DRF

Closed-loop and Open-loop Proportional Valve Controller

High Country Tek, Inc. reserves the right to improve this product at any time and without notice. This manual may contain mistakes and printing errors. The content is regularly checked and updated. Please check our website or contact our customer support for latest version. HCT accepts NO liability for technical mistakes or printing errors or their consequence.

Contents

Welcome

Welcome to **High Country Tek** Inc. HCT is North America's foremost independent designer and producer of modular, ruggedized digital and analog electronic controllers for the fluid power industry.

From our factory in California, we manufacture 'specialty' controllers for specific functions and the user programmable 'DVC family' to enable large area networked system solutions.

The modules are used in mobile, industrial and marine applications. They are also applied successfully in other industry segments.

HCT products are encapsulated in solid flame resistant material for maximum durability, electrical integrity and complete environmental security.

HCT is a market leader in many application arenas, including hydraulic generator, *e-Fan* and hydraulic fan system controls. These controllers facilitate significant fuel, emission and operational savings.

HCT's market neutrality offers integration with any hydraulic OEM valves, pumps, sub-systems or systems.

For more information, please visit us at: **www.hctcontrols.com**.

Cautions

Changing setup values or operating modes while a machine is running may cause unintended machine movement. It could lead to possible **injury** or **death**. Any moving parts should be disabled prior to changing setup values or operating modes. In every case, exercise caution and work should be completed only by qualified personnel.

Product Application Guidelines

ALWAYS do the following

- FULLY read this manual and accompanying data sheets BEFORE starting.
- Isolate this unit from all other equipment BEFORE any form of welding.
- Isolate the controller from ANY form of battery charging or battery boosting.
- Be aware of the electrical & mechanical connections, and the expected reactions of the equipment.
- Operate the units within the temperature range.
- Use the correct tools to do the job (i.e. P.C., software) etc.
- Separate High Voltage AC cables from Low Voltage DC signal and supply cables.
- Make sure power supply is CORRECT, ELECTRICALLY CLEAN, STABLE, and rated for the full load.
- Make sure the controller output voltage & current is compatible with the equipment.
- All unused wires / terminals should be terminated safely.
- Ensure ALL connectors have no unintended SHORT or OPEN circuits.
- Ensure ALL connectors are wired correctly, secure, locked in place and fully connected.
- Disconnect or connect wires to or from this unit only when the power supply is disconnected.
- Use adequate screening in areas of intense Radio Frequency fields.
- Ensure ALL work areas are clear of personnel before operating the controller.
- Follow and abide by local and country health & safety standards.

DRF Controllers

The DRF controller drives proportional solenoid valves in a closed loop system to follow a command signal. When the feedback is greater than the command input, the coil receives full current; when the feedback is less than the command input, the coil receives 0 current.

Once configured, the settings are permanently stored in the controller memory.

DRF Features

- Easily configured using HCT Graphical User Interface (GUI) or HCT Hand Held Interface (HHI)
- LED indication of power, output current and fault status
- DIN-rail mount housing with removable terminal blocks
- Multiple modes for open loop and closed-loop applications, programmable enable input
- All input and output limits are independently adjustable
- Adjustable output with short circuit protection, adjustable ramp up and ramp down rates
- Fully adjustable PID control loop

Operating Specifications

Supply Voltage	9 to 32VDC	
Supply Current	Valve current + 50mA (Quiescent Max)	
Output Current	**DRF-x06:** 600mA MAX. per channel **DRF-x12:** 1.2A MAX. per channel **DRF-x25:** 2.5A MAX. per channel	
Coil Resistance	2Ω MIN.	
Reference Voltages	+10V, -10V @ 20mA (DRF-Vxx versions only)	
Dither Frequency	30, 50, 75, 100, 125, 150, 175, 200, 225, 250, 275, 300, 1000 Hz	
Analog Input Range	**DRF-Vxx:** -10V to 10V	**DRF-Axx:** 0 to 20mA
Analog Input Impedance	**DRF-Vxx:** 38kΩ	**DRF-Axx:** 250Ω
Analog Input Resolution	10 bits	
Operating Temperature Range	-20º to 70º C; -40º to 85º C (storage)	
Enclosure	Polyamide	
Dimensions	Inch: 0.69 W x 4.50 H x 4.30 D; mm: 17.5 W x 114.5 H x 109.4 D	

Physical Description

There are PWR LED and OUTx LEDs. For DRF-4, there are 5 LEDs. The PWR LED is green when the applied voltage is within the operating range.

OUTx LEDs indicate current output for a given channel. The LEDs are yellow and the brightness will vary with the output current.

In the case of a fault the LEDs will flash red with a flash code. See Fault Status for details.

The DRF communicates with the Graphical User Interface through the USB port.

When connected to a PC, the DR controller is recognized as a USB device with or without power supply. However, it must be powered when configuring the settings.

User Interface

The DRF has a number of internal settings.

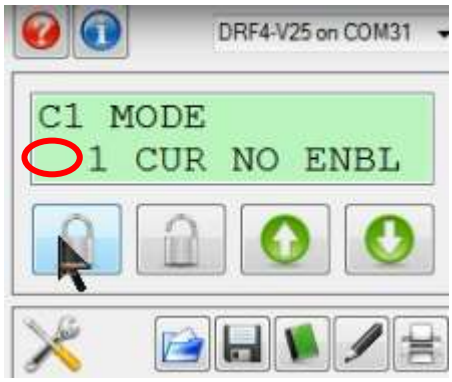
Users can open the Graphical User Interface to view, make changes and save the settings in a data file which can be uploaded to any DRF controller.

