CEM-PID-A

Description:

This closed loop PID module compares command and feedback signals, and applies traditional PID gain settings to the error signal. This modified signal is provided as an analog voltage (0 to +/-10v)output. It may be used to drive proportional pressure or flow control valves with on board electronics, or as a command to another amplifier module. It is suitable to provide dynamic closed loop control in pressure, force, or velocity systems.

A wide range of analog signals are accepted. User may select either voltage or current input mode. These inputs are easily scaled to match system requirements. Input command can be ramped. PID variables are adjustable over a wide range.

Output can be scaled to match the proportional valve being driven. If command current signal is outside of the proper range, the module is disabled. Digital outputs inform the user of system errors.

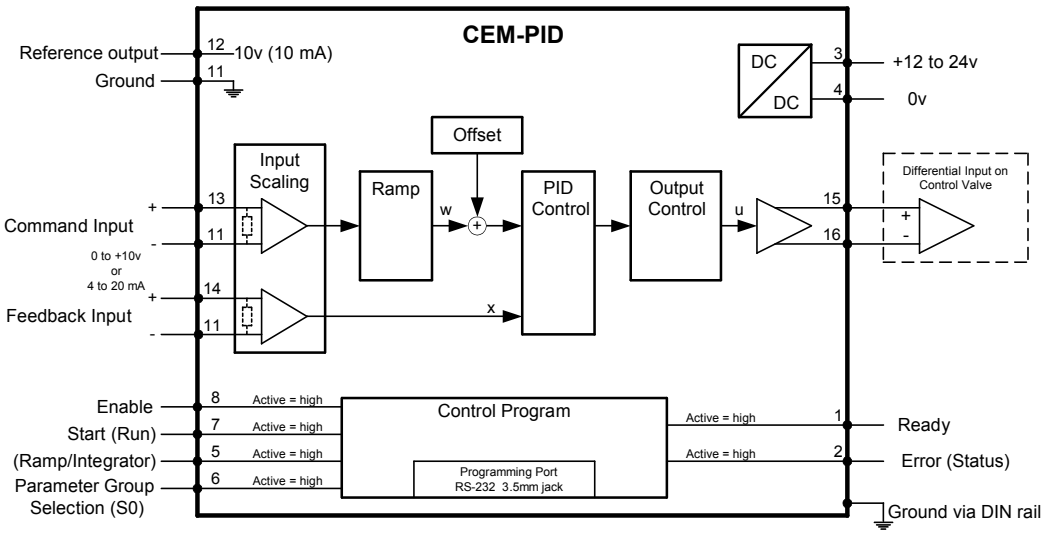
This module is easily adapted to a variety of system requirements. All variables are user adjusted with easy to use software on your Microsoft Windows laptop. Control variables are stored in non-volatile memory internal to the module. All variables can be read by the laptop, and reproduced exactly on other modules.

Technical Data:

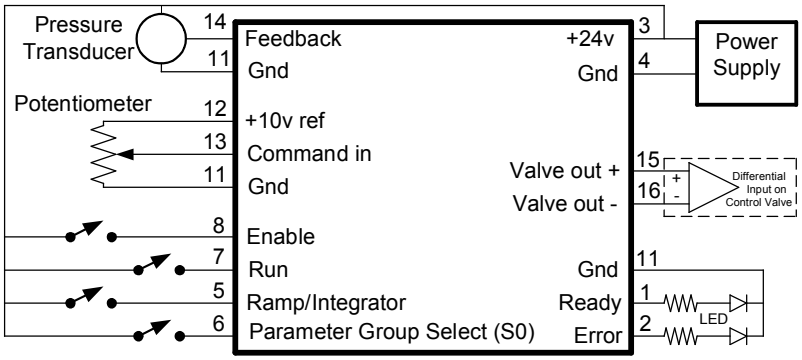
Power Supply		vDC	12 to 30 (including ripple)
	Consumption	mA	<100mA
	External Fuse	A	3 (medium action)
Analog Inputs	Voltage	vDC	0 to +10
	Impendance	ohm	33k
	Current	mA	4 to 20
	Impendance	ohm	250
	Resolution	%	0.012
	Sample Time	mS	1.0
	Reference Voltage	V	10 (10mA max)
Digital Outputs		V	Logical 0 = < 2 (50mA max)
		V	Logical 1 = ~ Power Supply
Electrical Connection			
	Programming Port		RS-232 3.5mm Stero Jack
	Power and Signal		4 strips with 4 screw terminals each
	Ground		via DIN Rail

