

National Centre for Radio Astrophysics

Internal Technical Report

Analysis and comparison of OLD PMAC(from m/s Maccon) and NEW PMAC (from m/s Delta tau)

Giant Metrewave Radio Telescope

Tata Institute of Fundamental Research

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I variable configuration

Basic I variable's configured are same for both the PMAC

I Variable	Value	Description
1100	1	To activate motor 1
		connected
18000	\$78000	Conversion table setup line.
		Configures 1/T extension of
		Encoder 1. \$ represents value
		is in hexadecimal
lxx24 (l124)	\$20001	Motor Flag control mode.
For motor 1		Configured for PMAC2 style
		servo IC. Hardware position
		limits are disabled
I7mn6(I7016)	1	Channel output configured as
For servo IC 0 channel 1		DAC output instead of PWM
lxx03 (l103)	\$3501	Position loop feedback
For motor 1		address configured for
		configured for conversion
		table line 0
lxx04 (l103)	\$3501	Velocity loop feedback
For motor 1		address configured for
		configured for conversion
		table line 0

DAC Calibration test

We are using output channel of PMAC in DAC mode (Refer I7mn6 variable mentioned earlier). DAC offset can be compensated for with Ixx29.

Procedure to calibrate DAC manually,

- 1. Issue a #100 command(zero percent torque command). If there is an offset motor will start rotating
- 2. If the motor moves in the positive direction, decrease Ixx29 appropriately until #no0 produces no motion
- 3. If the motor moves in the negative direction, increase Ixx29 appropriately until #no0 produces no motion

OLD PMAC	NEW PMAC
1129=-100	1129= -90

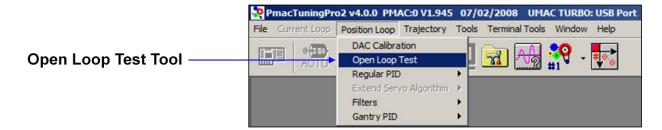
Inference from above test:

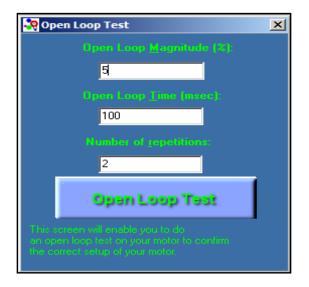
By changing value of Ixx29 initial offset of PMAC DAC output channel (Which is connected to Analog input channel of Servostar) can be minimized

Open loop test

Purpose of open loop test

The Open Loop Test makes sure that when outputting positive command, the encoder position count also goes up.

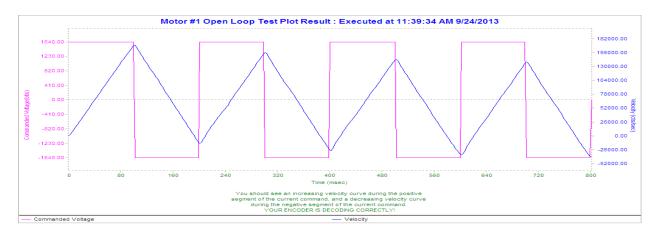




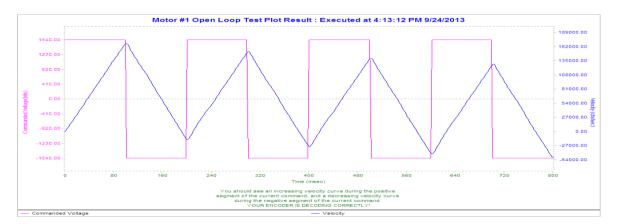
I variable to be configured in PeWin32-pro terminal window for doing open loop test

I variable	Value	Description
I7mn6 (I7010)	3	x4 quadrature decode CW.
		x4 quadrature decode:
		Signfies multiplication of
		counts per revolution it gets
		from Servostar by 4
		Counts per revolution in SS:
		4096
		Counts per revolution in
		PMAC: 16384 (4096*4)
		CW:
		Refer plot given

New PMAC plot



Old PMAC plot



Inference from open loop test

For positive segment of current command voltage increasing velocity curve is observed, and a decreasing velocity curve during the negative segment of the current command.

