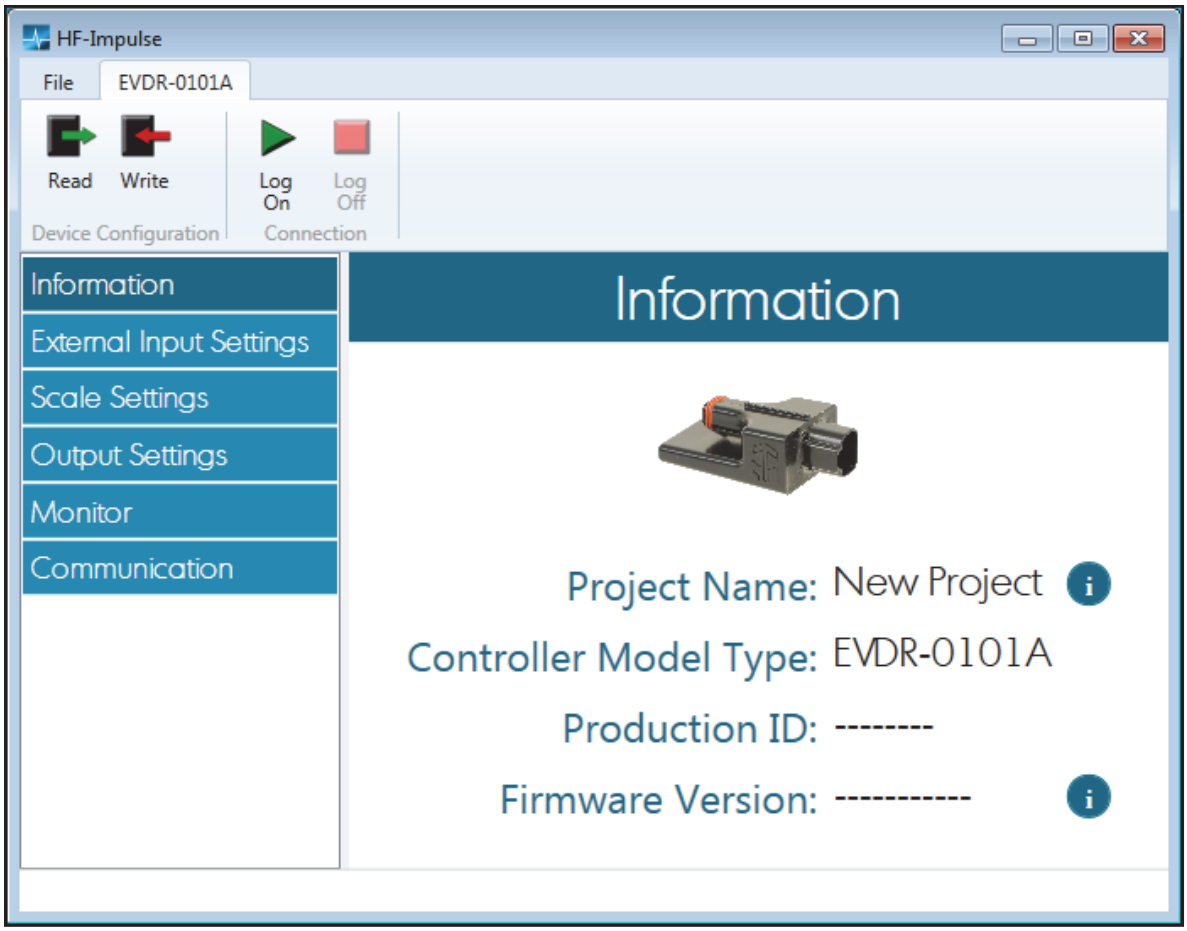
The firmware version displays after HF-Impulse reads or writes settings to the controller. The firmware consists of a 6-digit number which identifies the model type.

- 4100122_R** is the EVDR-0101A.
- 4100118_R** is the ETDR-0101A.
- 4100147_R** is the EGDR-0101A

The _R** represents the version number. Prototype versions are the letters _RA thru _RZ. Production release versions are the numbers _R1 thru _R99. Use the Firmware Update utility on the Communication screen to update.

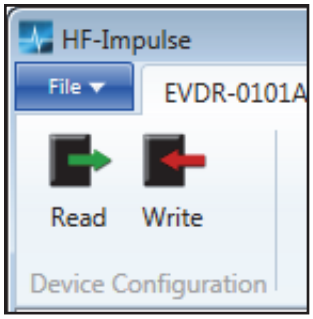
The *Project Name* is assigned when the configuration file is saved. The default name is New Project. To save the project with a new name, use File/Save As.

The *Production ID* should be the same as the serial number on the EVDR-0101A label. Some older EVDR-0101A models do not have a *Production ID* value.

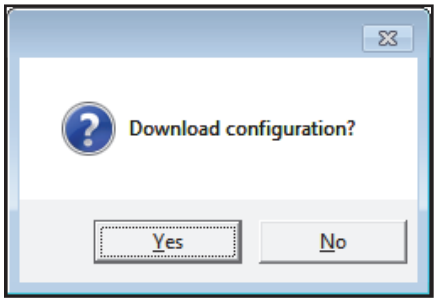


Reading and Writing Settings

Once communication is established, the user can read or write the settings to the ExDR-0101A. Either operation affects all settings for each screen.

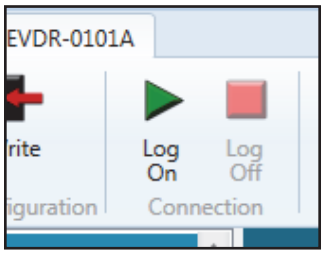


After the **`Write`** button has been clicked, *HF-Impulse* responds, asking to confirm download. A success message displays when complete.



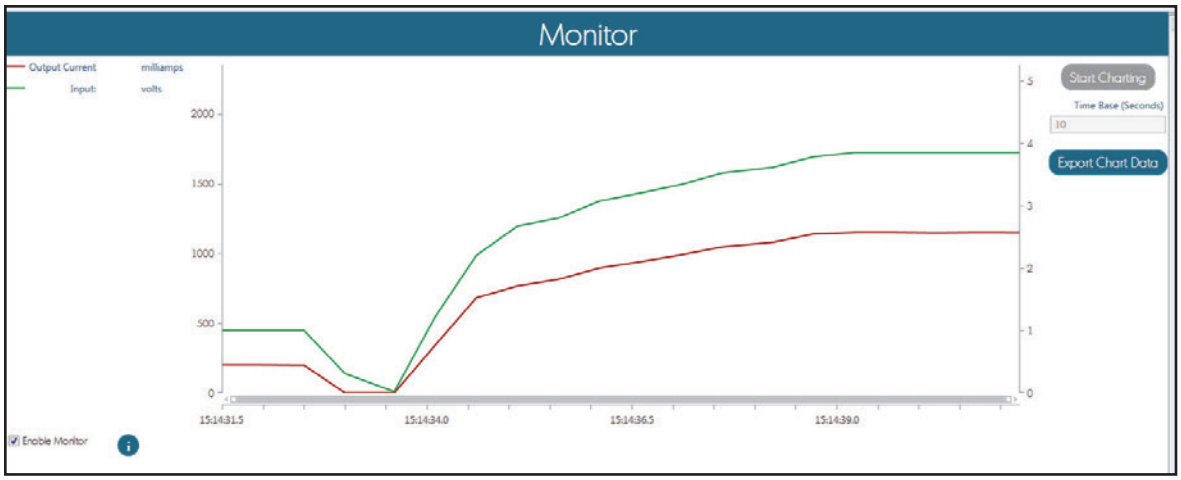
Logging On and Monitoring

The ExDR-0101A has the ability to send data during operation. This requires a special wiring connection. To make this electrical connection, refer to the *ExDR-0101A Technical Reference*.