Digital Inputs		V	Logical 0 = < 2
		V	Logical 1 = > 10
	Impendance	ohm	25k
Analog Output	Voltage	vDC	0 to +/- 10
	Current	mA	5 (max)
	Resolution	%	0.024
Housing	Module		Snaps to 35mm DIN Rail EN 50022
	Material		Polyamide PA 6.6
	Combustability Class	UL94	V0
	Protection Class	IP	20
	Working Temperature	C	-20 to +60
	Storage Temperature	C	-20 to +70
	Humidity	%	95 (non condensing)
Electro Magnetic Compatibility			
	Emission		EN 61000-6-2
	Immunity		EN 61000-6-3
	Vibration Resistance		EIC 60068-2-6

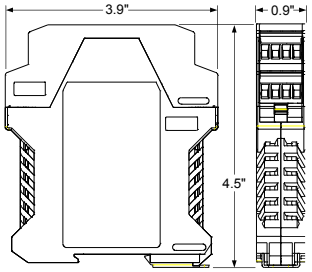
Functional Diagram:



Wiring Example:



Dimensions:



Steps to install and configure a new application:

1. Mount the module in a suitable location
2. Connect the power supply
3. Connect inputs and outputs
4. Adjust analog inputs to voltage or current, and adjust input scaling
5. Adjust analog output to match valve characteristics
6. Adjust ramping (if desired)
7. Adjust internal monitor functions (if desired)
8. Adjust PID error correction parameters to tune system performance

All parameters are adjusted using VEA-USB programming cable and CHI-PC Microsoft Windows application:

Module Mounting Location:

This module is to be mounted in a cabinet for protection from the local environment.
Ensure there is adequate free space around the module to allow for cooling air flow.
This module is designed to snap onto an industry standard 35mm DIN rail.
Do not mount near other modules that emit high power electrical interference, such as motor controllers and high power contactors.

Power Supply:

This module is designed to operate on DC power from a regulated power supply ranging from 12 to 30 volts. Match valve solenoid voltage rating to power supply, typically 12 or 24 volts.

A 3 amp medium action fuse is recommended in the “+” power supply line.

Adjust MODE to STD or EXP:

Simple parameters may be adjusted while in STD mode.

EXP mode allows for more complex parameter adjustments.

MODE parameter valid options are STD and EXP. Default is STD.

Adjust module output to match valve requirements:

The CEM-PID module has a 0 to +/-10v differential output. This output is designed to directly interface to proportional valves with on board electronics. It can also command other modules that accept 0 to +/-10v analog inputs.

The parameter OUTPUT allows the switching the output from 0 to +/-10v to 0 to +10v. Valid options are BIPOLAR and UNIPOLAR.

This output signal may be configured to more closely match the valve characteristics. The parameters used to adjust the output signal include:

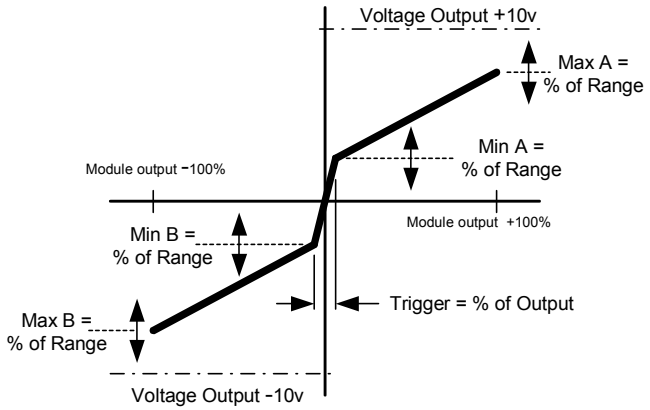
MAX:A
MIN:A
TRIGGER
MAX:B (not used when OUTPUT=UNIPOLAR)
MIN:B (not used when OUTPUT=UNIPOLAR)

MAX:A and MAX:B are set with software as a percentage of the native +10v output. MAX:A and MAX:B are set at 100% (10000) for a valve that has a 10v input rating. To reduce the maximum flow from a valve with a spool that is too large, set MAX to a number less than 100%. Valid range is from 5000 to 10000. Default is 10000. Units are 0.01%

MIN:A and MIN:B are adjusted via software for the purpose of deadband elimination. A valve with a minimum control point (cracking point) will give best performance if this deadband is eliminated. Valid range is 0 to 5000. Default is 0. Units are 0.01%.