The Hand Held Interface can also be used to view and make changes, but this device does not have the capability to save the settings in a data file. The programmer, cable and adapter are self-contained which makes the HHI a viable alternative for field work.

Configuration

The GUI has 4 buttons (ran from a PC): Lock, Unlock, Up, and Down. There are short-cut keys: '/'(lock), '*'(unlock), '+'(up), and '-'(down).

The HCT Hand Held Interface has the same 4 buttons and 2-line LCD.



Use the up and down arrows to navigate through the parameter list. The display will show the next parameter in the list when pressed. The parameter name is on the first line and the value is on the second line. The list is in circular, stepping down from the last parameter to the first and vice-versa.

There are three types of parameters: **fixed; monitor; and variable**. **Fixed** parameters show the module's firmware version, etc. **Monitor** parameters display output current and system voltage. Use **variable** parameters to configure the controller, such as maximum output current, operating mode, etc. Some parameters combine variable and monitor in one line. Use it to set a variable according to the current monitor value.

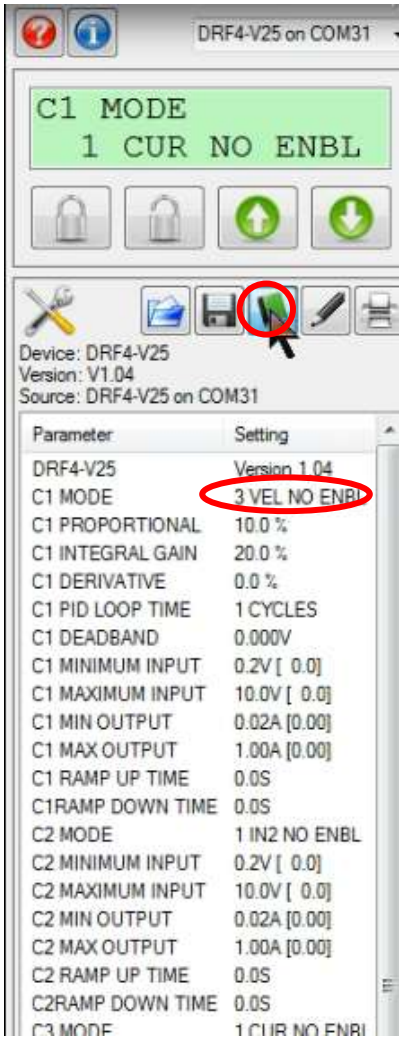
Press the unlock button to enter the edit mode. An asterisk (*) will appear at the beginning of the second line. Use the up and down buttons to change the value. For parameters containing both variable and monitor, the monitor data is in square brackets.

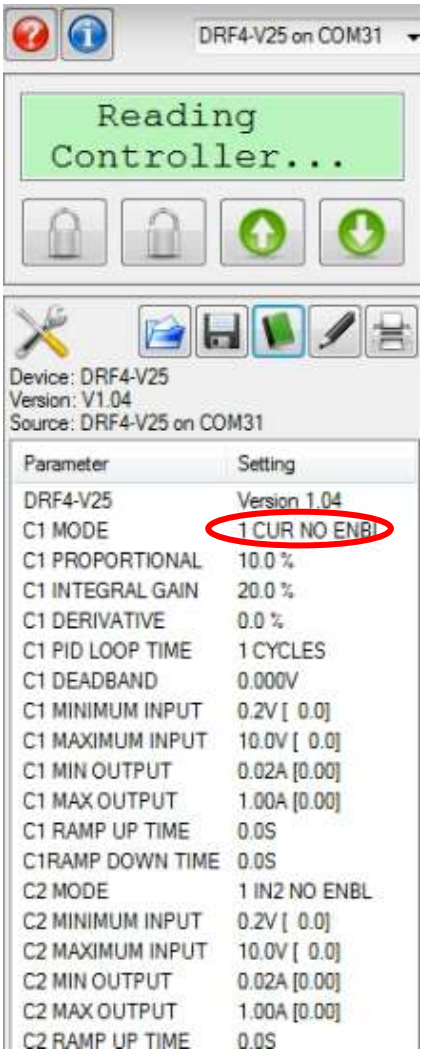
Press the lock button to save the parameters and end edit mode.

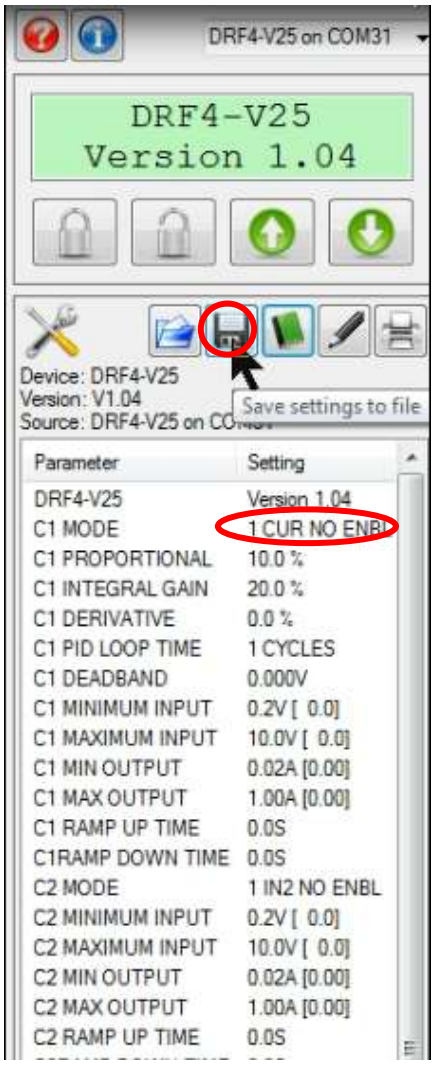
When the lock button is pressed, the changes take effect immediately. Change values only when the machine is **NOT** running.