Log On/Log Off works with the *Monitor* screen. To use the monitor, check the **`Enable Monitor`** check box. Write the settings to the ExDR-0101A.

The *Monitor* screen becomes active when logged on. The input and output values plot as a chart recorder. HF-Impulse monitors valve operation in real time, which is helpful for tuning and troubleshooting.



The chart area plots the output and input values per time. The Y axis on the left side is scaled from 0 to 2000 milliamps for the output. The Y axis on the right side is scaled in units based on the external input value. The X axis is scaled in time based on the entry in the *Time Base* box. Change *Time Base* as desired. HF-Impulse captures 10 samples per second.

The output values plot in red and the external input value plots in green.

The chart area X axis contains a scroll bar which allows the user to zoom into sections of the chart. To zoom, hover over the ends of the gray time bar. The mouse icon changes to a double arrow. Click and drag the bar to zoom in and out of the chart timing.

To stop the chart and export the data from the chart, click **`Export Chart Data`**. A file browser opens. Name a path and file for the data. The data becomes a **.csv* file.

Communication Screen

The *Communication* screen is accessible from the welcome screen or from the project. You can check the ExDR-0101A connection or transfer firmware.

Communication Device

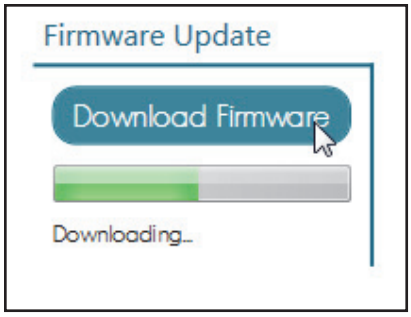
If the USB/serial adapter is connected correctly, the Com Port selection lists the COM port in use. If the selection is blank, the drivers are not properly installed or the USB/serial adapter is not connected.

EVDR Connection

Click **`Check Connection`**. A pop up message reports the ExDR connection status.

Firmware Update

If desired, you can update the ExDR-0101A to the latest firmware. Download new firmware from the HydraForce electronics portal. To upgrade the firmware, ensure the **.hex* files are available on the computer.



To update firmware:

1. Click **`Download Firmware`** and browse to the location of the **.hex* file; select.
2. Click **`Open`**. The firmware downloads to the ExDR-0101A. A progress bar displays the download progress. A status message appears below the progress bar. It displays "download complete" when finished.

The firmware file names are the 6-digit part number and the version number.

- 4100122_R**.hex is the EVDR-0101A.
- 4100118_R**.hex is the ETDR-0101A.
- 4100147_R**.hex is the EGDR-0101A.

The _R** represents the version number. Prototype versions are the letters _RA thru _RZ. Production release versions are the numbers _R1 thru _R99.

Note: *Before you can update the firmware in your ExDR-0101A, you must download the latest file from the electronics portal at www.hydraforce.com/electronics. Check the file number and revision to ensure it is the correct firmware for your device.*

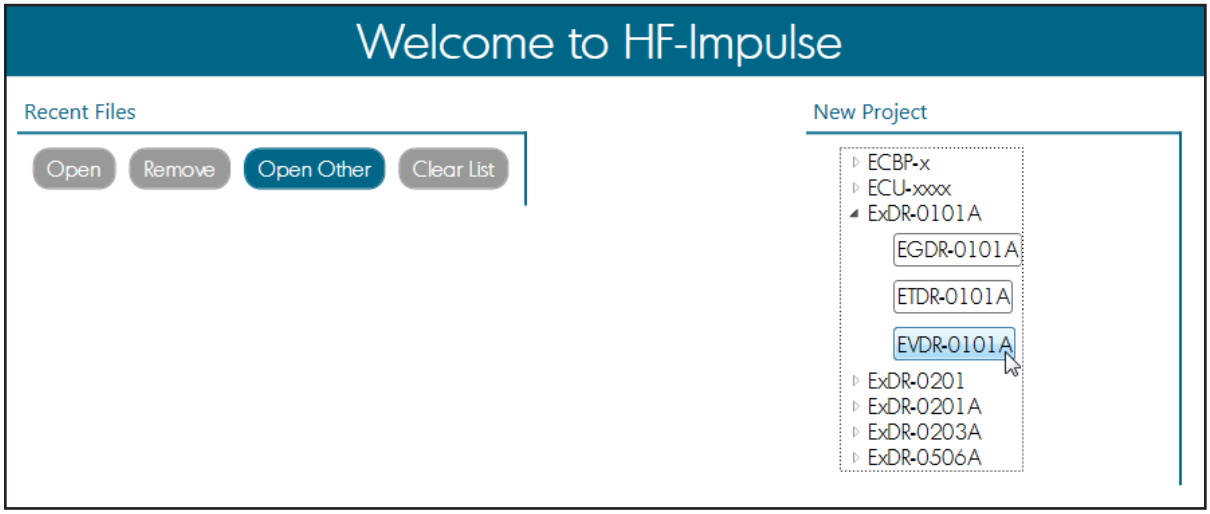
EVDR-0101A

Overview

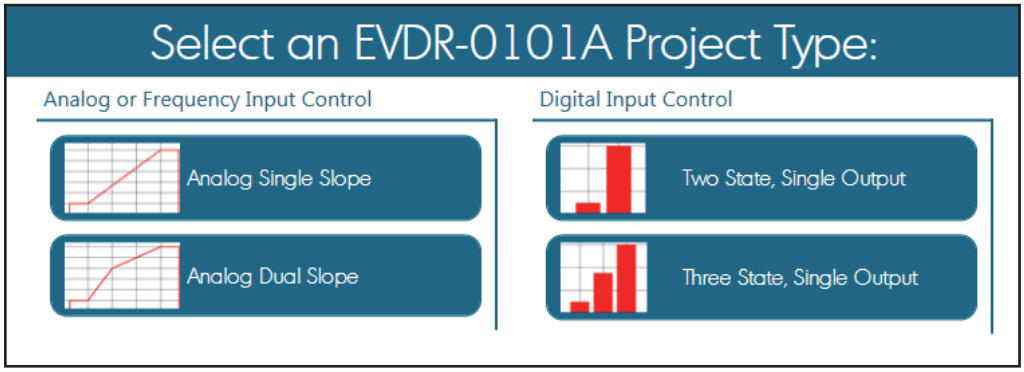
The EVDR-0101A allows an input signal to control a hydraulic valve through precise amperage control. You can use HF-Impulse to configure the input type and the output response.

