

## Application Note #5521

### ALIO $\mu$ II (Micro2) Linear Stage and Galil High Performance Motion System

The  $\mu$ II linear stage is part of a family of products from [ALIO Industries](#) that has micron precision with travel ranging from 100mm to 1meter. The stages can be used in a single axis setup or in various other configurations such as stacked in an XY orientation or in parallel for gantry operation. This provides the user with a lot of flexibility on how to set up their motion system. The  $\mu$ II stage can be coupled with a Galil controller and drive for an easy-to-use high performance motion system.



Single Axis Galil DMC-30012 Controller and Drive with  $\mu$ II Linear Stage

The [DMC-30012](#) uses a built-in sinusoidal PWM servo amplifier running a current loop at 33kHz. This provides smooth motion with high responsiveness in the motor. In order to run multiple servo motors, the [DMC-40x0](#) or [DMC-41x3](#) multi-axis controllers with the D3540 sinusoidal servo amplifier can be used to achieve a multi-axis coordinated motion system.

## PROGRAMMING & SETUP

At power up, the controller goes through a small initialization procedure to auto-commutate using the BX command. In the motor under test, the BM (Brushless Modulus) was set to a value of 30.48mm (BM 304800 with an encoder resolution of 0.1 $\mu$ m per count). Here is a sample program to initialize the motor and get it to move 50mm back and forth:

```
#alio
JS #init
JS #params
JS #loop
EN
#loop
PR 500000;BG A;AM A;
WT 1000
PR -500000;BG A;AM A
WT 1000
JP #loop
EN
#params
m= 1000000
k= 100000
SP 3*m
AC 50*m
DC 50*m
KP 50
KD 110
KI 2
EN
#init
'INIT
MO
AG 0
AU 1
TL 8
BA A
BM 304800
BX 3
SH A
MG "INITIALIZATION COMPLETE"
EN
```

**Notes:** The  $\mu$ II linear servo motor under test had a 3.2A continuous current rating so a Torque Limit (TL) was set to 8 (80% of max) with the amplifier gain (AG) set to the lowest setting of 0 (4Amp max output). The command to set the peak torque value on the controller is TK. This can be set to 9.9 (99% of max) for peak torque of 4Amps. A higher AG setting could be used to achieve higher peak torque as long as the TL value is reduced to limit the continuous current to the motor.

## SAMPLE MOVES

Move and settle for 50mm move (24V supply, 0.1 $\mu$ m resolution)

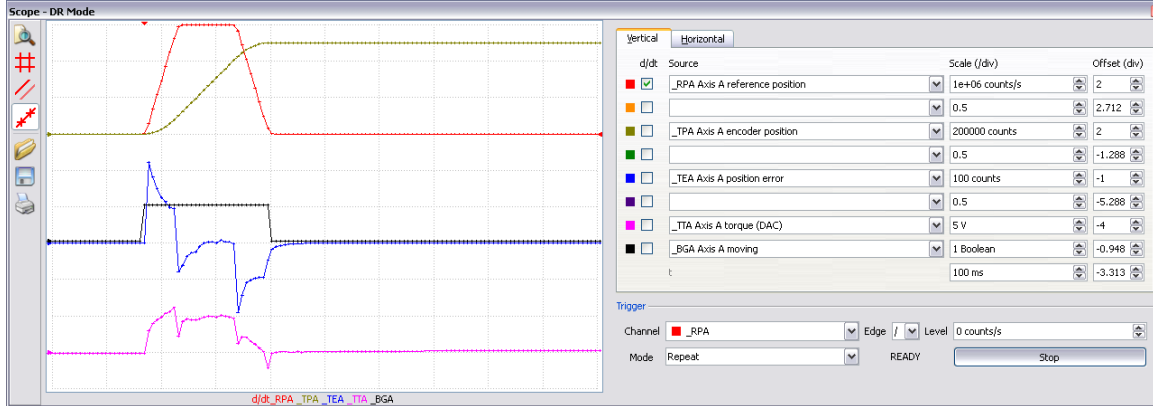
PR 500000 cts (0.050meters)

SP: 3M cts/sec (0.3 meters/sec)