“Read settings from controller” displays a static table of values from non-volatile memory. The changes made to the settings by selecting “lock” are not updated in the table unless “read settings from controller” is selected again.

To save the settings into a file for future use, click “read settings from controller” before clicking “save settings to file”.

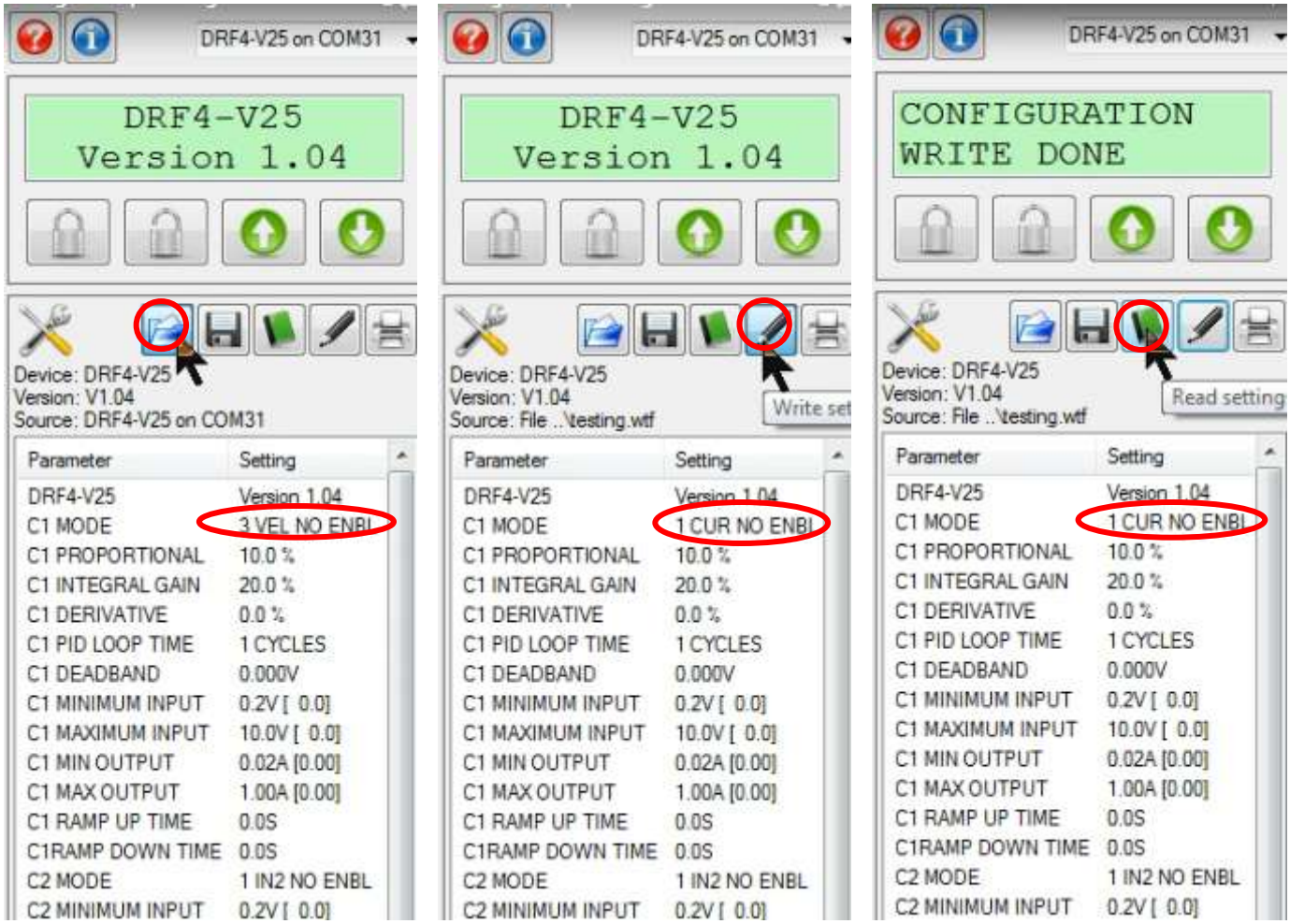






When uploading settings from a data file, the static table shows the settings from the data file, but they are not in the controller yet.

Click “write settings to controller” before clicking “read settings from controller”. After this step, the static table will display the DRF settings from the data file.



Parameter List

The following table outlines the DRF parameters as well as the limits and units of measure for each parameter.

Parameter	Limits	Units
DRFx-xxx		Version #
C1 Mode	See Mode Description	Mode #
C1 Proportional gain	0.0 to 100	%
C1 Integral gain	0.0 to 100	%
C1 Derivative gain	0.0 to 100	%
C1 PID loop time	1 to 30	Cycles
C1 Deadband	0.0 to 2.0	V (mA)
Previous 5 parameters repeated for channel 3[2]		
C1 Min input	-10 to +10.0; 4 to 20.0	V (mA)
C1 Max input	-10 to +10.0; 4 to 20.0	V (mA)
C1 Min output	0 to 600[1]	mA
C1 Max output	0 to 600[1]	mA
C1 Ramp up	0.0 to 120.0	Seconds
C1 Ramp down	0.0 to 120.0	Seconds
Previous 6 parameters repeated for all channels[2]		
Dither frequency	30 to 1000	Hz.
C1 Command input		V (mA)
C1 Output current		mA
Previous 2 parameters repeated for all channels[2]		
Supply voltage		Volts
Fault status		Fault

[1]0 to 1.2 A for **–12A** version, 0 to 2.5 A for **–25A** version

[2]Parameters starting with C1 are repeated for each channel and are displayed as C2 to C4

DRFx-xxx - The title parameter is fixed. It displays the model number and the firmware version.

