MyCNC closed loop configuration

A proportional-integral-derivative controller (PID controller) is a control loop feedback mechanism widely used in industrial control systems and a variety of other applications requiring continuously modulated control. A PID controller continuously calculates an error value E(t) as the difference between the desired setpoint position (POS) and a real position measured by encoders (ENC) and applies a correction based on proportional, integral, and derivative terms (denoted P, I, and D respectively).

PID controller formula implemented in myCNC is

$$U_{PID} = K_0 + K * V + K_p * E(t) + K_i * \int_0^t E(t) dt + K_d * dE(t) / dt$$

where

- Kp is the proportional gain, a tuning parameter,
- Ki is the integral gain, a tuning parameter,
- Kd is the derivative gain, a tuning parameter,
- E(t) = (POS ENC) is the position error (difference between a job position real position measured by encoder),
- **t** is the time (the present).

Digital-Analogue Converter (DAC) output voltage is the sum of the PID and a DAC offset volage

$$U_{OUT} = U_{PID} + U_{Offset}$$

Enable/Disable PID control does not affect the DAC voltage offset.

If PID control is disabled for selected channel, output voltage is equal to DAC Offset

U_out = U_offset

PID controllers setup

To setup Closed-loop analogue PID

 Goto "Encoders" configuration widget. Setup Encoder resolution for each channel you going to use

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 Set Multiplication ratio to "2" and divider (/2^Div) ratio to "1" to get result ratio 2/(2^1)=1

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Multiplicator and divider ratio needed for pulse-dir closed loop system to adjust encoder resolution (encoder lines-per-rotation) to motor driver pulse-dir resolution. For Analogue closed loop system this ratio should be "1"

Adjust DAC offset ratio to get "0V" value on DAC output for each channel. Theoretical DAC value for 0V is the middle of 12bits range 4096/2=2048.
 A real value may vary +/-5%.

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• Fill Encoder channel for each PID (Motor#).

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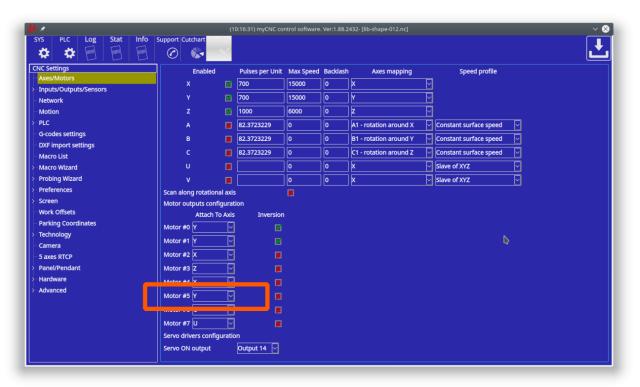
• To test selected channel, check "Enable" checkbox for the channel and enter initial value of "50" for Proportional P-ratio of PID controller. Press "Save" button to save the changes. We test PID#5 (motor channel #5) on the screenshot below.

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- Click on "Servo-ON" button to reset & enable selected PID and turn ON "Servo-ON" signal. Servo-On procedure will ...
 - Reset position error registers **E(t)** and its Integral value.
 - $\circ\,$ Turn ON Servo-ON output to enable a servo driver
 - Turn ON all "Enabled" PID controllers (Checkboxes "Enable" are checked).
- Select the channel for a scope widget to control and tune PID controller ratios.

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• Check which Axis the PID controller attached to (Y axis for the screenshot below).



• Jog buttons can be used to move the axis while testing and tuning the PID coefficients.