Example: A directional control valve has an input range of 0 to +/-10v. The valve is factory calibrated to begin flow at 1v, and max flow is at 10v. Adjust the CEM-PID parameters:

MAX:A = 10000 (100% of +10v)
MIN:A = 900 (9% of 10v = +0.9v)
MAX:B = 10000 (100% of -10v)
MIN:B = 900 (9% of -10v = -0.9v)



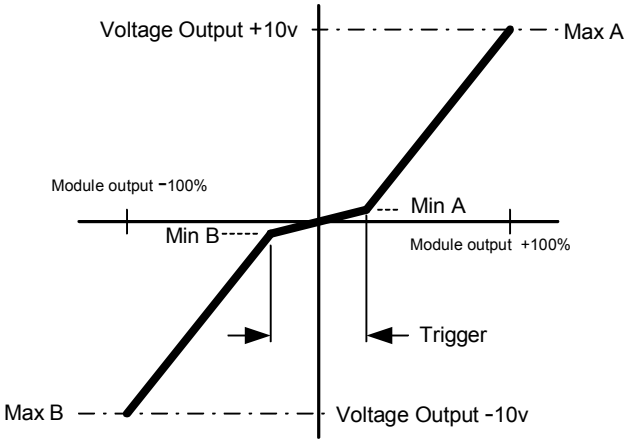
TRIGGER and MIN can be used together to optimize valve performance near zero.

When using a proportional valve with an overlap spool, adjust TRIGGER to 200 (2%), and MIN:A and MIN:B to slightly less than the “crack point” of the valve.

Adjust module output to match valve requirements (continued):

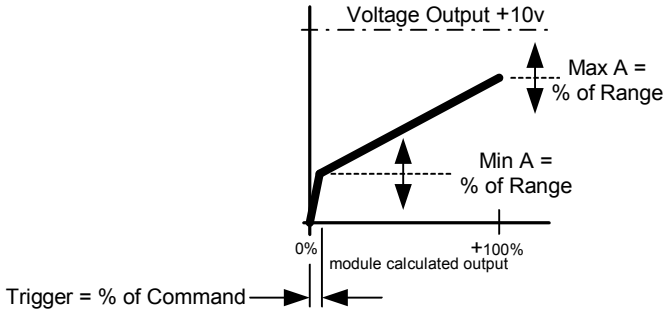
When using a proportional valve with an underlap spool ("zero" lap), the flow gain in the area of the underlap is about double that outside the underlap area. Adjusting TRIGGER and MIN:A and MIN:B as suggested will give more stable results.

Example: Adjust TRIGGER to 200 (2%) and MIN:A and MIN:B to 100 (1%). These settings reduce the flow gain in the underlap region, and usually allow for higher gains and more stable operation.



When setting the OUTPUT parameter to UNIPOLAR, the adjustment of MIN:A and TRIGGER are usually less important then when in BIPOLAR mode. But similar control concepts apply.

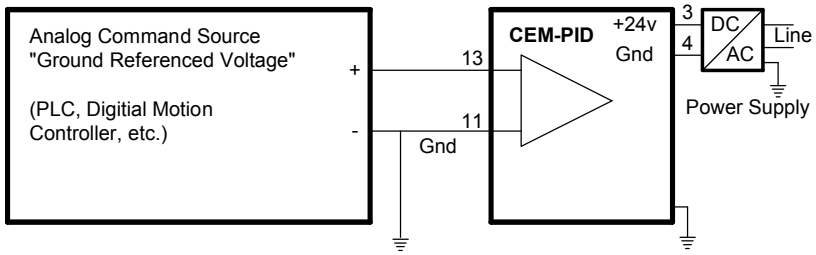
Example: A flow control valve has an input range of 0 to 10v. The valve is factory calibrated to begin flow at 1v, and max flow is at 10v. Adjust the CEM-PID parameters:
MAX:A = 10000 (100% of 10v)
MIN:A = 900 (9% of 10v = 0.9v)



