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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	Support Cutchart								
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CNC Settings	Encoders	#0	#1	#2	#3	#4	#5	6 #7	#8
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- DXF import settings		0	0	0	0	0	0	0	
– Macro List	Position		0.0000						Ť
> - Macro Wizard	Attached to motor	#4 🗸	#5	#8 🗸	#8 🗸	#8 🗸	#8 🗸	#8 🖂 #8	✓ #8
> - Probing Wizard									
>- Preferences									
> - Screen									
- Work Offsets									
Parking Coordinates									
> - Technology									
- Camera									
- 5 axes RTCP									
>- Panel/Pendant 									
Common naroware settings									
Encoders									
– Pulse-Dir Closed Loop									
ET2/ET4									
>- Advanced									
	<								≥

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

* * • •													
CNC Settings – Axes/Motors	Encoders	#0	#1	#2		#3	#		#5	#6		#7	#8
- Inputs/Outputs/Sensors	Encoder Resolution	2048	2048	2048		2048	~ 20	048 -	2048	20	148	512	✓ 512
Network	Current value	3913	4184	2046		10	20	046	10				
- Motion	11								-				
- PLC	Mul	2 🗘	2 🗘	2	÷	2	2	÷	2 🌲	0	÷	0	÷ 0
- G-codes settings	/(2^Div)	1 🗘	1 🗘	1	÷	1	1	÷	1 🗘	1		1	÷ 1
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- Macro List	Position		-0.0014										
- Macro Wizard	Attached to motor	#4 🖂	#5 🗸	#8		#8	- #	8 🗸	#8 ~	#8	3 🗸	#8	₩8
Probing Wizard						· · · ·							
- Preferences													
- Screen													
- Work Offsets													
Parking Coordinates				1									
- Technology													
– Camera													
5 axes RTCP													
- Panel/Pendant													
Hardware													
Encoders													
Encoders													
Pulse-Dir Closed Loop	T												
ET2/ET4													

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%.

SYS PLC Log Stat Inf ☆ ☆ ↓ ↓ ↓ ↓		itchart	\sim								-				ł
CNC Settings – Axes/Motors		Enable	PI	D, K	PID, K	0 PID, Kp	0/1024 PID, Kd/10	024 PID, Ki/81	92 Integral Limi	t Encoder c	hannel Dea	ad Zor	DAC offs	et	
>- Inputs/Outputs/Sensors	Motor#0	×	0	<<	0	0	0	0	1000	0	0	÷	1978	÷ 🗌	
– Network	Motor#1	×	0		0	 0	 0]	1000	0	•	÷	1971	÷ I	
- Motion	Motor#2	×	0		0] <mark>0</mark>	1000	0		÷		÷.	
PLC	Motor#3		0		0] [0	1000	0		÷		Ť.	
G-codes settings	Motor#4		0		0] <mark>0</mark>	1000	0		÷		Ì	
– DXF import settings – Macro List			0		0] (<u>0</u>	1000	1		÷		÷.	
- Macro List	Motor#5												1980		
- Probing Wizard	Motor#6			\leq						0				-	
Preferences	Motor#7	×		<<						0	•	÷		÷	
- Screen												on Err		eed Contro	
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- Technology	1000	+ ·								· · +	#3	white		white	
– Camera – 5 axes RTCP	0	+ ·								· · +	#4	red		cyan	
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- Hardware	-2000) + ·								· · +	#6 🐹		<u> </u>	white	Y
Common Hardware Settings	-3000) <u>+</u> ·								· · -	#7 🐹	white		white	~
											Sampling	Rate:	10		
Analogue Closed Loop	(+	Y+	·Z+	A+	B+	C+	U+ V+								5
ET2/ET4								í _							H
Advanced	X-	∥Y-	- Z-	'∥A-	• B–	C-	U-V-	1							ล