Cx MODE - Four modes of operation.

Mode	Enable	Channels	comments
1 CUR NO ENBL		1,3	Open loop, use its own input
2 CUR USE ENBL	X	1,3	Open loop, use its own input
3 VEL NO ENBL		1,3	Closed-loop, C1 & C3 are the command inputs
4 VEL USE ENBL	X	1,3	Closed-loop, C1 and C3 are the command inputs
1 IN2 NO ENBL		2,4	Open loop, single-coil valve, use its own input; Closed-loop, feedback
2 IN2 USE ENBL	X	2,4	Open loop, single-coil valve, use its own input; Closed-loop, feedback
3 IN1 NO ENBL		2,4	Open loop, dual-coil valve, use inputs from C1 & C3
4 IN1 USE ENBL	X	2,4	Open loop, dual-coil valve, use inputs from C1 & C3

Open Loop Modes -

Modes 1 and 2 are open loop modes for channel 1 & 3.

For modes 1 & 2, channels 2 & 4 use its own inputs.

For modes 3 & 4, channels 2 & 4 use the inputs from channel 1 & 3 for dual-coil applications.

E.g., to drive a two-coil directional proportional valve, set C1 mode 1 and C2 mode 3. Do not overlap the input ranges.

Closed Loop Modes - Modes 3 and 4 use the velocity PID algorithm. Channel 1 or 3 input is the command input; channel 2 or 4 input is the feedback. Only channel 1 or 3 has output current.

When the feedback is bigger than the command, the output reduces to 0A; when the feedback is smaller than the command, the output current increases to maximum current until the feedback matches the command.

PROPORTIONAL GAIN – Sets the P term in a PID control loop. It is a multiplication of the error added to the output. The higher the setting, the faster the response will be. Also, higher settings result in shorter ramp time, but it can cause oscillation. It is variable type.

INTEGRAL GAIN – Sets the I term in a PID control loop. It is the sum of the error over time. It overcomes an offset in the output or to correct for small deviations over time. A higher gain will result in more integral control but can cause oscillation. It is variable type.

DERIVATIVE GAIN – Sets the D term in a PID control loop. It is the rate of change of error. The higher the derivative gain, the quicker the system will respond to sudden changes. It is variable type.

PID LOOP TIME - Sets the PID loop closure time in number of dither cycles. The lower the number, the more quickly the system responds to error. It is a variable type.

DEADBAND - Sets the error tolerance of the PID loop. The control will only respond to error greater than the Deadband parameter. For a velocity loop the output will remain at a fixed level. For a position loop both outputs will remain off. This parameter is a variable type.

Cx MIN INPUT - Sets the minimum command input. The input can be inverted. The value in the brackets is the present command input.

Cx MAX INPUT - Sets the maximum command input. The input can be inverted. The value in the brackets is the present command input.

Cx MIN OUTPUT - Sets the minimum output current (milliamps for -06A, amps for -12A,-25A). The value in the brackets is the present output current.

Cx MAX OUTPUT - Sets the maximum output current (milliamps for -06A, amps for -12A,-25A). It cannot be inverted. The value in the brackets is the present output current.

Cx RAMP UP/DOWN - Sets the time for Output current to ramp **UP** or **Down** through the full input range. These parameters are variable.

DITHER FREQ. – Options: 30, 50, 75, 100, 125, 150, 175, 200, 225, 250, 275, 300, and 1000 Hz. Set the PWM or dither frequency according to the valve specifications. This parameter is variable.

Cx COMMAND INPUT - Displays the present input. This parameter is a monitor type.

Cx OUTPUT CURRENT - Displays the present output current. This parameter is a monitor type.

SUPPLY VOLTAGE - Displays the module's power supply voltage. It is helpful for troubleshooting. This parameter is a monitor type.

FAULT STATUS - The STATUS LED will flash red 2 times for Coil Open and 3 times for Coil Short in both open-loop modes and closed-loop modes.

In open loop mode, the LED will continue to flash until clearing faults by moving the command signal out of active range or cycling the power.

In closed-loop mode, only power cycle can clear the faults.

PID Algorithm

The controller uses a digital, velocity PID algorithm as shown:

O(t) = O(t-1) + P*(e(t)-e(t-1)) + I*T*e(t) + D/T*(e(t) + e(t-2) – 2*e(t-1))

Where:
O = output
P = proportional gain term
I = integral gain term
D = derivative gain term
e(t) = error at time t
T = PID loop time

Setup Procedure

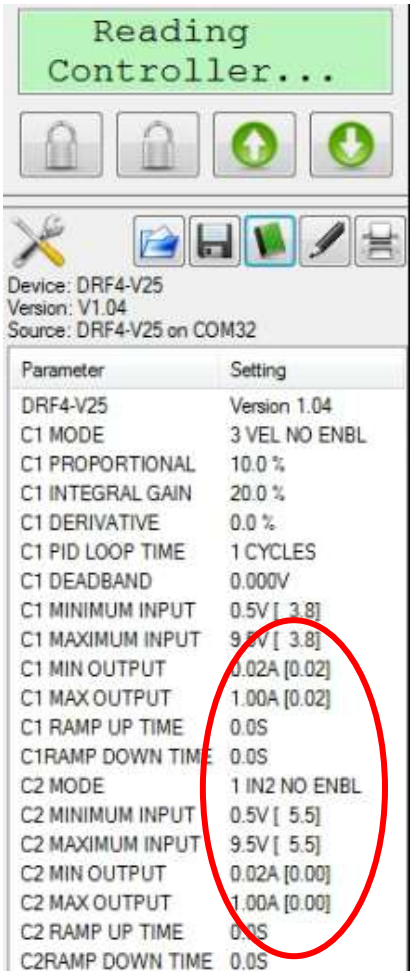
1. Select the operating frequency.
2. Set the Minimum and Maximum Outputs according to the valve specs.
3. Set the Dither Frequency according to the valve specs. Higher dither frequencies can improve frequency response.
4. Start with Proportional only to achieve a stable system.
5. Add Integral.
6. Add Derivative to improve system response and/or stability.