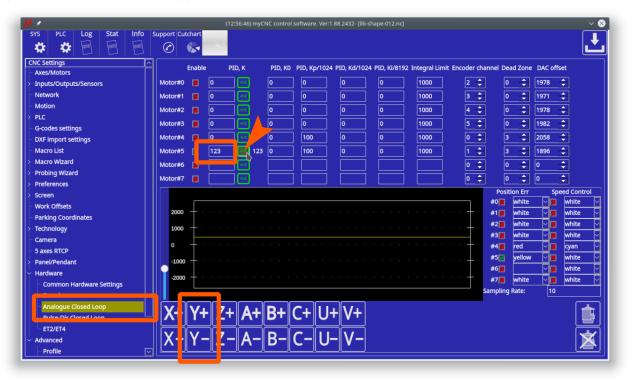
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 An analogue servo driver normally has a linear function of rotation speed depends on input voltage. A linear coefficient of this function depends on Servo driver and motor, gears, ballscrew etc.

PID K value represent this coefficient.

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– Network	Motor#1 📕	0 <	0	0	0	0	1000 3	• • •	1971 🜲
- Motion	Motor#2		0	,] [0	0	0	1000 4	• • •	1978 🗘
>-PLC	Motor#3				0	0		÷ • ÷	1982 🗘
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The value can be tuned manually. If rotate a motor shaft with speed more than 20 turns/sec, the controller calculates real Speed/Voltage coefficient and print it on the configuration widget. You can use this value as information to tune the PID **K** ratio. A button « to the right of **PID K** input line can be used to copy the measured **K** ratio to **PID K**.



Servo ON handling

Depends on machine configuration you may want

• On-Screen buttons to turn ON/OFF your Servo drivers

• Automatic turn ON Servo Drivers when CNC control loaded and ready to go

Both options can be implemented with myCNC control software.

There are few ways to Enable/Disable Servo PID loops in myCNC software

1. On-Screen button. To enable/disable Servo PID control button should have actions:

```
action="servo-pid-on" (enable pid)
action="servo-pid-off" (disable pid)
```

For example

Buttons for Servo-ON and Servo-OFF

```
<gitem where="toolbar-servo" image="motor/motor-start" action="servo-pid-on"
height="80" event="pressed-delay-1000" type="button"/>
<gitem where="toolbar-servo" image="motor/motor-stop" action="servo-pid-off"
height="80" type="button"/>
```

Popup widget container for Servo Pid On/Off buttons

Button to show containner with 2 buttons for servo-on/servo-off buttons and led to show current servo pid state

```
<gitem where="magic" position="960;0" width="80" height="80"
image="motor/servo-driver"
action="mypopup-toggle:popup-servo" xattr="56;4;20;20;led;green;round"
address="outputs" number="47" type="xbutton" />
```

2. Using Global Variables API. Global variables 60000 and 60001 are mapped to turning On and Off Servo PID control.

- Write "1" to register number 60000 will turn ON Motor closed-loop control PIDs
- Write "1" to register number 60001 will turn OFF Motor closed-loop control PIDs

Reading this registers has no effect and return zero value. Read more about Servo ON/Servo OFF commands in this short manual: Servo ON/OFF.

3. Automatic Servo ON/OFF. There are 2 handler procedures in Software PLC can be used to automatic PID ON/OFF.

• **_HANDLER_INIT** - procedure executed once just after CNC control software loaded, connection

with myCNC controller established and a complete configuration is sent to the controller.

• **_HANDLER_EXIT** - procedure executed while myCNC control software shut down the process.

To handle automatic Servo ON/OFF writing to registers 60000, 60001 should be added to handler procedures. Example is below

```
__HANDLER_INIT.PLC
```

```
main()
{
   gvarset(60000,1); //turn Servo PIDs On
   exit(99);
};
```

____HANDLER_EXIT.PLC

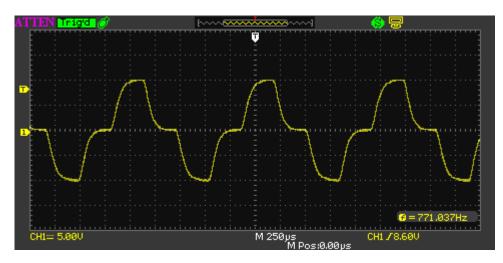
```
main()
{
   gvarset(60001,1); //turn Servo PIDs Off
   exit(99);
};
```

Analogue -10V/+10V outputs Test Mode

To test DAC outputs voltage range, rising/falling edges timings **DAC Test mode** is used. DAC Test mode is activated if in **Hardware**→**Encoders** configuration dialog, /(2^Div) line for **Encoder#11** column set "99" value and press "Save" button.