Starting a New Project

On the HF-Impulse welcome screen choose **ExDR-0101A | EVDR-0101A** from the *New Project* column.

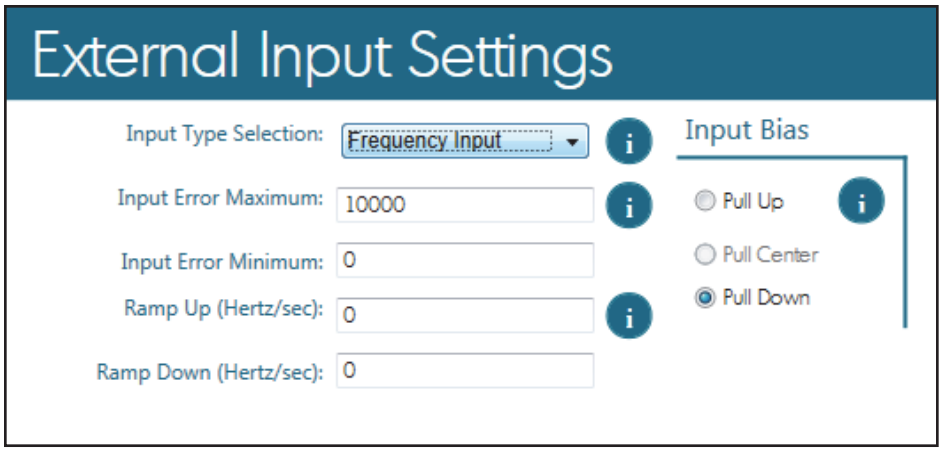


Select the predefined project type closest to your needs. This loads a project with most of the common settings. Modify your selection as needed for your application. The predefined project types below are a starting point for configuration.



External Input Settings

The *External Input Settings* screen contains controls for the external electrical input pin of the EVDR-0101A. This pin is configurable to receive different types of electrical signals. Error limits for the electrical signal are also found on this screen. A three-category selection determines the bias on the pin with *Pull Up*, *Pull to Center*, and *Pull Down* selections. Refer to the *ExDR-0101A Technical Reference* for more information about the electrical characteristics.

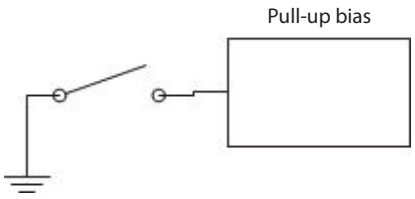


Select an input type from the choice list:

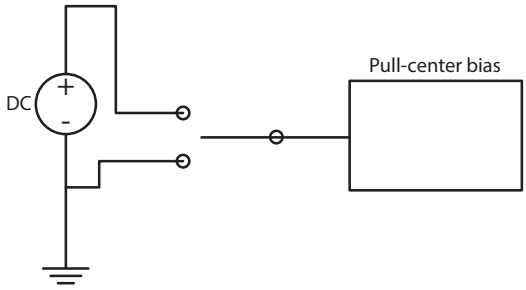
- 0 to 5 Volt
- 0 to 10 Volt
- 0 to 20 milliamp
- 0 to 6000 ohms
- ERT120 Input
- Digital Input
- PWM Input
- Frequency Input

If you selected a *Digital Input*, *PWM Input*, or *Frequency Input*, select the *Input Bias:*

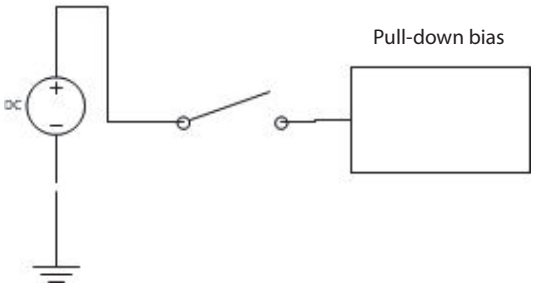
- *Pull Up*—an internal resistor biases the input pin to supply voltage: for sinking devices. When using as a digital input, wire the switch between ground and the input.



- *Pull Center*—only available with digital type. An internal resistor biases the input pin to 3.3 volts. Provides three-state selection: high/low/float. Use a three-position switch with the poles wired to ground and positive supply and the throw wired to the input.



- *Pull Down*—an internal resistor biases the input pin to ground: for sourcing devices. When using as a digital input, wire the switch between positive supply and the input.

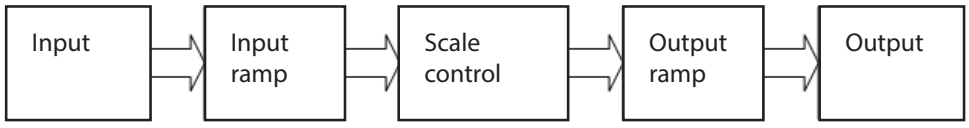


Note: *Selecting Pull Center creates a three-state digital input (high/low/float).*

- *Input Error Maximum*: signal above this value sets fault condition. When the value is at full scale, the error control turns off. In this case there is no trigger of the error when the input is greater.
- *Input Error Minimum*: signal below this value sets fault condition. When the value is zero, the error control turns off.
- *Ramp Up* (units per second): this acts as an input delay for input signals that increase in value. This ramp value makes the output current follow the profile created on the *Scale Settings* screen.
- *Ramp Down* (units per second): this acts as an input delay for input signals that decrease in value. This ramp value makes the output current follow the profile created on the *Scale Settings* screen.

Note: *Do not use ramp values that are too small. The delay then becomes so slow that the unit appears not to react.*

The input ramps are different from the output ramps because they are processed before the scaling control. The output current waveform follows the path created by the scale settings profile. Do not use the input ramp and output ramp in the same application because it could be difficult to predict the result.