DRF Closed-loop control:

Place channel 1 in Mode 3 or 4, channel 2 in mode 1 or 2.

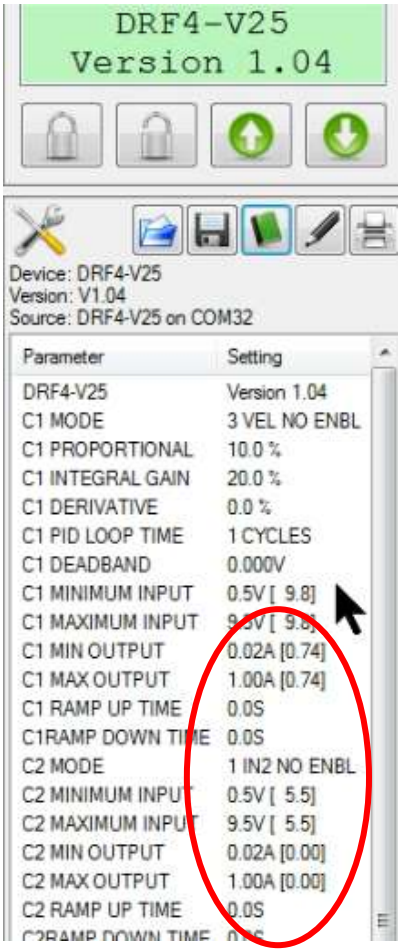
When the feedback (channel 2 input 5.5V) is greater than the command (channel 1 input 3.8V), DRF outputs 0A to Channel 1.

Channel 2 does not have an output.



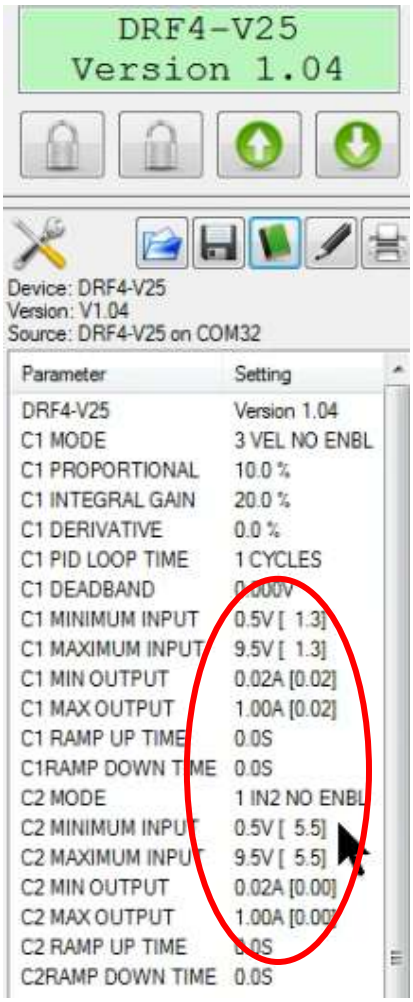
When the feedback (channel 2 input 5.5V) is less than the command (channel 1 input 9.8V), DRF outputs 0.74A to Channel 1.

Channel 2 does not have an output.



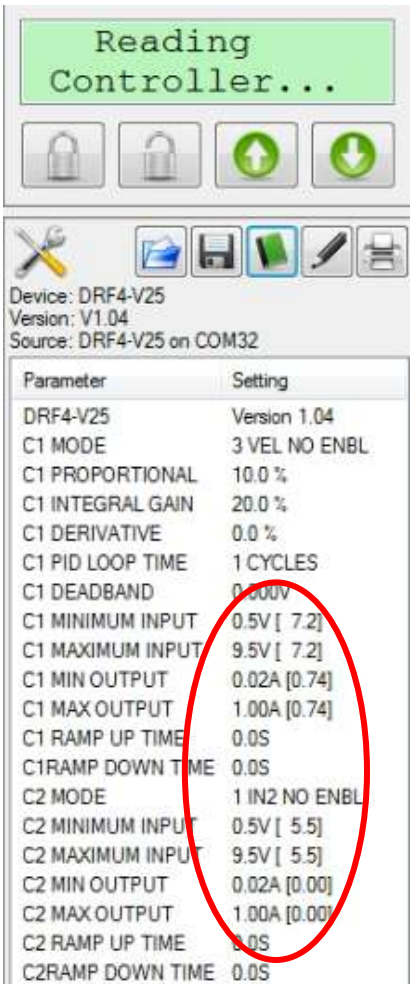
When the feedback (channel 2 input 5.5V) is greater than the command (channel 1 input 1.3V), DRF outputs 0A to Channel 1.

Channel 2 does not have an output.



When the feedback (channel 2 input 5.5V) is less than the command (channel 1 input 7.2V), DRF outputs 0.74A to Channel 1.