NC Settings		Encoder	r#0	Encode	r#1	Encode	er#2	Encode	r#3	Encode	r#4	Encoder	r#5	Encoder#6	Encode	er#7	Encode	er#8	Encod	er#9	Encod	er#10	Encod	er#1
Axes/Motors	ution	65536	~	2500	~	2500	~	2500	~	2500	~	2500	~	2048 ~	2048	~	512	~	512	~	512	~	512	~
Network		2046		2046	_	2046		2	_	2046	_	2046	-						_		_	_		
Motion		2040		2040		2040		1		2040		2040					-		_					
Hardware PLC		_	_	_				-																
Software PLC		2	$\hat{}$	2	$\hat{}$	2	$\hat{}$	2	$\hat{}$	2	$\hat{}$	2	$\hat{}$	2 🗘	2	$\hat{}$	2	$\hat{}$	2	$\hat{}$	2	Ŷ	2	÷
G-codes settings		1	$\hat{\mathbf{C}}$	1	٢	1	٢	1	0	1	٢	1	0	1 0	1	0	1	0	1	٢	1	<u>^</u>	99	0
DXF import settings		<u> </u>		<u> </u>	~			<u> </u>		<u> </u>		· · ·	<u> </u>	• •	<u> </u>		<u> </u>		<u> </u>		<u> </u>	Ľ		~
Macro List	on		_																			_	_	
Macro Wizard		_		_						_		_					_				_			
Probing Wizard	otor	N/C	\sim	#0	~	N/C	~	N/C	\sim	N/C	\sim	N/C	\sim	N/C 🗸	N/C	~	N/C	~	N/C	~	N/C	~	N/C	\sim
Preferences																								
Screen																								
Work Offsets																								
Parking Coordinates																								
Inputs/Outputs/Sensors																								
Technology																								
Camera																								
Camera 5 axes RTCP																								
5 axes RTCP																								
5 axes RTCP Panel/Pendant																								
5 axes RTCP Panel/Pendant																								
5 axes RTCP Panel/Pendant Hardware																								
5 axes RTCP Panel/Pendant Hardware Common Hardware Settings																								
5 axes RTCP Panel/Pendant Hardware Common Hardware Settings Encoders																								

In DAC Test mode all DAC outputs generate **Zero** » **MAX** » **Zero** » **MIN** sequence with frequency about 700Hz. Scope screen example is shown below.



Value "99" should be used for DAC test mode ONLY! For working mode any other value from "1" to "90" should be used in "/(2^Div)" line for "Encoder#11".

Analogue -10V..+10V/Incremental encoder closed-loop setup

- 1. Goto **Encoders** settings tab.
 - 1. Setup **Encoder resolution** for All Encoders used.
 - 2. Set Multiplication ratio **Mul** to "2" for all the Encoders.
 - 3. Set Divider /(2^{Div}) to "1" for all the Encoders. Result Ratio will be $2/(2^{1})=1$
 - 4. Setup Attached to motor for all Encoders used.

Pulse-Dir/Incremental Encoder closed-loop setup

Example: Let's use Motor output #2 (configured as axis X) and Encoder #1 to build closed-loop PID control.

