

## Application Note #5495

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### Connecting a Galil Controller & Drive to H2W Voice Coil Linear Actuator

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This application note describes the connection of the H2W Technologies voice coil positioning stage (Part Number VCS03-050-CR-001-C) to a Galil controller and amplifier. The complete specifications on the voice coil actuator can be found directly from the H2W website located here:

A picture of a H2W voice coil actuator is shown here:



Some key benefits of voice-coil linear actuators are:

- 1) High bandwidth (ie: high velocity and high acceleration capability)
- 2) Precise positioning in a compact size
- 3) Force control capability
- 4) High reliability & low maintenance

## PRODUCT LINE-UP

A standard “brush” style servo amplifier can be used to control a voice-coil – however for PWM servo amps, the switching frequency and ability to handle low inductance motors is critical to avoid over-heating. Galil has multiple amplifier options for connecting a voice-coil linear actuator including the -D3040 or the -D3540 (graphs of performance are shown below). These units can handle 500 to 600W of power per axis with up to 8 axes per controller.



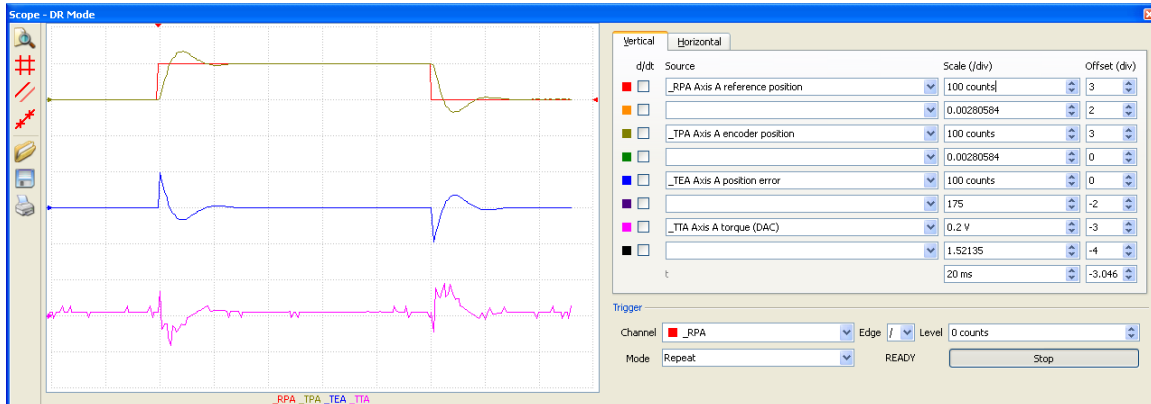
For very low current/low force applications (ie: under 20W) a “linear” amplifier can give the benefit of having high bandwidth and no PWM switching noise. This can be accomplished with the -D3140 or the -D3640 (with a special modification to get a “brush-only” version – contact Galil for more details)



For single axis applications the DMC-30012 is a controller/amplifier combination that has similar characteristics as the -D3540 amplifier but with higher current capability (800W).