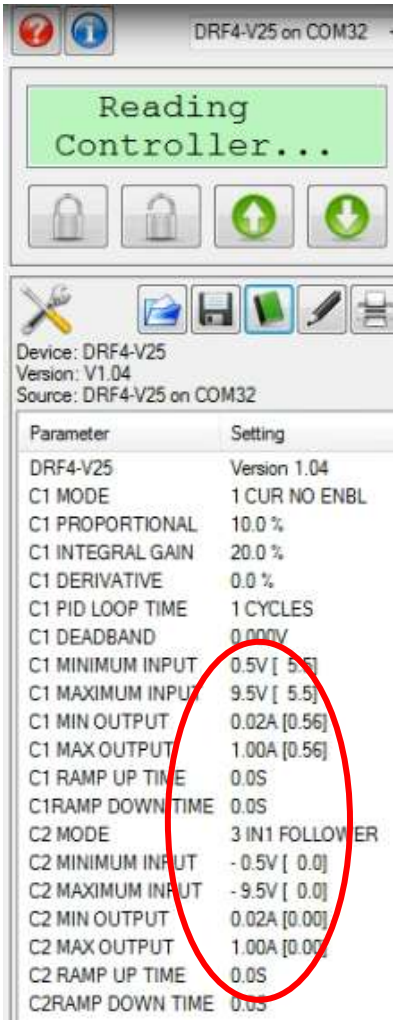
Channel 2 does not have an output.



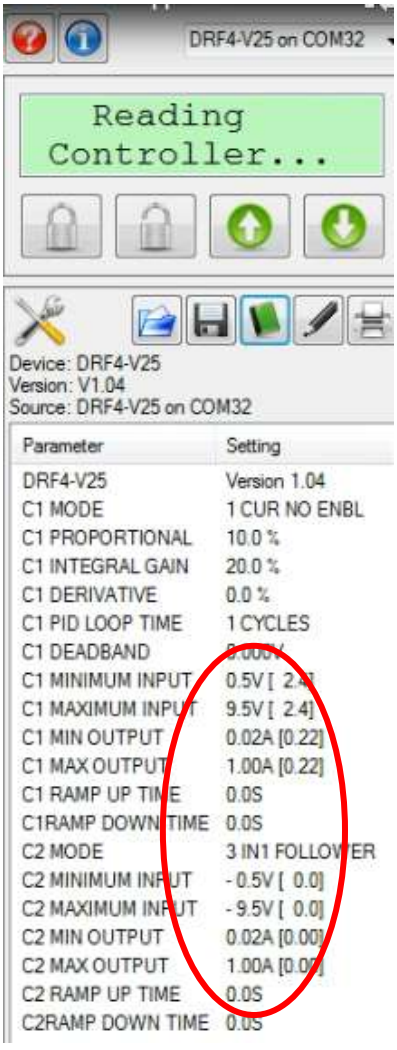
Open-loop dual coil Mode:

0.5V to 9.5V drives the channel 1 output, -0.5 to -9.5V drives the channel 2 output.

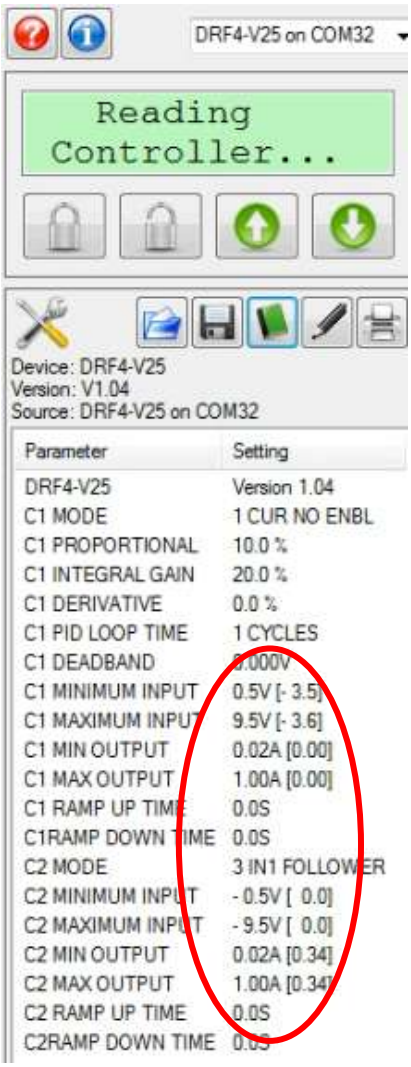
Channel 1 has an output of 0.56A because the input is 5.5V.



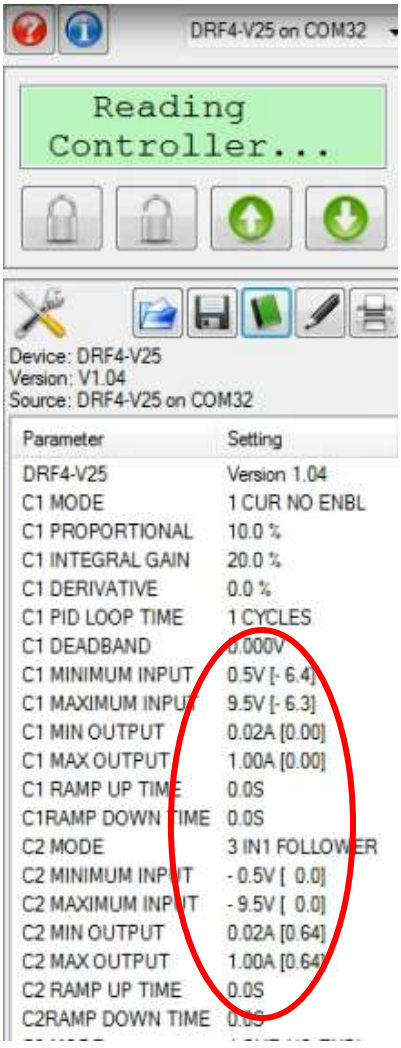
Channel 1 has an output of 0.22A because the input is 2.4V.