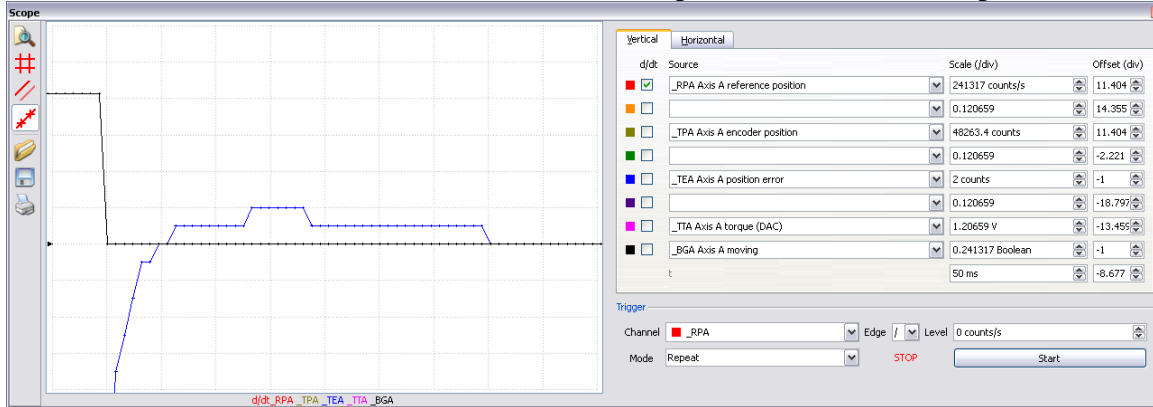
AC/DC: 50M cts/sec

TM1000;AG0;KP50;KD 110;KI 2

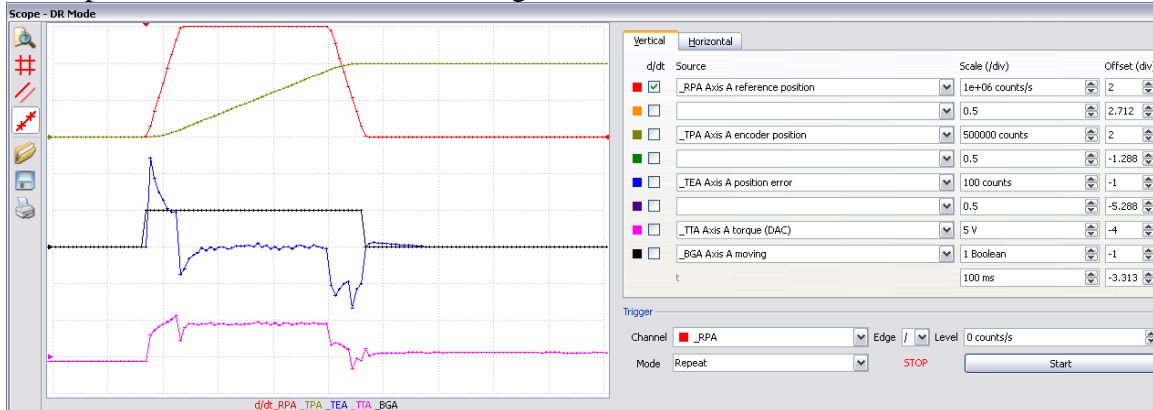
Total time for move and settle is 250msec.