 Goto Encoders settings tab. If rotary encoder is used as a feedback - setup Encoder resolution for Encoder #1. For linear encoder set resolution 2500.

arcoder Resolution 2500 - urrent value 9839 position - ul 2 +	#0 Encoder#1 2500 ▼ 467 ↓ 4 ↓ ↓ ↓ 1 ↓	1 Encode 2500 9980 2 1	er#2	Elosed Li Encode 2500 2 1 1 N/C	er#3		er#4	Closed Cl	er#5		2/ET4 er#6 •	_	er#7 •	Encod 512 2 1 N/C				Encode 512 2 1 N/C		Encod 512 2 99 N/C	er#11	
acoder Resolution 2500 - urrent value 9839 position 2 - ul 2 - Div) 1 - sition -	 2500 ▼ 467 467 4 ▲ 4 ▲<th>2500 9980 2 1</th><th></th><th>2500 2 1</th><th></th><th>2500 2 1</th><th></th><th>2500 2 1</th><th></th><th>512 2 1</th><th></th><th>512 2 1</th><th></th><th>512 2 1</th><th></th><th>512 2 1</th><th></th><th>512 2 1</th><th></th><th>512 2 99</th><th></th><th></th>	2500 9980 2 1		2500 2 1		2500 2 1		2500 2 1		512 2 1		512 2 1		512 2 1		512 2 1		512 2 1		512 2 99		
urrent value 9839 position ul 2 ¢ 2^Div) 1 ¢ sistion	467	9980 2 1		2		2		2	•	2		2	•	2		2		2		2 99		
position 2 ul 2 2^Div) 1 incoder Position sition		2	\$	1	•	1	\$	1	\$	1	•	1	•	1	\$	1		1	•	99	•	
2^Div) 1	1	1	\$	1	•	1	\$	1	\$	1	•	1	•	1	\$	1		1	•	99	•	
ncoder Position																						
sition	✓ #2 	N/C	¥	N/C	•	N/C	¥	N/C	•	N/C	•	N/C	•	N/C	•	N/C	•	N/C	•	N/C	•	
tached to motor N/C 👻	▼ #2 ▼	N/C	•	N/C	•	N/C	•	N/C	•	N/C	•	N/C	•	N/C	-	N/C	•	N/C	•	N/C	-	

 Set Mul and /(2^Div) ratios to get result Encoder resolution equal to Pulses-per-Unit resolution. For example

```
Servo driver with 2500 pulses per revolution,
Electronic gears "1" and ball screw 5mm are used.
Linear encoder with 1um resolution used as a feedback.
=>((A)) Pulses per unit value is (2500*4)/5=2000 pulses per mm
Original Linear encoder resolution (1um) is 1000 pulses per mm, need to
set
multiplier to "4" and divider to "1" to get result ratio
4/(2^1)=4/2=2 and
=> result Encoder resolution is 1000* 4/(2^1)=2000 pulses per mm (which
is equal to ((A))
```

- 3. Set Attached to motor to "#2"
- 4. Goto **Pulse-Dir Closed Loop** ang setup PID parameters for PID attached to Motor#2.

SYS Q	PLC CFG			SUPPOR		CFG										P
Preferenc	es Profile	Macro	s PLC Bu	uilder	Axes/Motors	Inpu	its/Sensors	Techno	logy	Networ	k Camera	5 axes RTCP	Panel/Pendant	Hardware	Advanced	
Common	Hardware Se	ttings	Encoders	Analog	ue Closed Lo	op F	ulse-Dir Clo	sed Loop	ET2/	ET4						
	PID Enable	PID, KO	PID, Kp	PID, Kd	PID, KI I	ntegra	l Limit Enc		nnel D							
Motor#0								12 🌲		0						
Motor#1								12 🌲		0						
Motor#2	✓	0	100	0	0	0		1 🗘		0						
Motor#3								12 🌲		0						
Motor#4								12 🌲		0						
Motor#5								12 🌲		0						

The most important parameters are

- 1. PID proportional ratio Kp
- 2. PID integral ratio Ki
- 3. PID integral limit. An integral value will be limited by given value.
- 4. Encoder channel used as PID feedback

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Permanent link: http://docs.pv-automation.com/mycnc/closed_loop_configuration

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