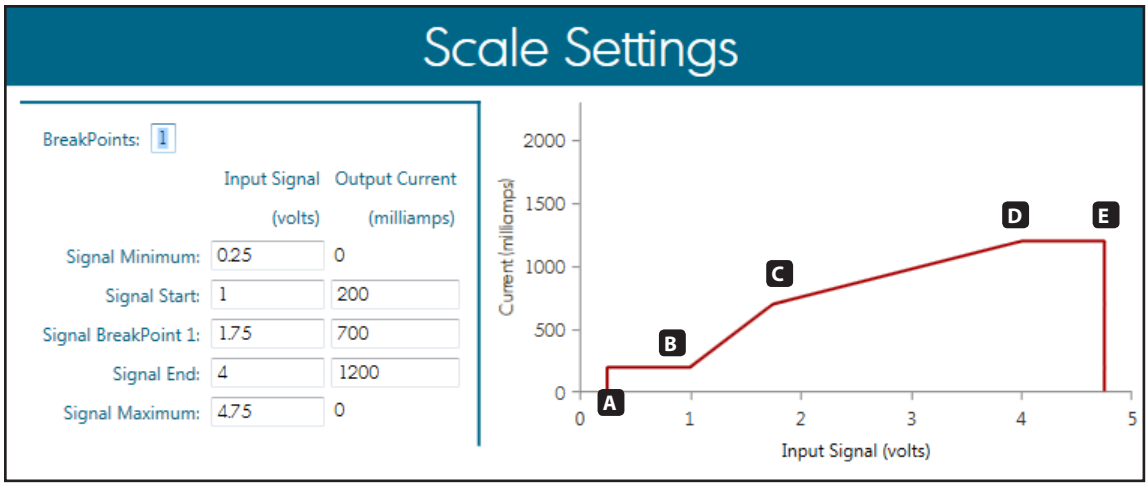


Scale Settings

The *Scale Settings* screen contains the ratio control of the input to output signal. A graph represents the ratio of input signal to output current. Two types of graphs are used. For analog inputs the graph is line-type and plots from point to point. For digital inputs a column-type graph is used with only two to three states.

Analog Input Settings

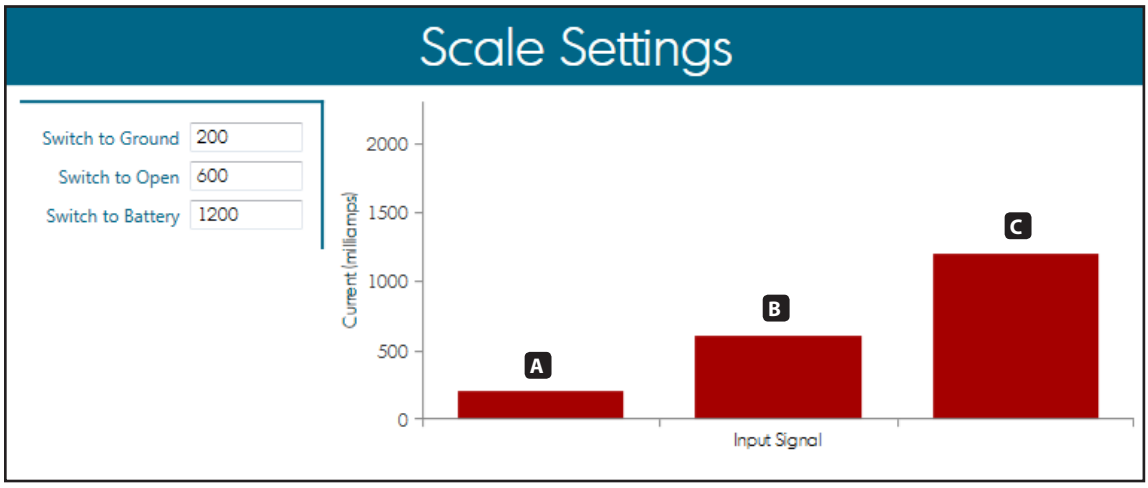
An entry table allows plotting the response of the input to the output. Up to 3 breakpoints can be added.



The values which define the input to output profile.

- A: Coil signal minimum (dead band)
- B: Coil signal start
- C: Coil signal breakpoint 1
- D: Coil signal end: (end of second slope)
- E: Coil signal maximum: (dead band)

Digital Input Settings

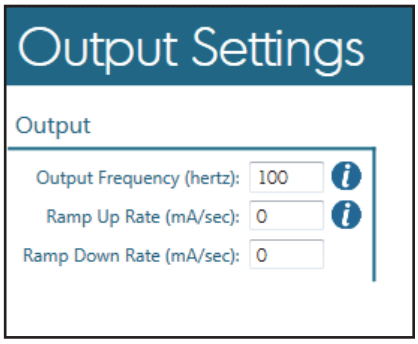


When the external input is set to digital, the following parameters are available to modify the output signal for three-state digital input:

- A: Coil switch to ground
- B: Coil switch float
- C: Coil switch to battery

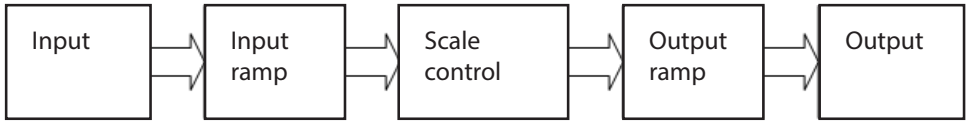
Output Settings

The *Output Settings* screen has sections for the A and B outputs. Each of these contain settings for output frequency, ramp up rate, and ramp down rate.



- *Output Frequency*—The range is 40 to 400 hertz. Refer to the specifications for the hydraulic valve to determine the best frequency.
- *Ramp Up Rate*—This can act as a delay to changes in increasing output current. The effect is for the rate of change for the increasing current to slow.
- *Ramp Down Rate*—This can act as a delay to changes in decreasing output current. The effect is for the rate of change for the decreasing current to slow.

The output ramps differ from the input ramps because they are applied after the scale settings control. Therefore the response is linear and does not follow the profile on the scale settings. The units are in milliamps per second. Do not use the input ramp and output ramp in the same application, because it could be difficult to predict the result.



Note: *Do not use ramp values that are too small. The delay becomes so slow that the* EVDR-0101A *appears not to react.*