In above graph,

Current command voltage is represented by square wave

Velocity curve is represented by triangular wave

Tuning PMAC

Auto Tuning

Under PEWIN32PRO2, Tools menu, PMAC Tuning Pro2

PmacTuningPro2 v4.0.0 PMAC:0 V1.945 07/02/2008 UMAC TURBO: USB Port
File Current Loop Position Loop Trajectory Tools Window Help
AUTO INTER AUTO INTER 🛄 🖬 🚧 👯 - 🌄
Auto Tuning for Position

Following steps are done as part of tuning process. Comparative plots and images are given along with steps for old and new PMAC

1. Preliminary parameters setting:

New PMAC

😽 PID AutoTuning Motor #1	
Amplifiter Type	Auto-Tune Parameters
Current Loop	Max Excitation Magnitude*(%)
C Velocity Loop	*Exercise Caution! - See manual
Design Goals	
BandWidth (Hz): 8	Excitation Time (ms): 50
	1000
L	Maximum Motor Travel (cts): 4000
Damping Ratio: 0.6	Minimum Motor Travel (cts) : 400
<u> </u>	
Auto-Select BandWidth	PID Advance Options
Auto-Select Sample Period	
Include Low Pass Filter	
,	
Velocity Feed Forward	
Acceleration Feed Forward	<u>A</u> utoTune
Integral Action	
🔽 None	
	Exit
	<u> </u>

Old PMAC

RID AutoTuning Motor #1		
Amplifiter Type	Auto-Tune Parameters	
 Current Loop Velocity Loop 	Max Excitation Magnitude*(%) 10	
Design Goals	*Exercise Caution! - See manual	
BandWidth (Hz): 8	Excitation Time (ms): 50	
	Maximum Motor Travel (cts) : 400	0
Damping Ratio: 0.6	Minimum Motor Travel (cts): 400	
Auto-Select BandWidth Auto-Select Sample Period Include Low Pass Filter	PID Advance Options	
 Velocity Feed Forward Acceleration Feed Forward 	<u>A</u> utoTune	
Integral Action		
View None		
	Exit	

2. Click on Auto tune button gives required PID values for PMAC

New PMAC

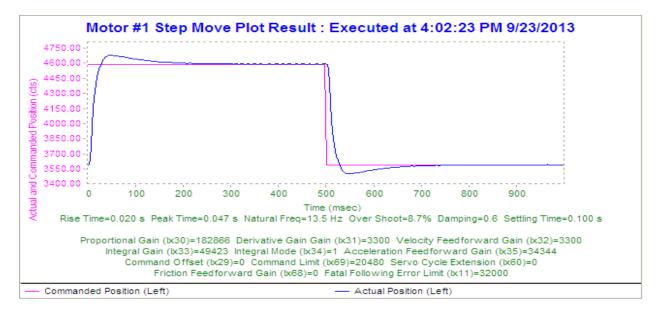
🦃 PID Interacti	veTuning Motor	#1						
Present PID Ter		Implement Auto	p-Tuning Gains	uning Gains				
Іхх30 (Кр)	182866		riginal Gains	Step Size (cts):	1000			
lxx31 (Kd)	3300		-	Step Time (ms) :	500			
lxx32 (Kvff)	3300	Trajectory Selection	iagram					
lxx33 (Ki)	49423	Position St						
Ixx34 (IM)	1	C Position Rar	•		tep Move			
lxx35 (Kaff)	34344			DUA	Teb Mote			
lxx29	0	C Parabolic V		☐ Kill Motor After Step Move ☐ <u>M</u> ove in one direction				
lxx69	20480	C Trapezoidal						
lxx60	0	C S-Curve Vel	ocity					
		C Sinusoidal						
lxx68	0	C Sine Sweep		Left Axis Plot				
lxx11	32000	C User Define	d	Position	•			
			(Right Axis Plot				
Kill M	otor #1	<u>N</u> otch Filter Calculator	Low Pass Filter Calculator	None	-			
<u> </u>	E <u>x</u> it	Notch/Low Pass Filter Setup						
~~	>>	Notch/Low Pass I						