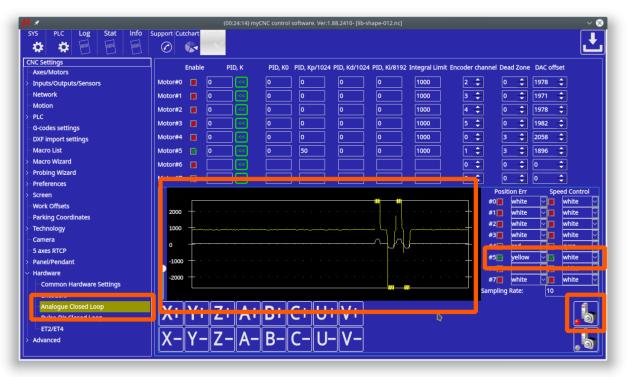
• Fill Encoder channel for each PID (Motor#).

		nyCNC control software. Ver:1.88.2410- [lib-shape-012.nc]	$\sim \otimes$
SYS PLC Log Stat Info	Support Cutchart Config		
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CNC Settings			
Axes/Motors	Enable PID, K	PID, K0 PID, Kp/1024 PID, Kd/1024 PID, Ki/8192 Integral Lim	Encoder channel ead Zone DAC offset
> - Inputs/Outputs/Sensors	Motor#0 📕 0 🤜	0 0 0 0 1000	2 🗘 0 🗘 1978 🗘
- Network	Motor#1 📕 0 <		3 🗘 0 🗘 1971 🗘
Motion	Motor#2 🕱 0		4 🗘 🗘 🗘 1978 🗘
>-PLC	Motor#3 🕱 0		
G-codes settings			
 DXF import settings 	Motor#4 📕 0		
– Macro List	Motor#5 🧝 0 <	0 0 0 1000	1 🗘 3 🗘 1896 🗘
> Macro Wizard	Motor#6 📕 🔤 <		
>- Probing Wizard	Motor#7 📕 🧹		
>- Preferences >- Screen			Position Err Speed Control
- Work Offsets	1500		#0 🐹 white 🖂 🐹 white 🖂
Parking Coordinates			#1 🐹 white 🖂 🐹 white 🖂
> - Technology			#2 📕 white 🖂 📕 white 🖂
Camera	500 - · · · · · ·		#3 📕 white 🖂 🛒 white 🖂
- 5 axes RTCP	• + · · · · · ·		#4 🛒 red 🖂 🙀 cyan 🖂
> - Panel/Pendant	-500 - · · · · · · ·		#5 yellow V white V
- Hardware	-1000 + · · · · · · · ·		white ₩
Common Hardware Settings	-1500 + · · · · · · · ·		. #7 White White White Sampling Rate: 10
			Sampling Rate: 10
Analogue Closed Loop		+ B+ C+ U+ V+	
Pulse Dir Closed Loop			
ET2/ET4			
>- Advanced			<u>୍</u> ଷ୍ୟ

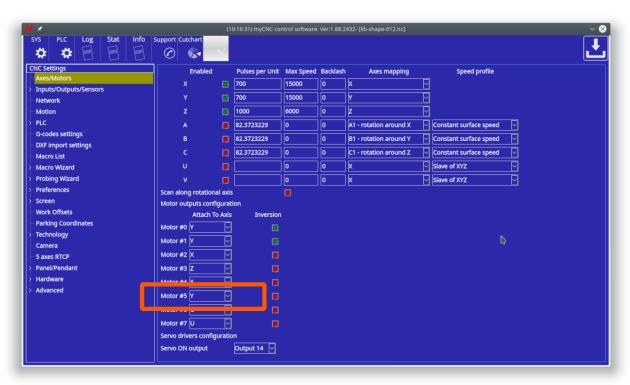
• To test selected channel, check "Enable" checkbox for the channel and enter initial value of "50" for Proportional P-ratio of PID controller. Press "Save" button to save the changes. We test PID#5 (motor channel #5) on the screenshot below.