Channel 2 has an output of 0.34A because the input is -3.5V.



Channel 2 has an output of 0.64A because the input is -6.4V.



Wiring

Terminal functions are listed in the table below.

Terminal	Function
J1-1	+V Supply
J1-2	Supply Common
J1-3	Enable Input
J2-1	Output Ch. 1
J2-2	Common
J2-3	Output Ch. 2
J3-1	Output Ch. 3
J3-2	Common
J3-3	Output Ch. 4
J4-1	-10V Reference
J4-2	Common
J4-3	+10V Reference
J5-1	Command Input Ch. 1
J5-2	Common
J5-3	Command Input Ch. 2
J6-1	Command Input Ch. 3
J6-2	Common
J6-3	Command Input Ch. 4

Order Information

The following is a break-down of the DRF part numbering system:

DRF4-V12

- 06 = 600mA max
- 12 = 1.2A max
- 25 = 2.5A max

- V = -10 to +10V input
- A = 0 to 20mA

- # = Number of channels (2 or 4)

Required Communication Cables:

For the Hand Held Interface Device: P/N: HH2USB and PN: 108-00134

For the PC software SAM: PN: 108-00134

P/N: HHI2USB

P/N: 108-00134

Application Examples

Open Loop Double Solenoid Control (DRF2-Vxx)

The DRF can drive a dual-coil valve with a joystick or potentiometer of 10kΩ.

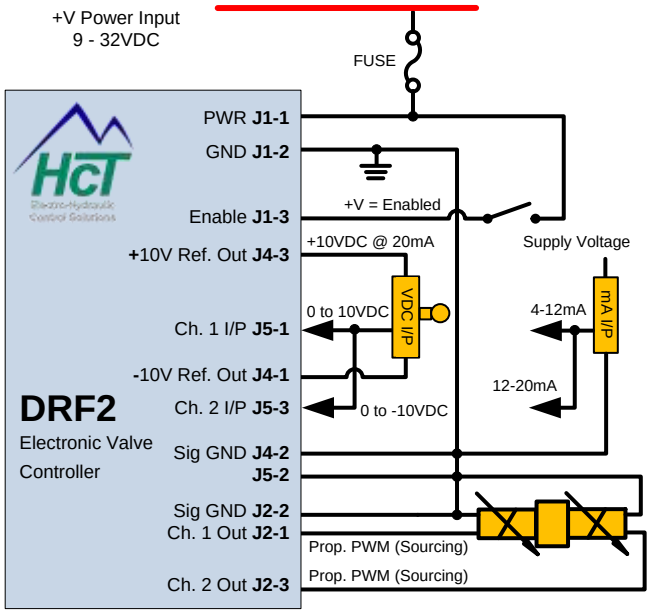
If enable switch is not used, set channel 1 to be Mode 1, channel 2 to be Mode 3.

If enable switch is used, set channel 1 to be Mode 2, channel 2 to be Mode 4.

The minimum and maximum input parameters for the two channels should not be overlap.

Set the dither and output settings according to the valve specifications.

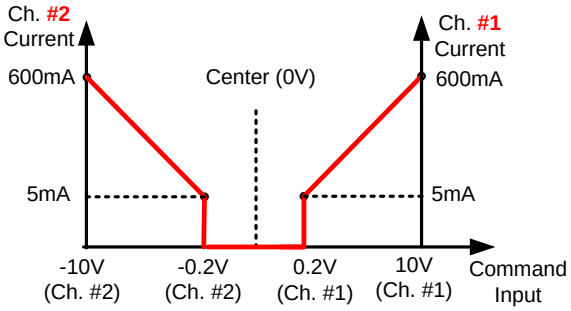
Schematic



Example Settings

Parameter	Value
C1 Mode	2 CUR USE ENBL
C1 Min input	0.2 V
C1 Max input	10.0 V
C1 Min output	5 mA
C1 Max output	600 mA
C1 Ramp up	1 S
C1 Ramp down	1 S
C2 Mode	4 IN1 USE ENBL
C2 Min input	-0.2 V
C2 Max input	-10.0 V
C2 Min output	5 mA
C2 Max output	600 mA
C2 Ramp up	1 S
C2 Ramp down	1 S
Dither frequency	150 Hz.