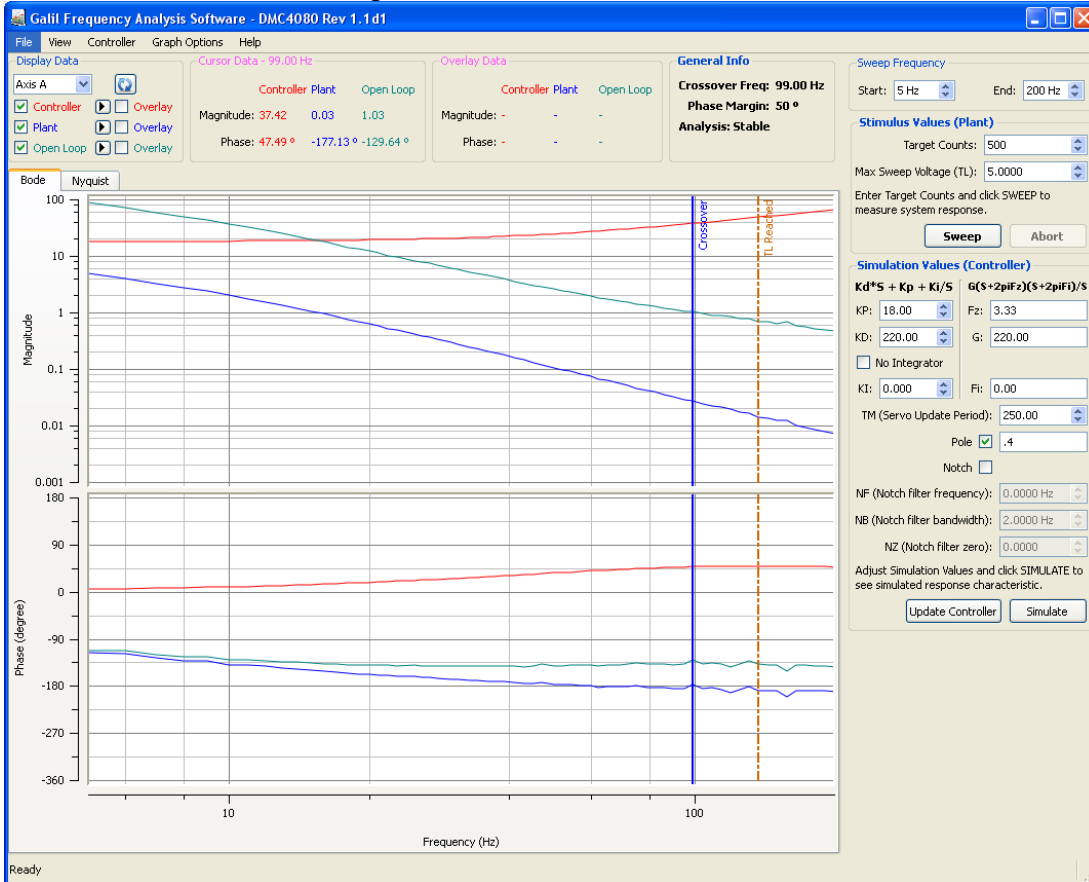
## ANALYSIS TOOLS

Using the GalilTools software, finding desirable PID gains is straight-forward by using the scope tool to watch the step response of the actuator. Due to the high bandwidth capability, it is recommended to adjust the update rate (TM) of the controller down from the default of 1msec to 500usec or lower. By adjusting the TM and PID gains, the following step response for the actuator was achieved:

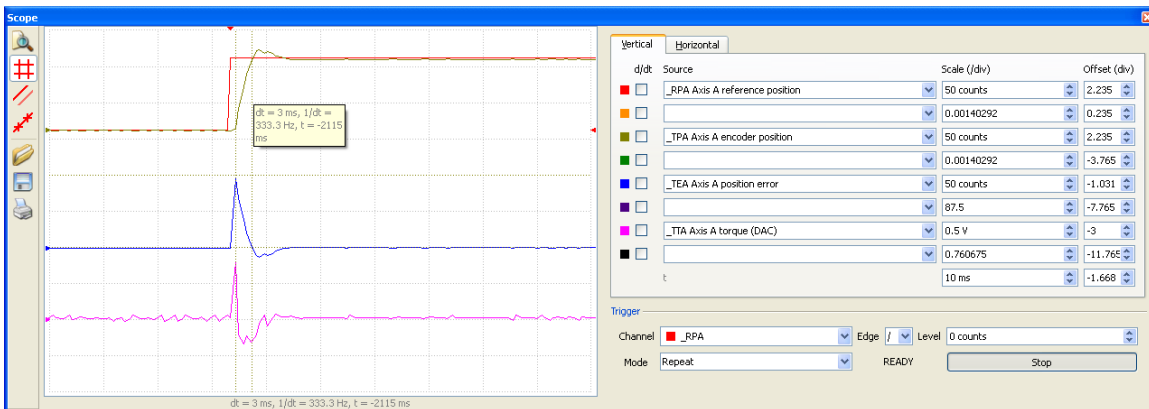


**D3040 Amplifier Step Response with Tuning parameters of TM250;KP8;KD106;KI0.1**

Galil's Frequency Analysis Software (FAS) allows the user to plot in the frequency domain by running the actuator through multiple frequencies and measuring the response. "Simulation" mode lets the user adjust the PID values and see how the Bode plot will change without re-running the hardware sweep. FAS is available for the DMC-40x0 and DMC-41x3 controllers and gives the following Bode plot for this linear actuator connected to the -D3040 amplifier:

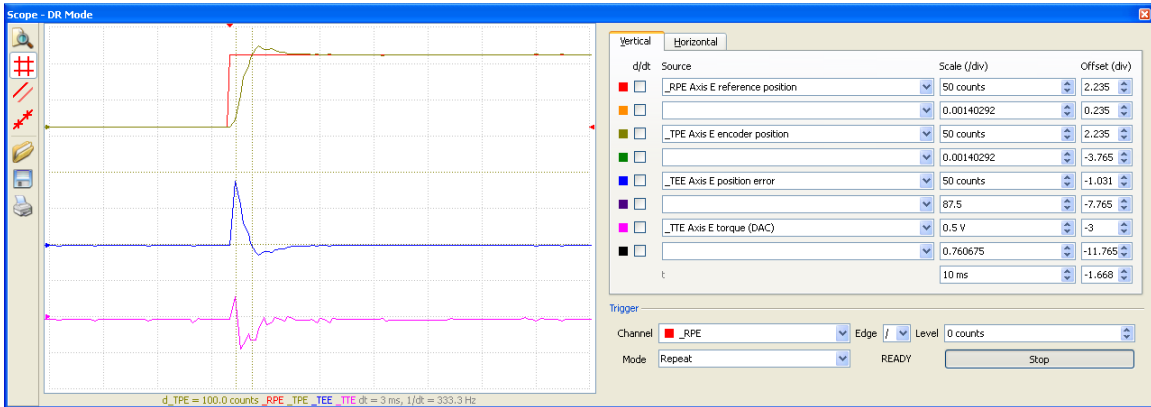
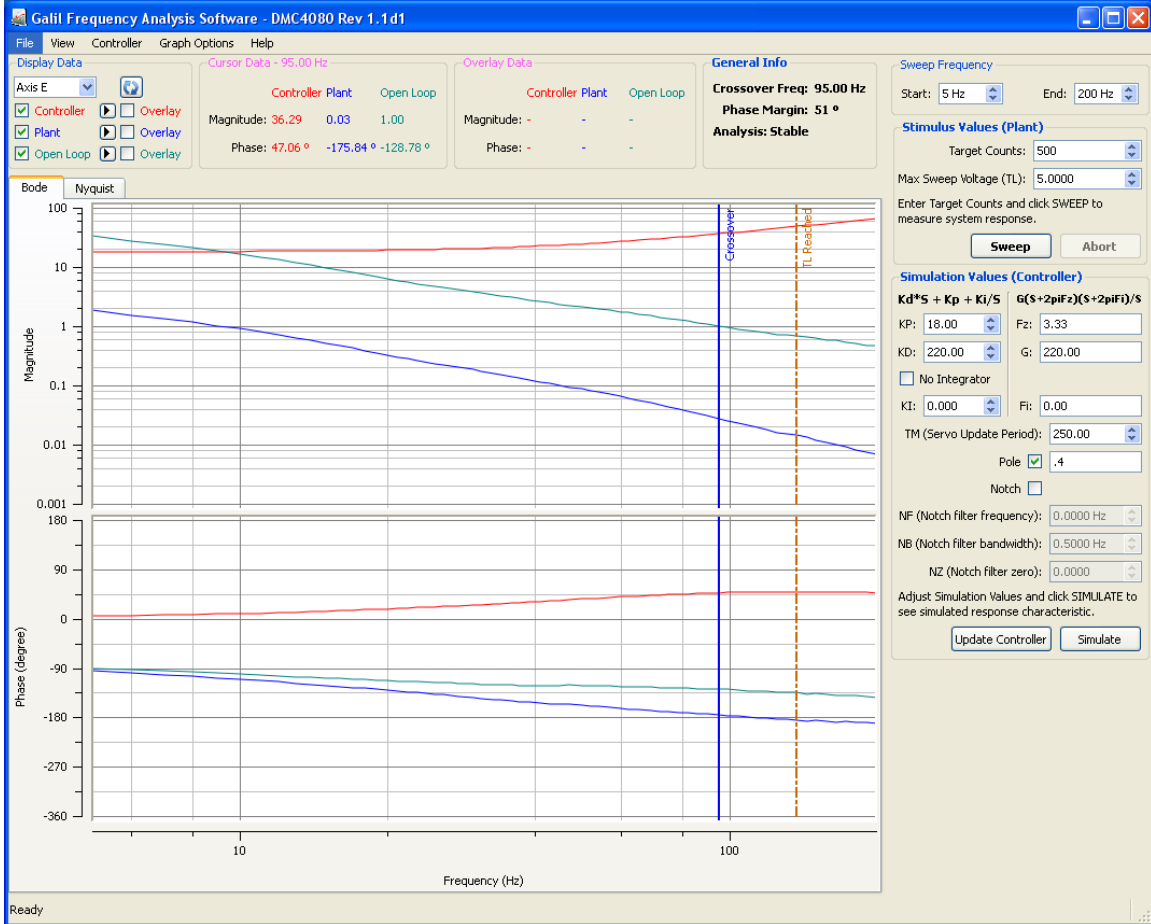