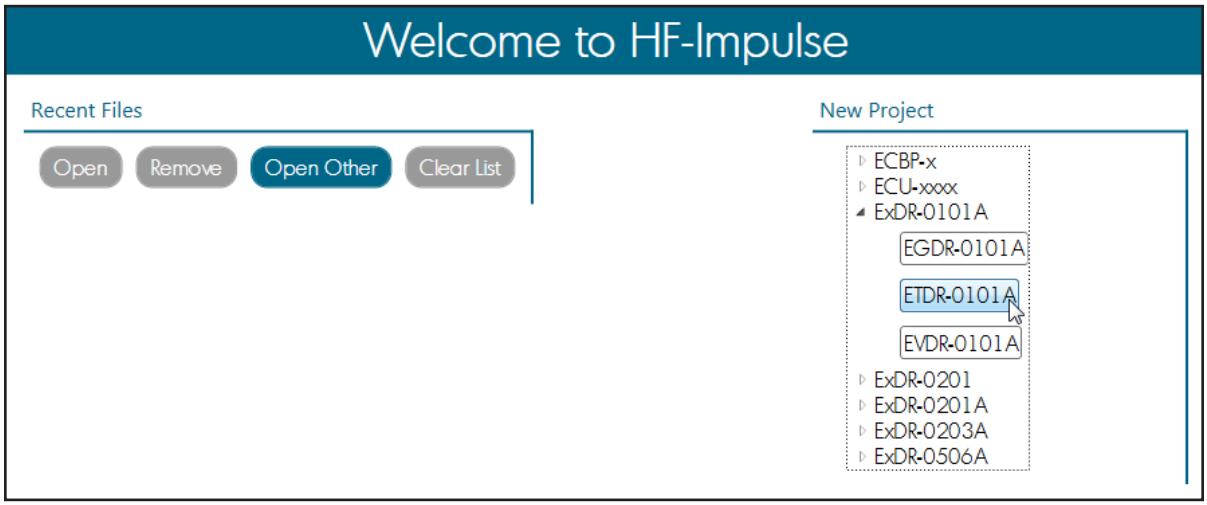
ETDR-0101A

Overview

The ETDR-0101A allows a timed profile to control a hydraulic valve, through precise amperage control. a switch input triggers the timing profile. The trigger is considered *On* when the input is either switched to a positive supply value or bias pulled high by the input circuit. You can use HF-Impulse to configure the output profile.

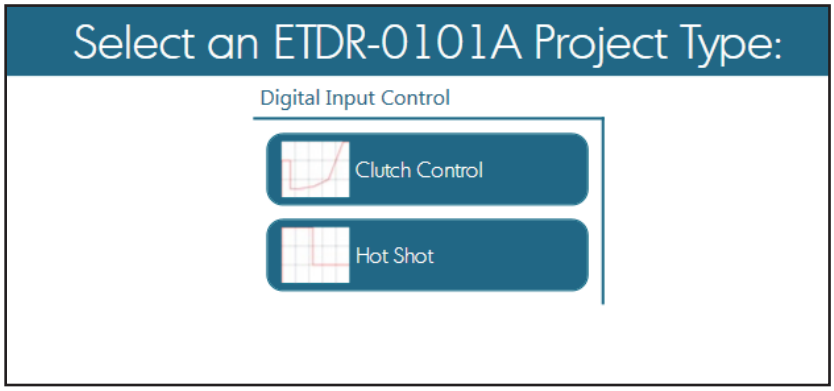
Starting a New Project

On the Welcome to HF-Impulse screen choose **`ExDR-0101A|ETDR-0101A`** from the *New Project* column.



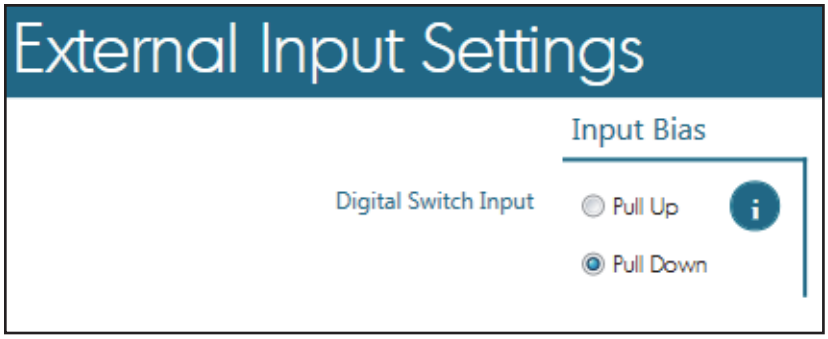
Select the predefined project type. There are two types of projects:

- *Clutch Control*—The clutch control is designed for a PTO clutch. The setup time periods are:
  - Fill—fills the empty clutch cavity with hydraulic fluid quickly
  - Hold—settling delay
  - Ramp 1
  - Ramp 2
  - Ramp 3
- *Hot Shot*—This control conserves energy. It delivers a high current shift pulse then drops to a low current hold state. The initial pulse can be increased to 3 amps for one second.



External Input Settings

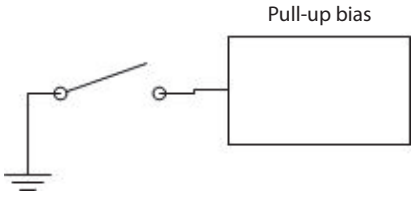
You can only use a switch with the ETDR-0101A input. Only the bias of the input is alterable.



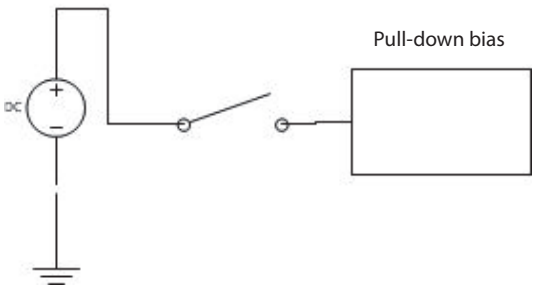
Input State

The input state determines if the timing profile starts and shuts down. The input state is *On* when the input is connected to positive supply or if the input bias is set to *Pull Up* and the switch input is open. The input state is *Off* when the input is switched to ground (negative supply) or if the input bias is set to *Pull Down* with an open switch.

- *Pull Up*—An internal resistor pulls the input pin voltage up to the supply voltage. This selection is meant for a switch to ground. With this selection the timing sequence begins when the input switch is open. To stop the timing sequence, switch the input switch to ground.

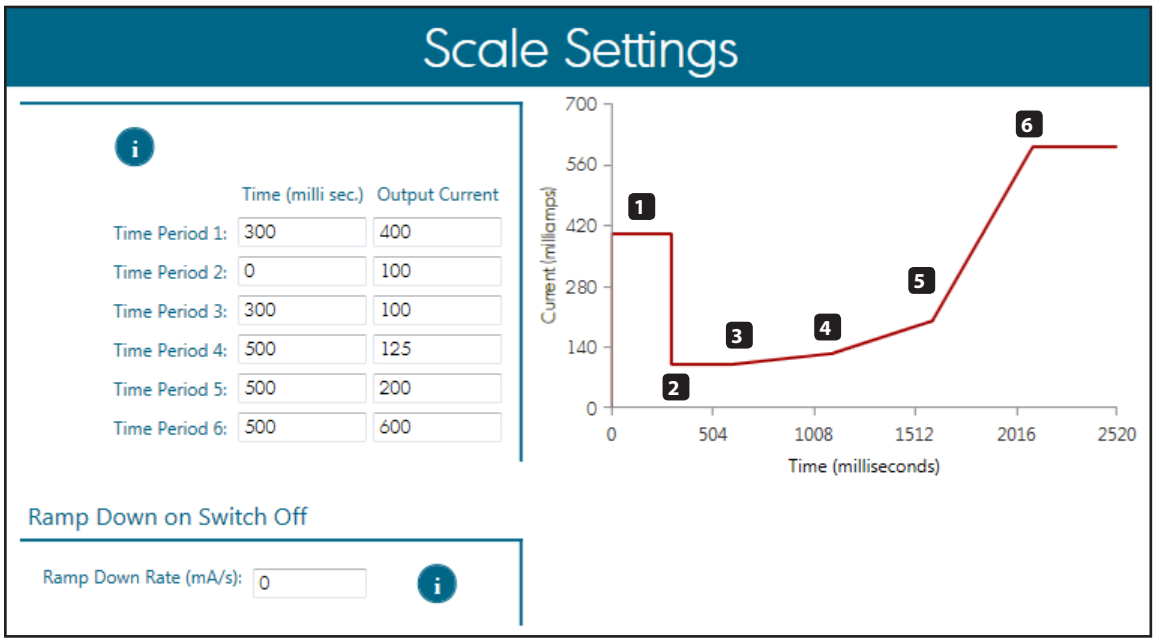


- *Pull Down*—An internal resistor pulls the input pin voltage down to the ground. This selection is meant to be used with a switch to positive supply. With this selection the timing sequence begins when the input switch is closed. To stop the timing sequence, open the input switch.