Input / Output Diagram

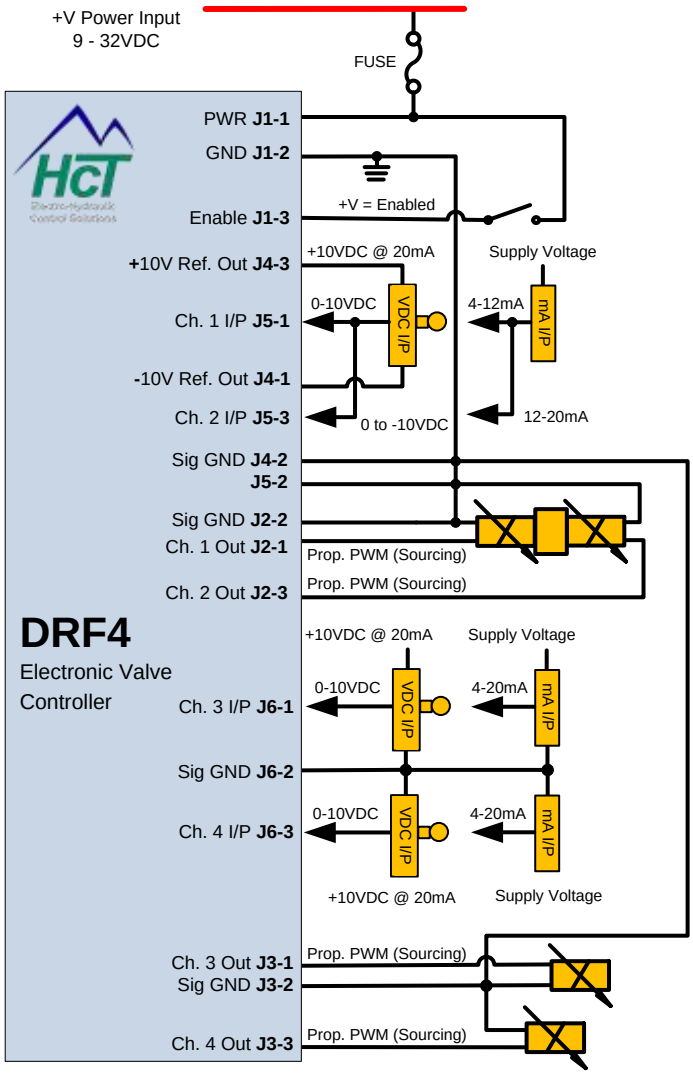


Double/Single/Single Solenoid Control (DRF4-Vxx)

The DRF drives a dual-coil valve with joystick input J5-1 and 2 single-coil valves with joystick input J6-1 and J6-3.

Set the dither and output settings according to the valve specifications.

Schematic



Example Settings

Parameter	Value
C1 Mode	2 CUR USE ENBL
C1 Min input	0.2 V
C1 Max input	10.0 V
C1 Min output	5 mA
C1 Max output	600 mA
C1 Ramp up	1 S
C1 Ramp down	1 S
C2 Mode	4 IN1 USE ENBL
C2 Min input	-0.2 V
C2 Max input	-10.0 V
C2 Min output	5 mA
C2 Max output	600 mA
C2 Ramp up	0 S (NOT USED)
C2 Ramp down	0 S (NOT USED)
C3 Mode	2 CUR USE ENBL
C3 Min input	0.2 V
C3 Max input	10.0 V
C3 Min output	5 mA
C3 Max output	600 mA
C3 Ramp up	1 S
C3 Ramp down	1 S
C4 Mode	2 IN4 USE ENBL
C4 Min input	0.2 V
C4 Max input	10.0 V
C4 Min output	5 mA
C4 Max output	600 mA
C4 Ramp up	1 S
C4 Ramp down	1 S
Dither frequency	150 Hz.

Closed Loop Velocity Mode (DRF2-Vxx)

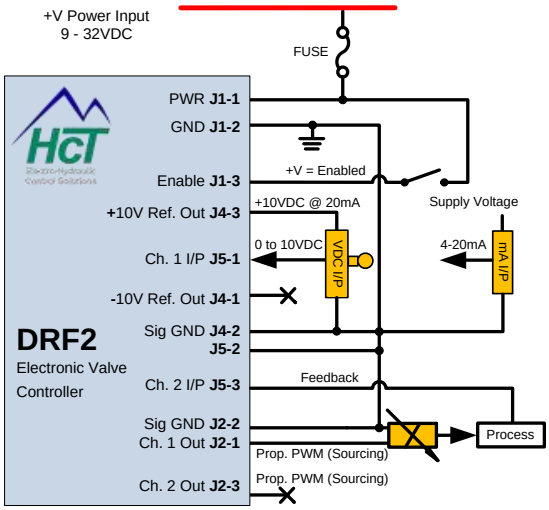
The DRF can drive a single solenoid valve in closed loop velocity mode.

Set the input ranges to match the desired command and feedback range.

NOTE: The feedback (C2 input) setting should be inverted for reverse-logic valves. The minimum must be greater than the maximum.

Set the dither and output settings according to the valve specifications.

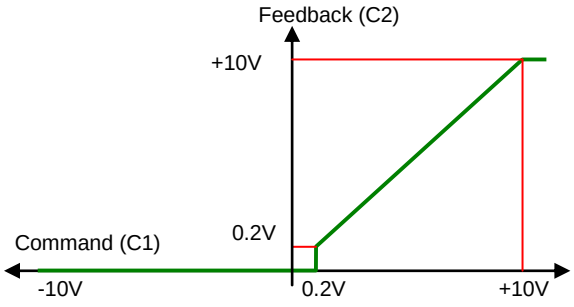
Schematic:



Example Settings

Parameter	Value
C1 Mode	4 VEL USE ENBL
C1 Min input	0.2 V
C1 Max input	10.0 V
C1 Min output	5 mA
C1 Max output	600 mA
C2 Mode	2 IN2 USE ENBL
C2 Min input	0.2 V
C2 Max input	10.0 V
C2 Min output	5 mA
C2 Max output	600 mA
Dither frequency	150 Hz.

Command/Feedback Transfer Diagram



- Mining & Exploration
- Agriculture
- Cranes & lifts
- Refuse & Re-cycling
- Construction
- Off-Road vehicles
- Forestry, Wood & Pulp
- Reclamation & Salvage
- Oil Field & Sands
- Demolition Equipment
- Cooling Solutions
- Military Apparatus
- Specialty Use
- Remote Control
- Power Generation
- Emission Controls
- Integrated Drivers
- Valve & Pump Controls

HCT Product Sales and Support:

For a full list of authorized distributors worldwide, please visit:

www.hctcontrols.com/distributors/index.htm

Need More Information ?

For customer service, pricing, order placement and application support, contact us through E-mail at:
info@hctcontrols.com

www.hctcontrols.com

A SUN Hydraulics Company

High Country Tek, Inc.
208 Gold Flat Court
Nevada City, CA, 95959
Tel: (1) 530 265 3236
Fax:(1) 530 265 3275