Adjusting the PID's and adding a PL filter of 0.4 to filter "high frequency" noise shows a good response characteristic with high bandwidth and a stable phase margin. Sending these parameters to the controller, a new step response can be grabbed using GalilTools.



**D3040- Step response with TM250; KP18;KD220;PL.4**

Switching over to the D3540 amplifier (gain of AG0 and TL5). The FAS plot is shown here:



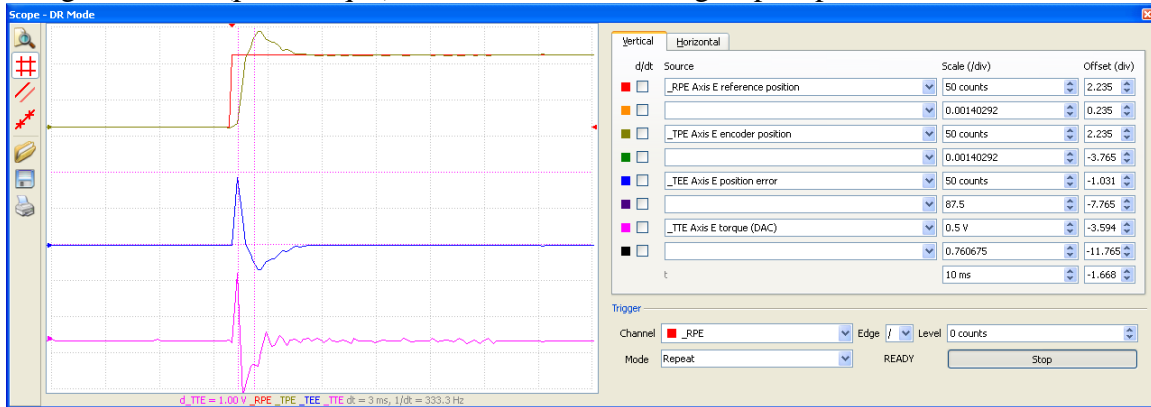
**D3540 – Step Response with TM250; KP18;KD220;PL.4**

As a recap, the following parameters were applied:

TM250	KD*=220	AG*=0
TL*=4.8	KI*=0	AU*=1
KP*=18	PL*=.4	BR*=1

Note: on the unit under test, the actuator had a 1.0 micron resolution encoder.