Scale Settings

The *Scale Settings* screen contains the timing diagram for the output response. It is divided into three sections: table entry, chart, and ramp down. The timing profile begins when the input is in the *On* state. When the end of the timing profile is reached, the output remains at the *Time Period 6* value until the input transitions to the *Off* state.



Entry Table

The entry table has 6 groups of timing periods. Each timing period has an associated *Time* value in miliseconds and *Output Current* in miliamps.

- *Time Period 1*
- *Time Period 2*
- *Time Period 3*
- *Time Period 4*
- *Time Period 5*
- *Time Period 6*

Timing Chart

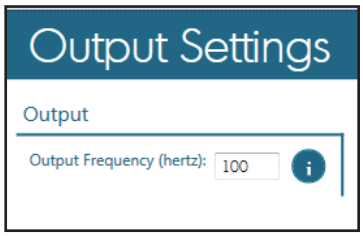
The timing chart plots out the data as the you enter it into the entry table.

Ramp Down Switch Off

The ramp down becomes active when the input transitions to the *Off* state. The timing sequence then stops and the output current ramps down at the Ramp Down Rate as specified. The value is in mA/sec. If the value is zero, the output immediately turns off.

Output Settings

The *Output Settings* screen only contains an entry for the output frequency. The range is 40 to 400 Hz. Refer to the hydraulic valve specifications to determine the best frequency.



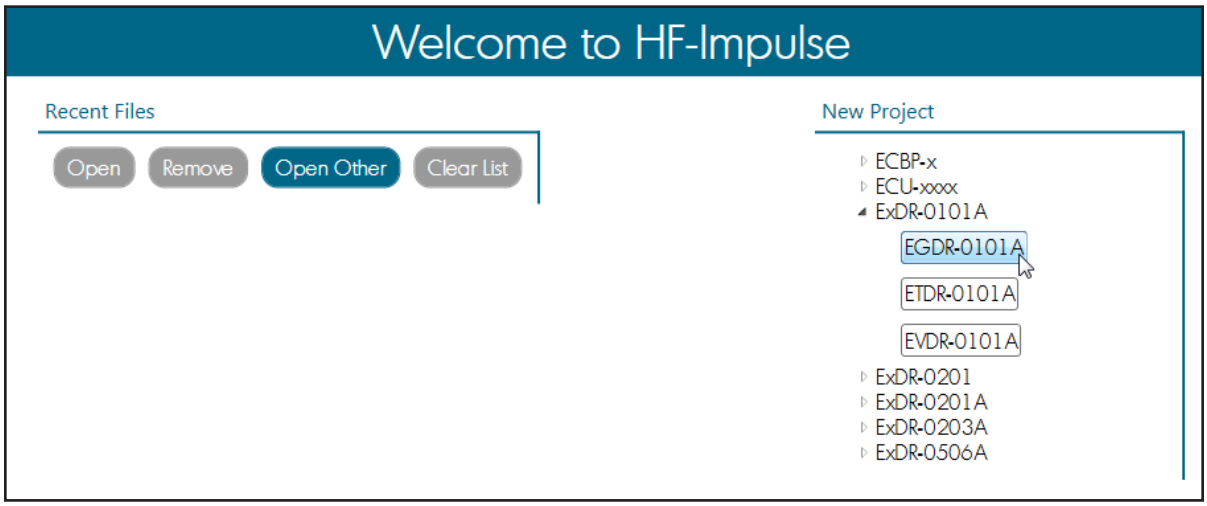
EGDR-0101A

Overview

The EGDR-0101A is a closed-loop control with feedback input and a user-defined set point. It accepts inputs from commonly available analog or digital devices (pressure sensors, pulse inputs, etc.). This user-configurable control drives a coil with voltage, current, resistance, or frequency, first providing timing output and then switching to feedback to the closed loop control PID logic. This enables accurate and proportional metering control of the hydraulic valve. The PID loop controls the output to the setpoint. It is very useful as a generator speed control when coupled with an AC frequency input.

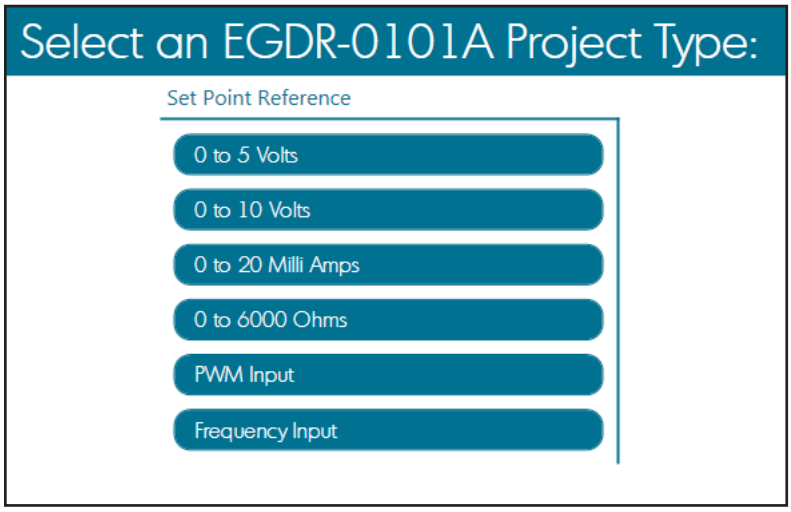
Starting a New Project

On the Welcome to HF-Impulse screen choose **`ExDR-0101A|EGDR-0101A`** from the *New Project* column.

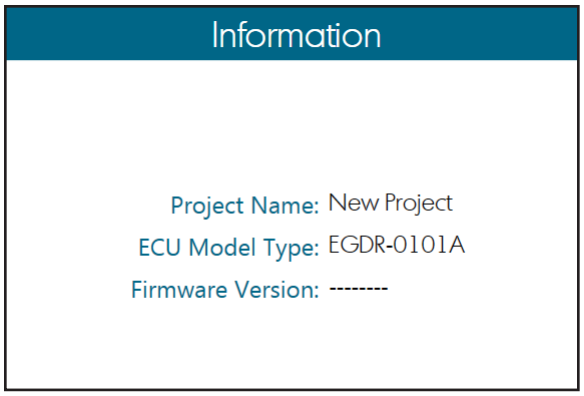


Project Type

Select a preset *Project Type* based on the available input types for the feedback signal.