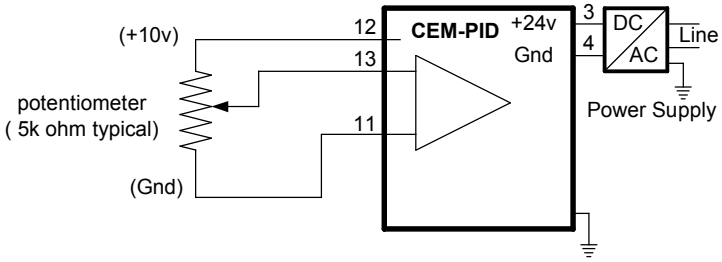
Valid values for MAX:A and MAX:B are 5000 to 10000. Units are 0.01%. Default is 10000.
Valid values for MIN:A and MIN:B are 0 to 5000. Units are 0.01%. Default is 0.

Command input with Voltage:

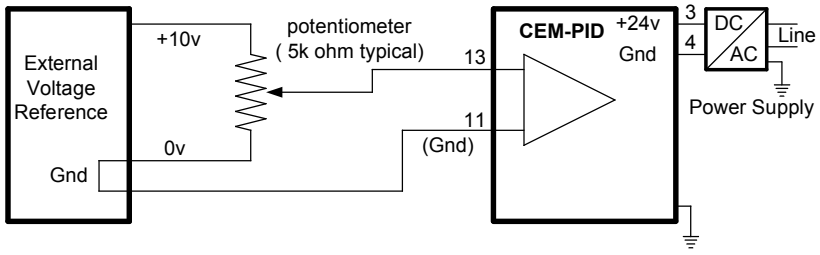
An analog source voltage may be either “differential” or “ground referenced”. The CEM-PID has analog command and feedback inputs that are ground referenced. Examples are shown for command only, feedback signals are wired to Pin 14(+) and Pin 11 (GND).



Pin 12 is a regulated 10vdc output pin that may be used as a reference voltage for generating command signals. It is limited to 10mA output. It is internally referenced to module ground (pins 4 and 11).



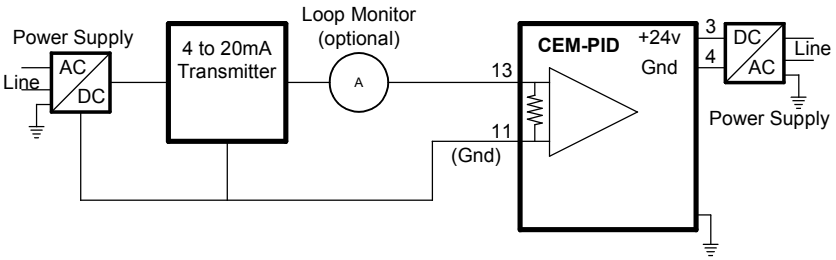
An external voltage source must be referenced to ground for proper operation.



Command input with current:

The analog inputs can also be software set to accept a current command. Either input can be individually adjusted to accept either voltage or current. When current is chosen, a 250 ohm resistor is internally inserted across terminals 13 and 11, and/or between terminals 14 and 11. This resistor converts the current to a voltage. This voltage is measured by the amplifier to become the system command (13/11) or the system feedback (14/11).

Input current range is 0 to +20 mA, and is typically used at 4 to 20mA. This current is converted to voltage, and software scale and offset parameters are applied to meet system requirements.



All analog input signal cables must be shielded!

Good analog system design requires that all analog signals in an electrically noisy environment be shielded. Long wires act like antennas that pick up analog noise. The wire connecting the analog command source to command this module must be shielded! An unshielded cable can allow electrical noise to be added to the desired command signal, and can make the system response erratic.

Shielding a noise sensitive wire is accomplished by wrapping a noise blocking foil or braided shield around the signal wire. This shield must be grounded at only one end, usually the end that sends the signal. A control cable may have many individual conductors. The conductors may be shielded individually, or may be shielded as a group. Short signal wires in electrically quiet environments may not need to be shielded.

The CEM family of modules all have an internal ground connection to the DIN rail. For this module ground to be effective, please insure the DIN rail is properly grounded.

Scaling of analog input:

This module has a native analog voltage input range of 0 to +10v for both command and feedback. These inputs can be scaled and offset with software to allow a wide variety of input voltages. A few examples are:

0 to +10v, 0 to +5v, +1 to +5v, +0.5 to +4.5v

The AIN:W parameter adjusts command port, and AIN:X parameter adjusts the feedback port. Each can be independently set for either voltage or current command, and each can be independently scaled.