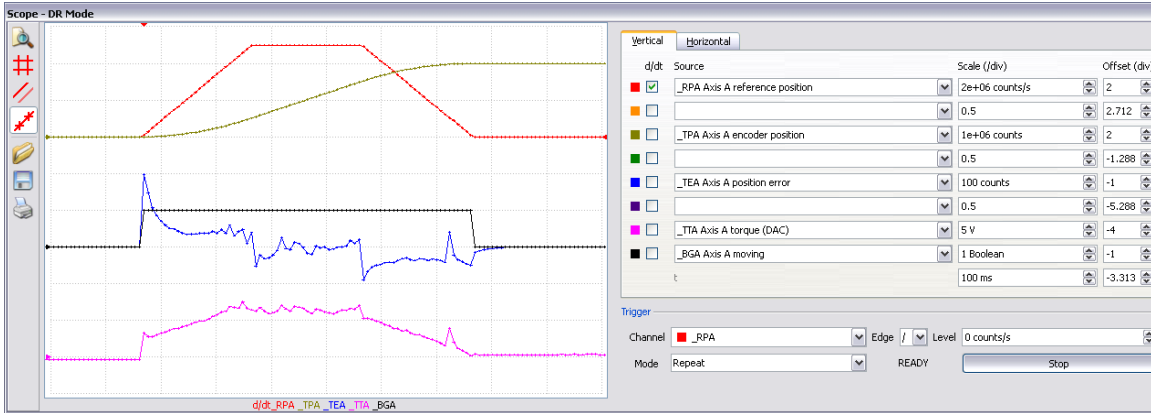
Zoomed in on settling time showing error of less than  $\pm 0.2\mu$ m within  $\sim 25$ msec of the end of the move. Black shows end of move, blue is position error. 50msec per division.



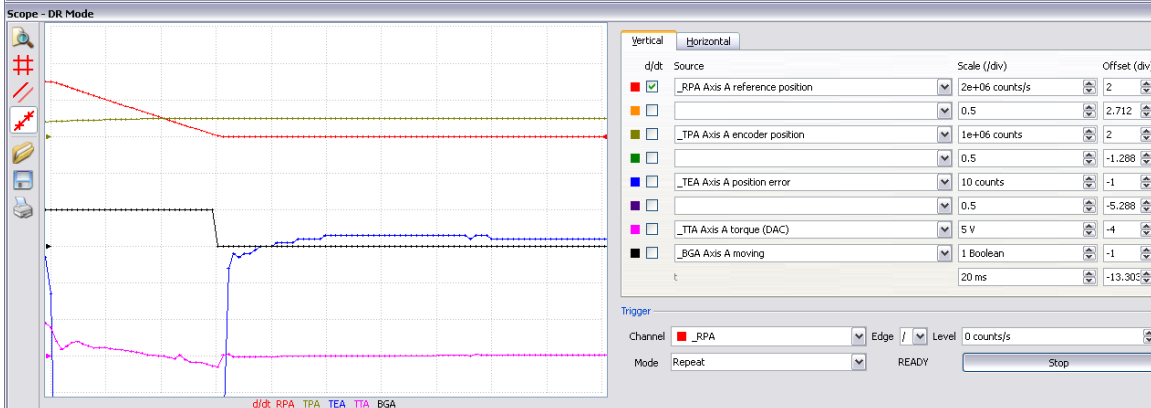
Same parameters as above but extending the move to 100mm:



Longer Move (200mm at 0.5meters/sec)  
 AC/DC: 25M cts/sec  
 SP: 5M cts/sec  
 PR: 2M cts/sec



For higher performance systems, the TM update rate can be lowered to 250usec. This can allow for faster settling times. Here is the same short move (50mm at 0.3m/sec) showing the stage falls within +/-0.5  $\mu\text{m}$  of the final position within 10msec of the end of the move.



The parameters used for the higher performance system are:

TM250

KP 50.00

KD 340.00

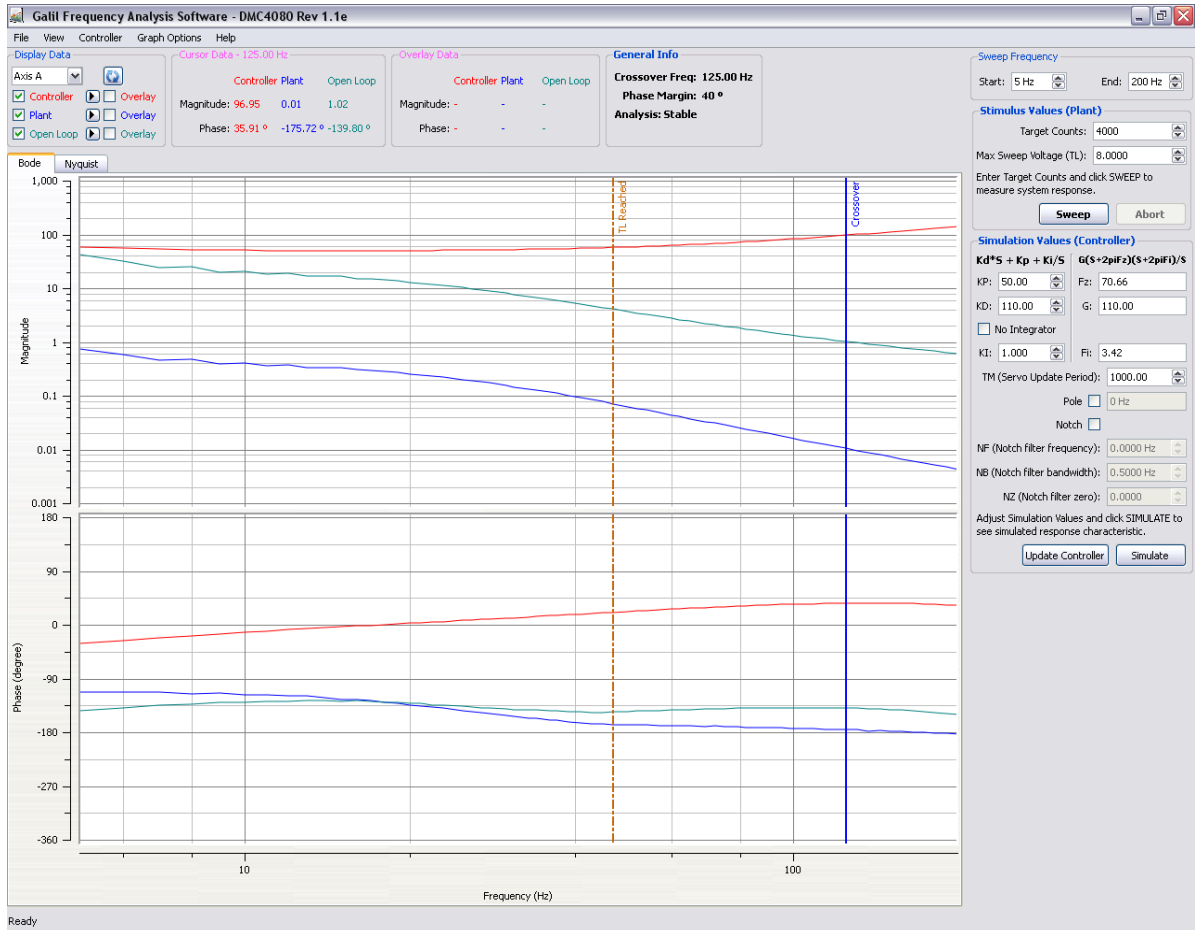
KI 0.5000

A pole filter (PL) may also help to reduce unwanted high frequency oscillation from occurring.