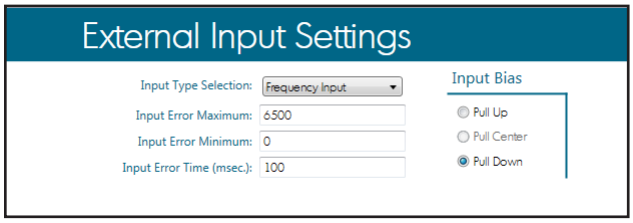
On the Information tab you can view the project details.



- *Project Name*—The project name changes when you save a file of the project. The file name will be the project name.
- *ECU Module Type*
- *Firmware Version*—The firmware version updates when you read or write to the configuration.

External Input Settings

Select **`External Input Settings`** to view and change the input type, input error limits, and input ramps. The input type loads from your previous selection, but you can change it here.



- *Input Type Selection*—Analog inputs are available for voltage or current sensing. Resistive 0–6 kΩ input is configured as a resistance. The PWM input and the frequency input can be read as pull-up or pull-down. Choose the input type from:
  - 0-5 Volt
  - 0-10 Volt
  - 0-20 Milliamp
  - Resistive 0-6000 Ω
  - PWM
  - Frequency
- *Input Error Maximum*—Signal above this value for specified *Input Error Time* sets a fault condition.
- *Input Error Minimum*—Signal below this value for specified *Input Error Time* sets a fault condition, if it occurs after startup.
- *Input Error Time (msec)*—Time frame in msec for signal to recover from violating minimum or maximum input error before setting the fault condition, if it occurs after startup.
- *Input Bias*—Applicable choices are available for PWM and Frequency input types.
  - *Pull Up*—Intended for sinking devices, this setting causes an internal resistor to pull the input pin voltage up to the supply voltage.
  - *Pull Down*—Intended for sourcing devices, this setting causes an internal resistor to pull the input pin voltage down to the ground.
  - *Pull Center* is not used.

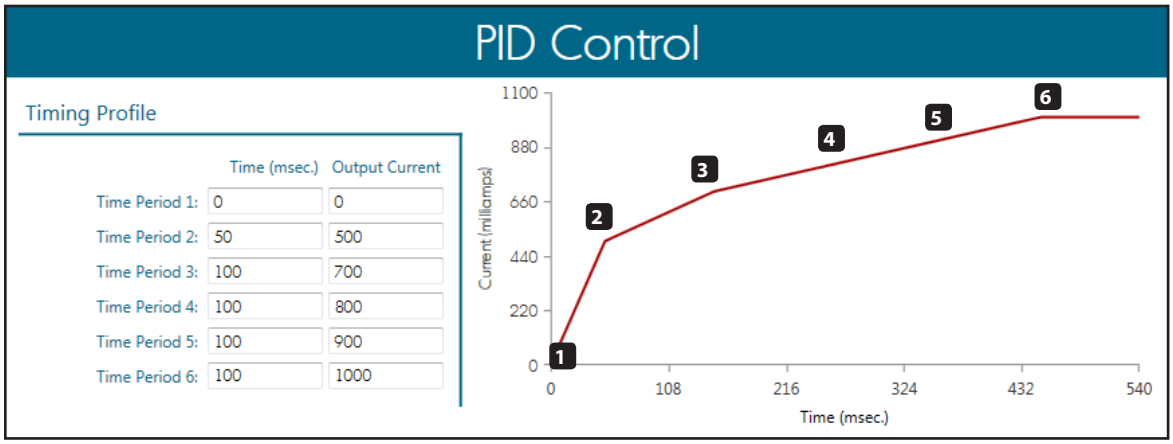
PID Control

Select **`PID Control`** from the navigation pane to view and change the *Timing Profile* and PID control settings.

Timing Profile Setting

The timing profile starts on power-up. If you set all the time periods to zero, the controller skips the timing profile and powers up with PID control. There are six time periods and the controller operates at the current level for the given time period. If there is a step in current values between two periods, the current ramps from one current level to the other in the given time period. The graph displays the timing profile output over the specified time periods.

Select any time period and adjust the values as needed. View how this timing profile behaves in the graph displayed next to the timing profile parameters.



The *Timing Profile* has 6 groups of timing periods. Each timing period has an associated *Time* value in miliseconds and *Output Current* in miliamps.

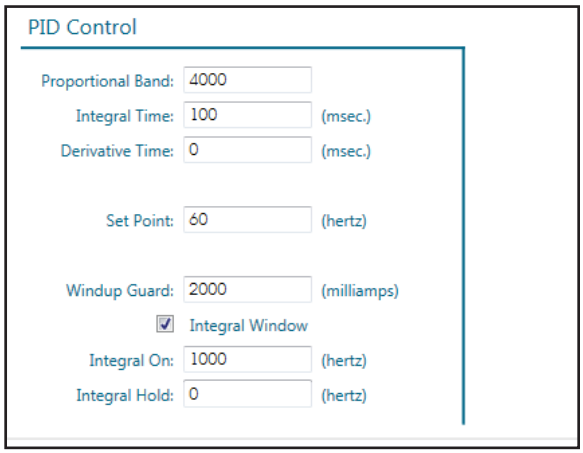
- *Time Period 1*
- *Time Period 2*
- *Time Period 3*
- *Time Period 4*
- *Time Period 5*
- *Time Period 6*

Timing Chart

The timing chart plots out the data as the you enter it into the entry table.

PID Control Settings

These settings define how the PID control is calculated, based on the set point, proportional term, integral term, derivative term, and the windup guard.



- *Proportional Band*—This term is proportional to the error signal of the output. The error signal is:

$$\boldsymbol{e = SetPointValue - CurrentValue}$$

The proportional band parameter amplifies the error signal of the output to determine the proportional term. With Proportional Band $\boldsymbol{K_p} \in$ [**0,10000**], the proportional term is:

$$\boldsymbol{P = 2000 \times \frac{e}{K_p}}, \boldsymbol{K_p} \in [\mathbf{1,10000}]$$

Where, $\boldsymbol{P} = \mathbf{0}$, $\boldsymbol{K_p} = \mathbf{0}$

- *Integral Time*—With the integral term, the output is proportional to the amount of time the error signal is present. With Integral Time $\boldsymbol{K_i} \in$ [**0,10000**] and $\boldsymbol{dt} = \mathbf{5ms}$, the integral term is:

$$\boldsymbol{I = I + (e \times \frac{dt}{K_i})}, \boldsymbol{K_i} \in [\mathbf{1,10000}]$$