Old PMAC

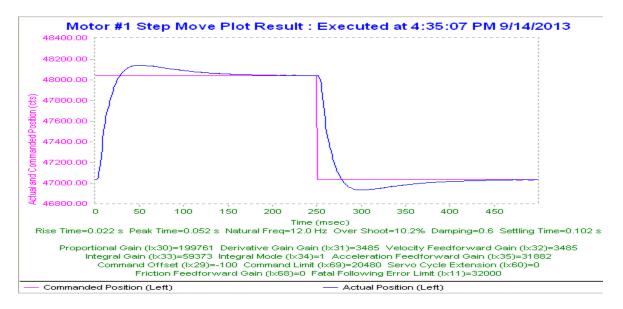
	tiveTuning Motor	#1							
Present PID To		Implement Auto	o-Tuning Gains	Parabolic Move					
Ixx30 (Kp)	199761	Emprement Auto	per uning dams	Move Size (cts):	4000				
lxx31 (Kd)	3485	I <u>m</u> plement O	riginal Gains	Move Time (ms):	1500				
lxx32 (Kvff)	3485		iagram						
lxx33 (Ki)	59373	Trajectory Selection							
Ixx34 (IM)	1	C Position Step			-L-E- M				
lxx35 (Kaff)	31882	C Position Rar		Do A Par	abolic Move				
1xx29	-91	© Parabolic		Kill Motor After Parabolic Move					
lxx69	20480	C Trapezoidal	-	Move in only one direction					
1xx60	0	C S-Curve Vel	ocity	🔽 Dwell Time After	Move 500 (ms)				
14400		Sinusoidal							
lxx68	0	C Sine Sweep		Left Axis Plot					
lxx11	32000	C User Define	d	Velocity	•				
				Right Axis Plot					
Kill Motor #1		<u>N</u> otch Filter <u>L</u> ow Pass Filter Calculator Calculator		Following Error	•				
E <u>x</u> it				Coordinate System					
		Notch/Low Pa	Notch/Low Pass Filter <u>S</u> etup						
<u> </u>	>>	Notch/Low Pass F	Filter Inactive						

3. Once required PID values are obtained give 'Do a Step move' command to get step response

New PMAC



Old PMAC



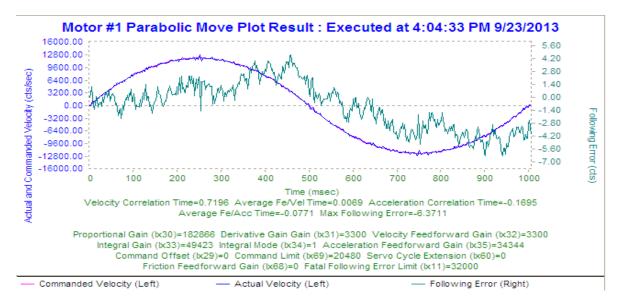
Inference from Step response test

Plot shows Actual and Commanded **position** on Y-axis with respect to **time** on X-axis. From step response plot obtained it can be seen that transient parameters measured (peak overshoot, Tr, Tp) for new PMAC is within permissible limits.

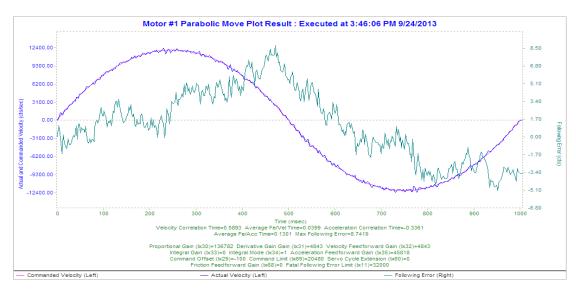
Response can be fine tuned further by changing PID gain values.

4. Give 'Do a Parabolic move' to obtain Parabolic response





Old PMAC



Inference from parabolic response test

Plot shows Actual and Commanded **velocity** on Y-axis with respect to **time** on X-axis. Difference between Actual and Commanded velocity (i.e) **following error** is also plotted. Scale for following error is magnified for better understanding. Axis for following error is on right hand side of plot.