Example: AIN:W V will set the command input to voltage. Default range = 0 to +10v
Example: AIN:W C will set the command input to current. Default range = 4 to 20mA

Example: AIN:X V will set the feedback input to voltage. Default range = 0 to +10v
Example: AIN:X C will set the feedback input to current. Default range = 4 to 20mA

Analog voltages or currents are scaled with the following linear equation:

$$\text{Output} = A/B * (\text{Input} - C)$$

"Output" of this scaling equation must always be equal to the module native input range, 0 to +10v. "Input" can be any voltage within this 10v range.

The ratio of A/B allows for a decimal scaling factor. These two numbers are chosen to provide a "gain" to the input signal. A and B must be whole numbers. Range is -10000 to 10000. (Default; A = 1000, B = 1000)

C is an offset, measured as a percentage of range. C has units of 0.01%, and has the range of –10000 to 10000. (Default; C = 0)

Scaling of voltage inputs:

Example: Typical AIN parameter settings for popular command and feedback voltages:

Command	A	B	C	description
0 to +10v	1000	1000	0	100% scale, 0% offset
0 to +10v	1	1	0	100% scale, 0% offset
0 to +10v	10	10	0	100% scale, 0% offset
0 to +5v	10	5	0	200% scale, 0% offset
+1 to +9v	10	8	1000	125% scale, 10% offset
+0.5 to +4.5v	10	4	500	250% scale, 5% offset
0 to 8v	10	8	0	125% scale, 0% offset

Scaling current inputs:

Example: Typical AIN parameter settings for popular command and feedback currents:

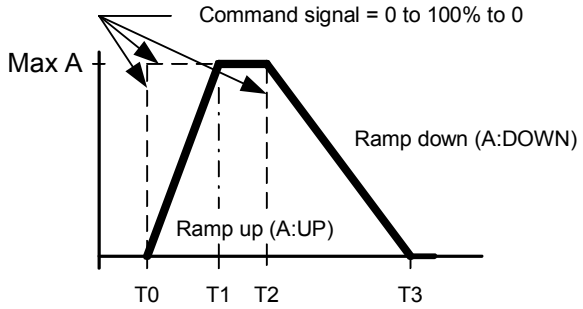
Command	A	B	C	description
4 to 20mA	20	16	2000	125% scale, 20% offset
4 to 20mA	1250	1000	2000	125% scale, 20% offset
4 to 20mA	5	4	2000	125% scale, 20% offset
0 to 20mA	20	20	0	100% scale, 0% offset

Swapping polarity with the POL parameter:

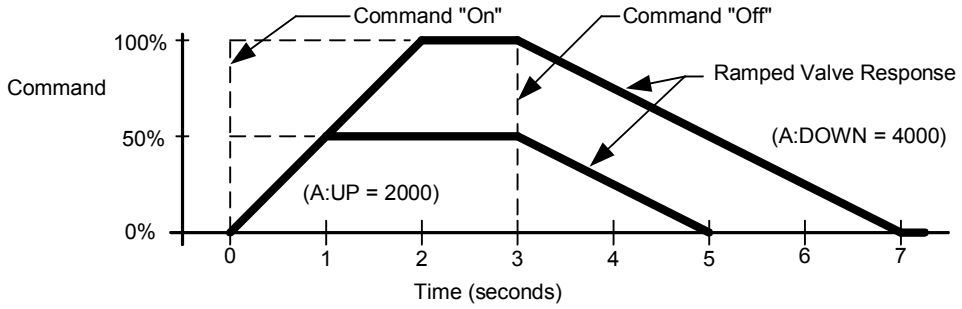
The input command polarity may be swapped with the POL command. Valid parameter values are "+" and "-". (Default = +).
Adjusting POL to "-" will change the output function from 0% to 100% to 100% to 0%.

Ramping:

Command input signals may be ramped.
There are two independently adjustable ramps, A:UP for ramp up, A:DOWN for ramp down.



Ramp rates are set via software. All ramps are specified in milliseconds, and are actually "time to ramp for a 0 to 100% signal change." For example, a value of 2000 will give a ramp time of 2 seconds for a 0 to 100% step command. The ramp time will be 1 second for a step command of 0 to 50%.