Where, $\boldsymbol{I} = \mathbf{0}$, $\boldsymbol{K_i} = \mathbf{0}$

- *Derivative Time*—With the derivative term, the output is proportional to the rate of change of the error signal. To calculate this term, save the previous error signal after each calculation so that you can use it in the next calculation. With Derivative Time $\boldsymbol{K_d} \in$ [**0,10000**] , the derivative term is:

$$\boldsymbol{D = (D + de) - (\frac{D}{K_d})}, \boldsymbol{K_d} \in [\mathbf{1,10000}]$$

Where, $\boldsymbol{D} = \mathbf{0}$, $\boldsymbol{K_d} = \mathbf{0}$

- *Windup Guard*—This setting is typically for a PID controller when there is a large enough error that the integral term itself accumulates significant error during its rise or fall in value during calculation. In the microcontroller, this causes overshoot that continues to increase because an integral value goes past the maximum current. Stop calculation of the integral term once you hit the maximum current to prevent this overshooting. The system also uses this windup guard value as a maximum value for output to prevent situations where error could occur from not limiting the output.

$$-\boldsymbol{Windup} \le \boldsymbol{P}, \boldsymbol{D} \le \boldsymbol{Windup}$$
$$\boldsymbol{0} \le \boldsymbol{I} \le \boldsymbol{Windup}$$

- *Output*—After bounding the terms with windup control, now sum up the terms and bound the output by the Windup Guard value.

$$\boldsymbol{0} \le \boldsymbol{(Output = P + I + D)} \le \boldsymbol{Windup}$$

- *Integral Window*—This setting allows control over when the integral value is being used in calculation. The conditions follow:

$$\boldsymbol{I} = \mathbf{0}, |\boldsymbol{e}| > \boldsymbol{IntegralOn}$$
$$\boldsymbol{I} = \boldsymbol{I}, \boldsymbol{IntegralHold} < |\boldsymbol{e}| < \boldsymbol{IntegralOn}$$
$$\boldsymbol{I} = \boldsymbol{Constant}, |\boldsymbol{e}| < \boldsymbol{IntegralHold}$$

When $\boldsymbol{I} = \boldsymbol{Constant}$, the calculation of $\boldsymbol{I}$ stops and stays set at the value last used that satisfies the conditions of $|\boldsymbol{e}| < \boldsymbol{IntegralHold}$.

Simple PID Tuning Procedure

Use the following procedure for a quick response from your PID control system. More tuning after this is suggested, as well as reading up on PID control and PID tuning. If you feel uncomfortable with any of this terminology, please consult an expert, textbook, or reliable online resources.

1. Begin with proportional band control. Set *Integral Time* and *Derivative Time* to zero. Set the rest of the parameters:

   Proportional Band: The larger the proportional band value, the slower the system will respond to error. Setting the proportional band too small can cause overshoot, and too much overshoot can cause oscillations in the output. So a smaller proportional band will result in faster rise time, but could potentially be hazardous. Note that proportional band control has steady state error, so output is not exactly at the desired set point. Start with a fair value for the proportional band, possibly 1000-5000.

   Set Point: Choose your set point. This is the desired output value of your system.

   Windup Guard: The *Windup Guard* should be no larger than 3000 mA. Try to use 2000 mA, because this will keep the controller from outputting current higher than 2000 mA. Another good windup guard value is the maximum current allowed for the coil that is in use, as long as this value is below 3000 mA. 2000 mA is a good value to start with.

2. Test these settings. Use the monitor window to see roughly how the output is responding to the current output. The desired output should have just a little overshoot and then come to the steady state output. If there is no overshoot, use half the current proportional band value until you have very little overshoot. If the output is oscillating, overshoot is too high, so double the proportional band value until you have reached very little overshoot. Once you have found an output with little overshoot, you can stop testing and make note of the value.

3. Set proportional integral control. Use all the same values as with the proportional band control (step 1), except now use an *Integral Time* value, such as 100 to 1000 ms. If there is no overshoot and it takes to too long to reach steady state, cut the *Integral Time* value in half until there is some overshoot and no oscillation in the output. If the output is oscillating, you should double *Integral Time* until these oscillations stop. Once you have very little or no overshoot, stop changing the values.

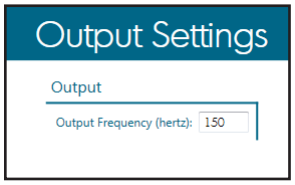
4. The controller is now tuned. Don't use *Derivative Time*, because this usually causes undesired behavior unless you are an expert and know the system you are working on extremely well. You may want to tweak the values of *Proportional Band* and *Integral Time* now to achieve a faster rise time, limit oscillations, or a more aggressive system. After playing around with these values, you should be able to find what works with your system and how each of the values affects the response of your system.

Output Settings

Select **`Output Settings`** to view and change the output frequency.

Adjust the output frequency.

- *Output Frequency*—The range is 40 to 400 Hz. Refer to the specifications for the hydraulic valve to determine the best frequency.



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HydraForce Inc.
500 Barclay Blvd.
Lincolnshire, IL 60069
Phone: +1 847 793 2300
Fax: +1 847 793 0086
Member: National Fluid Power Association
ISO 9001

HydraForce Hydraulics Ltd.
Advanced Manufacturing Hub
250 Aston Hall Road
Birmingham B67 FE England
Phone: +44 121 333 1800
Fax: +44 121 333 1810
Member: British Fluid Power Association and
Verband Deutscher Maschinen - und Anlagenbau e.V. (VDMA)
ISO 9001 & ISO 14001

HydraForce Hydraulic
Systems (Changzhou) Co. Ltd.
388 W. Huanghe Road, Building 15A
GDH Changzhau Airport Industrial Park Xinbel District
Changzhou, China 213022
Phone: +86 519 6988 1200
Fax: +86 519 6988 1205
ISO 9001

HydraForce Hydraulic Ltda.
Av. Laurita Ortega Mari,
499 Taboao da Serra
São Paulo, 06766-360
central@hydraulic.com.br
ISO 9001

GLOBAL SALES OFFICES

HydraForce Hydraulics India
Vatika Business Centre
Suite No. 22, Level 5, C Wing
Techpark One, Airport Road
Yerwada, Pune 411006
Maharashtra, India
Tel: +91 020 40111304
Fax: +91 020 40111105
Email: nileshr@hydraforce.com

HydraForce Hydraulics Ltd.
Prager Ring 4-12
D-66482 Zweibrücken, Germany
Tel: +49 (0) 6332 79 2350
Fax: +49 (0) 6332 79 2359
Member: Verband Deutscher Maschinen -
und Anlagenbau e.V. (VDMA)
Email: sales-germany@hydraforce.com

HydraForce Korea LLC
A-506 Bupyeong Woorim Lions Valley, 283
Bupyeong-daero, Bupyeong-gu,
Incheon, Korea 403-911
Tel: +82 32 623 5818
Fax: +82 32 623 5819
Email: jong-seongl@hydraforce.com

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