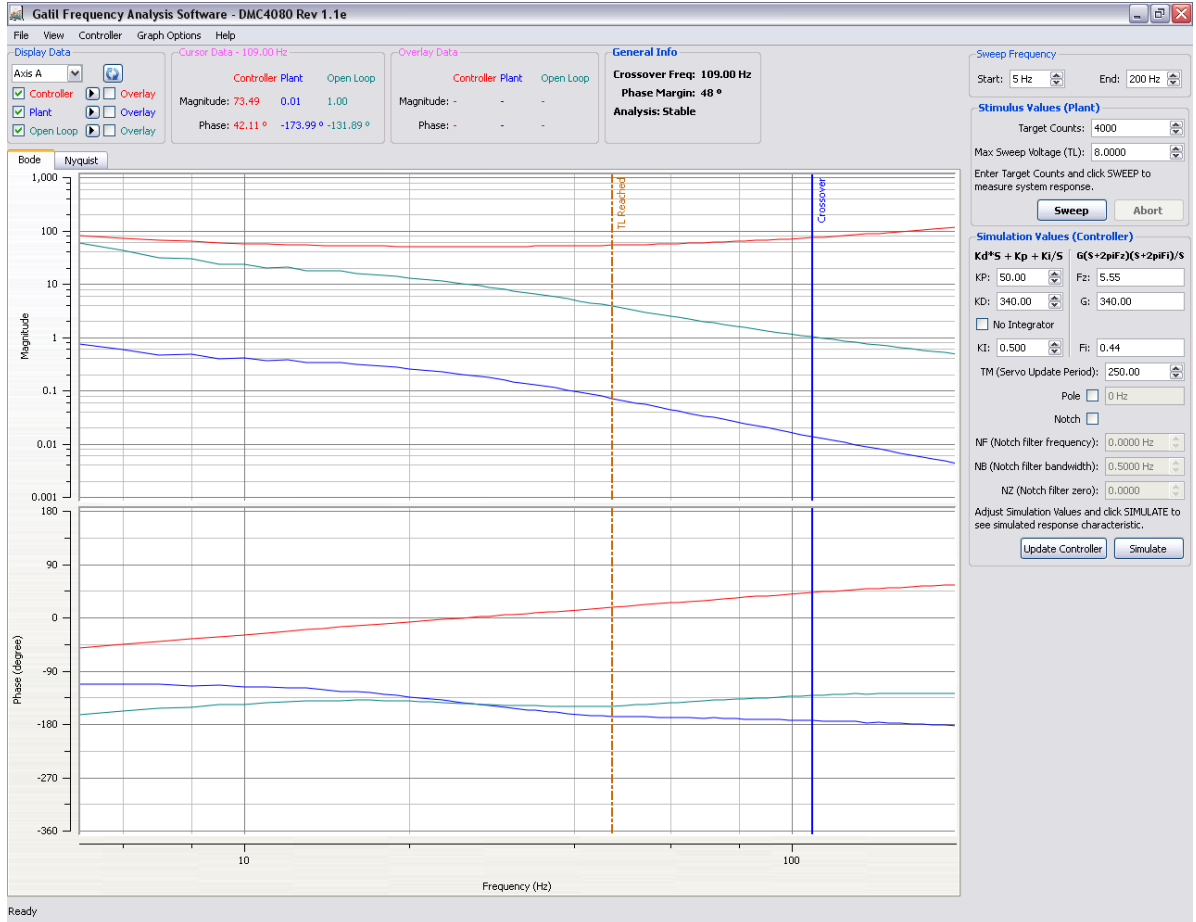
## FREQUENCY ANALYSIS

The following shows the Galil FAS (Frequency Analysis Software) that can be run on a DMC-40x0 or DMC-41x3 multi-axis controller. The software shows the Bode plot of the stage and its frequency response characteristic including the crossover frequency and phase margin.

FAS with TM1000:



## FAS with TM250:



## MOTOR SPECS AND PINOUT

Motor as tested had the following characteristics from ALIO  $\mu$ II datasheet:

Force Constant	lbf/A	6.4
Phase Resistance (@ 25degC)	Ohms	11.74
Inductance (@ 1kHz)	mH	2.3
Continuous Force	lbf	20.9
Continuous Current	A	3.25
Back EMF Constant	V/inch/s	0.7

Motor Wiring was in a Delta configuration and had the following connections to Galil:

Galil Phase	ALIO	Color
A	R	WHT/YEL
B	T	BRN/BLK
C	S	BLU/RED

## CABLES

ALIO Industries can provide a cable that converts the Renishaw Encoder to Galil 15pin High Density D-sub for an easy connection. The ALIO part number of this cable is **0061-03081**. Contact ALIO for more information on the cable specification.

## ENCODER PINOUT

Encoder as tested was a 0.1um Renishaw [TI0200A50A](#) with quadrature incremental output as shown here:

Digital outputs		Interface	
		TI0004 - TI20KD	TD4000 - TD0040
Function	Signal	Pin	Pin
Power	5 V	7, 8	7, 8
	0V	2, 9	2, 9
Incremental	A+	14	14
	A-	6	6
	B+	13	13
	B-	5	5
Reference mark	Z+	12	12
	Z-	4	4
Limits	P+	11	-
	Q	10	-
Set-up	X	1	1
Alarm <sup>‡</sup>	E+	-	11
	E-	3	3
Resolution switching <sup>‡</sup>	-	-	10
Shield	Inner	-	-
	Outer	Case	Case