rs PLC Log Stat Info	Support Cu	tchart	\times																Ŀ
IC Settings Axes/Motors		Enable	PII), К	PID, K	0 PID, K	p/1024 P	ID, Kd/10	24 PID, Ki/8	192 Integ	gral Lin	nit Enc	oder ch	annel (oead Zo		- IIS	et	
Axes/Motors Inputs/Outputs/Sensors	Motor#0	×	0	~	0			0	0	10	00		2 📫	1	0	19	78	¢.	
Network	Motor#1	-	0		0				0	\exists \succeq	00		3		0			÷	
Notion			0		0			0	0						0		70	-	
PLC	Motor#2	· •		9				<u> </u>	U	<u>_</u> _	00							-	
G-codes settings	Motor#3	×	0	\leq	0			0		4 12	00		5 🗘		0	= =		-	
DXF import settings	Motor#4		<u> </u>	<u> </u>	<u> </u>			0	0	10	00		0 🌩		3		56	÷	
Macro List	Motor#5		0	<<	0	50		0	0	10	00		1 🗘		3	189	96	÷	
Macro Wizard													0 🗘		0	0		÷	
Probing Wizard	Motor#7	×		<<									0 🗘	1	0	0		÷	
Preferences Screen												'		-	sition E	rr	Spe	eed Cont	rol
Work Offsets	1500	<u> </u>											1	#0	whit	te [white	\
Parking Coordinates	1000													#1 📕	·	L	-	white	
Technology	500												1	#2			_	white	
Camera													Ι	#3			_	white	
5 axes RTCP	0	T											Т	#4	_		_	cyan white	
Panel/Pendant	-500	T											Ι	#5 📕 #6 📕		L	~ X ~ X	white	
Hardware	-1000												Т	#7				white	
 Common Hardware Settings 	-1500													Samplir			10		
Analogue Closed Loop	∭X+	¥+	Z+	A+	B+	C+	U+	V+											6
ET2/ET4																			
Advanced	ШХ-	∎Y−	Z-	A-	∎B-	C-	U-	V-											a

- Click on "Servo-ON" button to reset & enable selected PID and turn ON "Servo-ON" signal. Servo-On procedure will ...
 - $\circ\,$ 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.



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

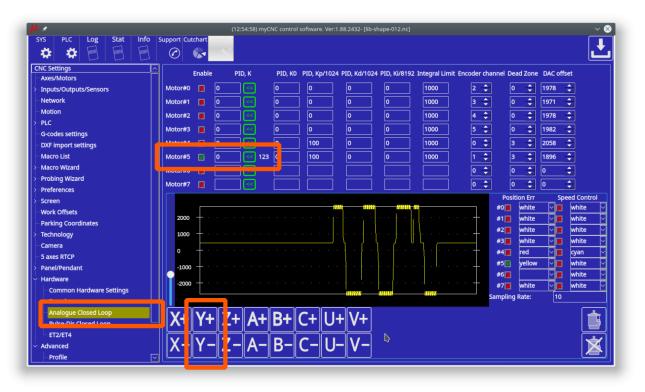


• Jog buttons can be used to move the axis while testing and tuning the PID coefficients.

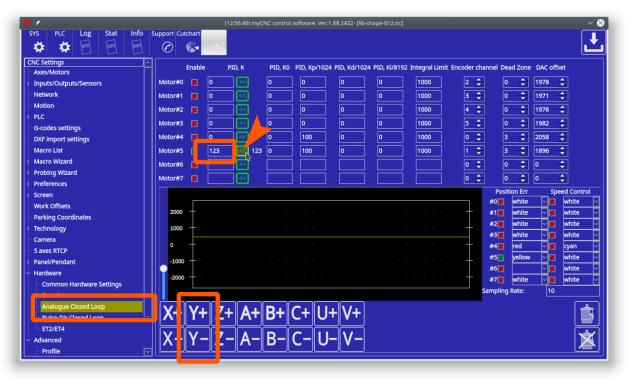
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CNC Se	ettings					Enable		PID, K			1024 PID, Kd/102		02 Integral Lin	ait Encodor d	hannel Dea	d Zopo	DAC off		
Axes	/Motors						'	-10, K	P1D, K0		1024 PID, Kd/ 102	4 PID, KI/61							
>-Inpu	its/Outpu	ts/Sensoi	rs		Motor#0	×	0	<<	0	0	O	0	1000	2	0	÷	1978	÷	
- Netv	vork				Motor#1	×	0	<	0	0	0	0	1000	3	0	÷	1971	÷	
- Moti	on				Motor#2	×	0	~	0	0	0	0	1000	4	0	÷	1978	÷	
>-PLC					Motor#3		0	าส	0] [<u>o</u>		0	1000	5		÷	1982	÷	
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Park	ing Coord	linates			2000	+ ·								· · †	#1 📕	white	<u> </u>	white	<u> </u>
>- Tech	nology				1000							,			#2	white		white	
- Cam	era				o								ν.			white		white	<u> </u>
- 5 ax	es RTCP				V							· · · •	P			red vellow		cyan white	
>-Pane	el/Pendan	t			-1000) + ·								· · +	#5 <mark>1</mark> #6 1	yellow		white	
	lware				-2000	, + ·								· · -		white		white	
- o	ommon H	lardware	Settings				_								Sampling	L	10		
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	T2/ET4					ļ	ĴĮ						L)						2
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	meed						╢-											•	2

 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.