Data gathering

PMAC can acquire data from any of its memory addresses at a sampling period as low as the servo period (I variable used: I5049)

PMAC can upload gathered data to the host software to generate plots and tables to be used for analysis

From within PeWin32Pro2, click Tools \rightarrow PMAC Plot Pro2:

🔏 P	EWIN32	PRO2 [C:\P	ROGRAM FILES	DELTA T	AU\PM	AC EXECUTIVE	PRO2 S	UITEVPE	WIN32PRO	2\PEWIN	32PRO2_	Default. IN
File	Terminal	Configure	View	PMAC Resources	Backup	Setup	Tools Window	Help					
							PMAC DPRAM	Test					
							PMAC Basic IS	peed Test					
							PMAC Plot Pro	2					
							PMAC Tuning	Pro2					
							P1Setup Pro2						
							P2Setup Pro2						
							Turbo/UMAC S	Setup Pro2	2				
							UmacConfig P	ro2					
							Geo Brick Setu	ιp					
							Geo Brick LV S	etup					
							Raw Terminal						
							Customize Too	ols Menu					

Gathering within a Motion Program

Procedure:

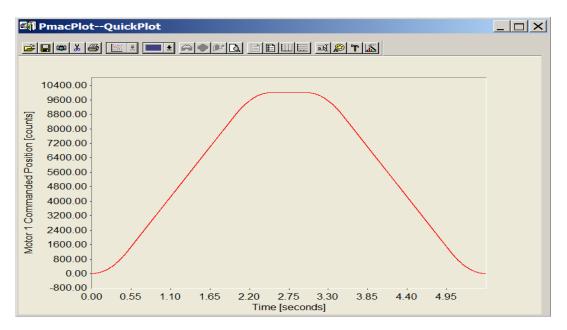
On the Quick Plot screen, choose to plot "Mtr 1 Cmd Pos" on the Left Plot Axis by clicking on it and then "Add to Left".

Open Save Configure	4.2.0 3/4/2008 UMAC(0)	
Quick Plot	Detail Plot	About
Plot Title		
Left Plot Axis Mtr 1 Cmd Pos	Possible Choices: Mtr 1 Act Pos Mtr 1 Act Vel Mtr 1 Act Accel Mtr 1 Act Jerk	Motors to Gather
Right Plot Axis	Mtr 1 Cmd Accel Mtr 1 Cmd Jerk Mtr 1 Fol Err Mtr 1 Cmd Vel	Begin Gathering End Gathering
Remove Item >>	< Add to Left	Gather Time 0:00:00 ms Upload Data
E <u>x</u> it Open Help	< Add to Right	Plot Data
Horizontal Axis:	Time (sec)	•

Then, minimize the window, open a new Editor window, and download the code given below on to the PMAC.

```
Undefine All ; Undefine all coordinate definitions
 End Gat; End any data gathering that might be happening presently
 Del Gat; Erase any defined gather buffer
Close ; Make sure all buffers are closed
                     ; Coordinate System 1
; Assign motor 1 to the X-axis - 1 program unit
&1
#1->1000X
                     ; of X is 1000 encoder counts of motor #1
 Open Prog 1 Clear ; Open buffer for program entry, Program #1
Linear ; Blended linear interpolation move mode
Abs ; Absolute mode - moves specified by position
15.0; Set no S-curve acceleration timeF 5; Set feedrate (speed) of 5000 units(cts)/secCMD"End Gat"; Stop gatheringCMD"Del Gat"; Deletes the gather bufferCMD"Def Gat"; Allocates all the available memory as gather bufferDwell 0; Force CMD lines to executeCMD"Gat"; Starts gathering of the dataDwell 0; Force CMD lines to executeX 10; Move X-axis to position 10000Dwell 500; Stary in position for 1/2 sec (500 msec)X 0; Move X-axis to position 0Dwell 0; Force CMD lines to execute
                     ; Set 1/2 sec (500 msec) acceleration time
; Set no S-curve acceleration time
TA 500
Dwell 0; Force CMD lines to executeCMD"End Gat"; Send On-line command to stop data gatheringDwell 0; Force CMD lines to execute
Close
                     ; Close buffer - end of program
```

- Click 'Begin gathering' to start gathering of data in plot pro window
- > Run the program by entering **&1 b1 r** into the Terminal window
- Click on 'End gathering' to stop gathering and then upload data using "Upload Data"
- > Then, click "Plot Data", and the following plot should load:



Inference from data gathering procedure and plots

Procedure to gather data and plot it using plot pro utility is same for new PMAC. Various parameters like motor velocity, position, acceleration and following error can be plotted using Plot-pro utility of PMAC.

Conclusion:

Preliminary tests done using New PMAC gives satisfactory results.

On account of this we can release payment to M/S Delta tau data systems India pvt. Ltd.

Further test includes integrating New PMAC into Antenna BLDC rack and loading Antenna PLC codes. This test will be done as soon as next BLDC rack is assembled.