For those needing an integrator term for steady state error, a small KI of 0.2 was added along with a TK (peak torque) of 9.9 and the following step response was achieved:



## SAMPLE APPLICATIONS

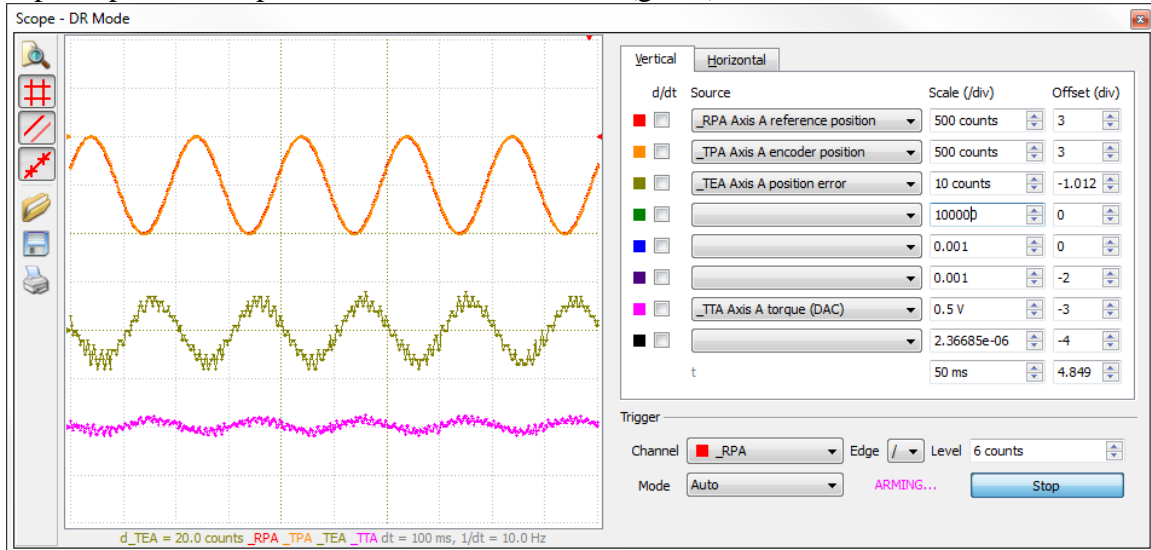
One typical application for a voice-coil is for life testing of a product by stretching, compressing, bending or flexing it for a determined number of cycles to simulate the use over the lifetime of the product. This can be in the millions of cycles - running 24hours a day, 7 days a week for up to a year or more. A sample program to run a continuous sine wave on the Galil controller is shown here:

```

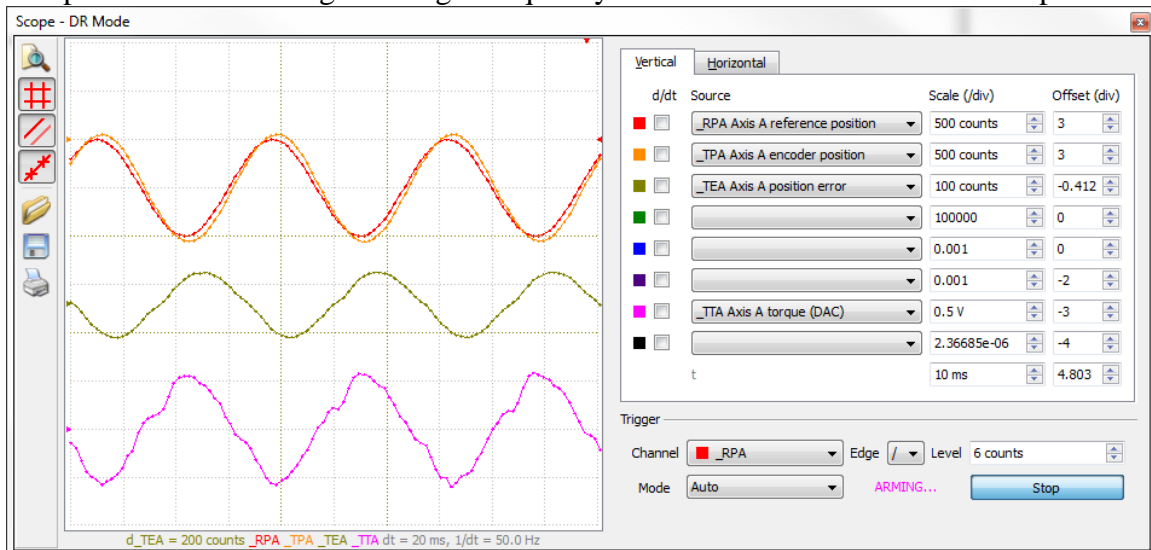
*****
'Description:
'This program produces a sine wave of a desired amplitude and frequency
'sine motion will go on continuously unless go=0 is entered into terminal
*****
#sine
SH A;      'turns on motor A
amp= 100;  'half of amplitude (in counts)
freq= 10;  'frequency in Hz
rate= freq*amp*6.2832;  'calculates correct speed
VS_rate
'set VA and VD if non-standard accel and decel are needed
#a
DPA= 0;    'sets position to zero- not necessary
#init
go= 1
'sine wave on "A" axis
VM AN
CR amp,0,360;  '1 sine wave to get started
BG S;        'starts motion
#1
CR amp,0,360;  'add 1 sine wave continuously
#wait
JP #1, _LM>1;  '_LM shows how many segments in buffer
JP #wait,go=1; 'continue adding sine waves until go=0 is entered
#stop
ST;         'stops motion
AM S;      'waits for motion to complete
VE;       'ends vector mode
CS S;     'clears all sine waves out of vector buffer
MG "FINISHED"
EN