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.

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

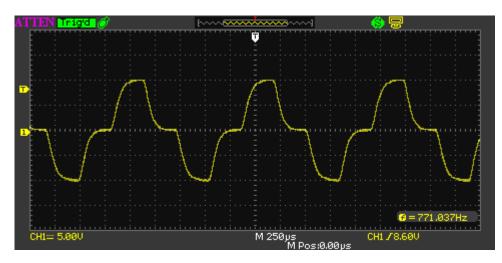
```
main()
{
   gvarset(60001,1); //turn Servo PIDs Off
   exit(99);
};
```

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.

IC Settings		Encode	r#0	Encode	er#1	Encode	er#2	Encode	r#3	Encode	r#4	Encoder	# 5	Encoder#6	Encode	r#7	Encode	r#8	Encod	er#9	Encode	er#10	Encod	er#1
Axes/Motors	ution	65536	\sim	2500	~	2500	~	2500	\sim	2500	\sim	2500	\sim	2048 ~	2048	\sim	512	~	512	~	512	~	512	~
Network		2046	_	2046	_	2046	_	2	-	2046	-	2046	1			_		_		_				
Motion		2040		2040		2040		1		2040		2040	-				-					_	-	
Hardware PLC		_	_	_				-															_	
oftware PLC		2	$\hat{}$	2 🗘	2	$\hat{}$	2	$\hat{}$	2	$\hat{}$	2	Ŷ	2	-										
i-codes settings		1	٢	1	٢	1	٢	1	٢	1	٢	1	$\hat{}$	1 0	1	٢	1	٢	1	٢	1	~	99	2
XF import settings		<u> </u>		<u> </u>		<u> </u>		<u> </u>	<u> </u>	<u> </u>	~	<u> </u>	×	· · ·	· · ·		<u> </u>		<u> </u>		<u> </u>	Ľ		`
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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.

references Profi	ile Macro	s PLC B	uilder Ax	es/Motors	s I	nputs/Se	ensor	rs Te	chno	ology	Net	work	Car	mera	5 ax	es RTC	P	Panel/	Pendar	it F	Hardware	Advanced	
Common Hardware	Settings	Encoders	Analogue	Closed L	.oop	Pulse	-Dir C	Closed L	oop	ET2	/ET4												
	Encoder#0	Encoder#	1 Encoder#	2 Encode	er#3	Encode	r#4∣	Encoder	r#5	Encode	er#6	Encode	r#7	Encode	er#8	Encode	er#9	Encod	ler#10	Enco	der#11		
Encoder Resolution	2500 👻	2500 -	2500 👻	2500	•	2500	•	2500	-	512	•	512	•	512	-	512	-	512	•	512	-		
Current value Z position	9839	467	9980		_								-				_						
Mul	2	4	2	2	•	2	+	2	\$	2	-	2	*	2	-	2	\$	2	-	2	\$		
(2^Div)	1	1	1 (1	-	1	÷	1	-	1	*	1	-	1	-	1	-	1	-	99	\$		
Encoder Position Position																							
Attached 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	Macros	5 PLC B	uilder	Axes/Motors	Input	s/Sensors	Techn	ology	Network	Camera	5 axes RTCP	Panel/Pendant	Hardware	Advanced	
Common	Hardware Se	ttings	Encoders	Analog	ue Closed Lo	op Pu	ulse-Dir Clo	sed Loop	ET2	/ET4						
	PID Enable	PID, KO	PID, Kp	PID, Kd	PID, Ki I	ntegral	Limit Enc									
Motor#0								12 🌲	J	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

From: http://docs.pv-automation.com/ - myCNC Online Documentation

Permanent link: http://docs.pv-automation.com/mycnc/closed_loop_configuration?rev=1539108455