Valid values for A:UP and A:DOWN are 1 to 60000. Default is 100.

Adjustment of SENS internal monitoring function:

This module has optional internal input and internal monitoring functions. The module can monitor command inputs for proper range.

There are three choices for SENS; AUTO (default), ON, and OFF.

OFF disables the internal sensing function.

ON and AUTO enable the internal sensing functions. The difference between ON and AUTO is how the module handles error correction.

> When ON is selected, if the module detects an error, and the error is corrected, the ENABLE pin must be cycled to reactivate the module.
>
> When AUTO is selected, if the module detects an error, and the error is corrected, the module will resume function without cycling ENABLE.

If the module has been configured to accept current commands, an out of range command current will disable the module, and cause the green READY LED to blink.

Use of Pin 8 ENABLE digital input:

ENABLE is a digital input that is active high. If there is a command present when ENABLE is brought high, the output will ramp to that commanded value. When enable is removed, the output will instantly go to zero.

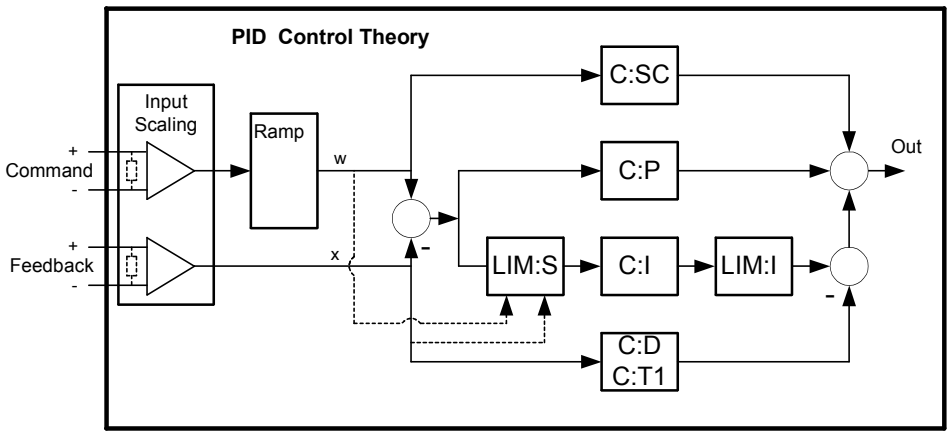
Use of Pin 6 “RUN””(START)” digital input:

RUN instructs the module to start the closed loop control process. To keep the module in closed loop mode, both ENABLE and RUN must be held high.

Adjusting closed loop PID parameters:

The closed loop control portion of the CEM-PID uses traditional PID error correction theory. There are two groups of PID parameters that may be set, group C0 and the optional group C1. Group C0 is active when Pin 6 is off (low). Group C1 is active when Pin 6 is active (high).

Within each group, there is a primary PID loop, and an optional secondary loop, with additional parameters for P_PT1 and T1_PT1



Group C0 parameters:

Parameter	name	range	default	units
C0:P	Proportional	0 to 10000	50	0.01%
C0:I	Integral	2 to 2050	4000	msec
C0:D	Derivative	0 to 120	0	msec
C0:T1	Time damping of D	0 to 100	50	msec
C0:SC	Feed Forward	0 to 10000	0	0.01%
C0:I_LIM	integrator limit	0 to 10000	2500	0.01%
C0:I_ACT	integrator activation	0 to 10000	2500	0.01%
C0:P_PT1	2nd loop - Proportional	0 to 10000	0	0.01%
C0:T1_PT1	2nd loop - Time damping of D	0 to 100	50	msec

Group C1 parameters:

Parameter	name	range	default	units
C1:P	Proportional	0 to 10000	50	0.01%
C1:I	Integral	2 to 2050	4000	msec
C1:D	Derivative	0 to 120	0	msec
C1:T1	Time damping of D	0 to 100	50	msec
C1:SC	Feed Forward	0 to 10000	0	0.01%
C1:I_LIM	integrator limit	0 to 10000	2500	0.01%
C1:I_ACT	integrator activation	0 to 10000	2500	0.01%
C1:P_PT1	2nd loop - Proportional	0 to 10000	0	0.01%
C1:T1_PT1	2nd loop - Time damping of D	0 to 100	50	msec

Adjusting closed loop PID parameters (continued):

LIM:I limits the integrator "windup". Larger numbers allow smaller long term following error. Smaller numbers give faster control for less overshoot. Default is 2500 (25%).