```

Running the above program at a frequency of 10Hz and an amplitude of 1000cts gives the following plot where the reference (red) and actual (orange) positions are superimposed on top of each other and the error (green) is the difference between them:



The plot is shown here again using a frequency of 25Hz and the same 1000ct amplitude:



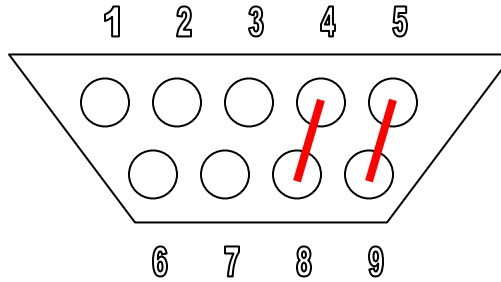
The parameters used in this test are shown here:

```
#init
MO
TM 500
TLA= 4.8
KPA= 30
KDA= 160
KIA= 0.1
PLA= .5
ACA= 0
AUA= 1
BRA= 1
SH A
EN
```

## CONNECTIONS

The wiring diagram of the system is shown here:

### MOTOR CONNECTIONS FOR 9 PIN "D" MALE



H2W PIN	FUNCTION	D3540 or DMC-30012	D3040 or CDS-33010
1	NOT CONNECTED		
2	NOT CONNECTED		
3	NOT CONNECTED		
4	Motor 1	Phase A	Phase B
5	Motor 2	Phase C	Phase A
6	NOT CONNECTED		
7	NOT CONNECTED		
8	Motor 1	Phase A	Phase B
9	Motor 2	Phase C	Phase A

Encoder connections:

Renishaw RGH41 Color	Signal	Galil 15pin High Density
BRN	+5V	15
WHT	GROUND	5
GRN	CH A+	3
YEL	CH A-	8
BLU	CH B+	2
RED	CH B-	7
VIO	CH Z+	1
GRY	CH Z-	6

**Conclusion**

For short stroke, high precision, high bandwidth applications – a voice coil linear actuator is hard to beat. Coupling it with a Galil controller and drive, this combination is a high performance linear motion system that has the benefits of being easy to set up, easy to use, and extremely reliable.