LIM:S set's the threshold for integrator activation. For LIM:S = 0, the integrator is always active. LIM:S threshold is calculated as a percentage of the difference between command (w) and feedback (x) values. A smaller value will increase long term stability. A larger number will decrease overshoots. Default is 2500 (25%).

REMOTE control:

The CEM-PID can be placed in REMOTE control mode. This function allows temporary software override of specific digital and analog inputs.

To operate the module in this mode, first set the REMOTE parameter to ON. Then set the software override for the W command with the RC:V parameter. Values for V can vary from 0 to 10000, and are in the units of 0.01%.

The following digital inputs can be software overridden:

Input	command bit
ENABLE (Pin 8)	1
RUN (Pin 7)	2
Ramp/ Integrator (Pin 5)	3
S0 Parameter Group Select (Pin 6)	4

RC:S is used to control these inputs. A decimal number from 0 to 15 is used to temporarily override the input status.

Decimal	Binary	S0	RAMP	RUN	ENABLE
0	0000	x	x	x	x
1	0001	x	x	x	ON
2	0010	x	x	ON	x
3	0011	x	x	ON	ON
4	0100	x	ON	x	x
5	0101	x	ON	x	ON
6	0110	x	ON	ON	x
7	0111	x	ON	ON	ON
8	1000	ON	x	x	x
9	1001	ON	x	x	ON
10	1010	ON	x	ON	x
11	1011	ON	x	ON	ON
12	1100	ON	ON	x	x
13	1101	ON	ON	x	ON
14	1110	ON	ON	ON	x
15	1111	ON	ON	ON	ON

PIN 5 control (optional disable of ramp or integrator function):

PIN 5 parameter has two valid options: RAMP or INTEG. (default is RAMP)

When PIN 5 is set to RAMP, the digital input (pin 5) enables or disables the ramping of the command signal. With pin 5 “ON” (high), the ramp is disabled. Pin 5 “OFF” (low) enables ramping.

When PIN 5 is set to INTEG, the digital input (pin 5) enables or disables the integrator function. With pin 5 “ON” (high) the integrator is disabled. Pin 5 “OFF” (low) enables the integrator. When PIN 5 parameter is set to INTEG, input command ramping is always active.

TS parameter:

TS sets the sample time of the closed loop control system. Valid settings are from 4 to 30, the units are msec. Default is 10. It is advised to keep this parameter set to 10.

ERROR parameter and STATUS Pin 2 digital output:

The module is constantly comparing the command and feedback values. ERROR sets a window of allowable difference between command and feedback. Output Pin 2 (STATUS) will be on (high) when the difference is smaller than ERROR, and off (low) when the difference is greater than ERROR. ERROR can be set between 2 and 10000, has the units of micrometer, and has a default value of 100.

The closed loop control function is not effected by the ERROR parameter, nor the state of STATUS (Pin 2). If the difference is smaller or greater than ERROR, the module continues to control the output.

EOUT parameter:

EOUT sets a default module output value. When ENABLE (pin 8) has been removed, or the module has become disabled, the output may be set to a value other than zero. This allows the machine to slowly extend or retract in the case of loss of electro hydraulic control.

Parameter valid –10,000 thru +10,000. Default is 0. Units of 0.01%

Note: Use this parameter with caution!

OFFSET parameter:

Parameter valid –5,000 to +5,000. Default is 0. Units = micrometer.

LED function:

Green (Ready)	Steady on	System OK
	Blinking	4 to 20mA current input is out of range
	Blinking	Internal error
Yellow (Status)	Steady on	No control error
	Off	Control error present

READY Pin 5 digital output:

The READY digital output reports the system status.
Pin 5 will be held “high” (on) when ENABLE is connected, and there are no system errors.
Pin 5 will be pulled “low” (off) under the following conditions:

1. When ENABLE is removed
2. When SENS is turned on and the input is outside the 4 to 20mA range
3. When other internal errors are present

This output follows the front panel yellow (Status) LED

Parameter monitoring using software:

The following parameters may be monitored in real time using Windows configuration software.

Parameter	Description	Unit
W	Command after scale & ramp	0.01%
X	Feedback after scaling	0.01%
XW	Command – Feedback	0.01%
V	Velocity	0.01%
U	Output	0.01%