SERVOTRENDS

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New DMC-40x0 Accelera Controller with Ethernet/RS232

Galil is pleased to announce their new DMC-40x0 controller family, the latest addition to its ultra high-speed Accelera line. The DMC-40x0 Ethernet/RS232 controllers follow the highly successful DMC-18x6 PCI controllers, which launched the Accelera series. Representing Galil's 5th generation of motion controllers, the Accelera series incorporate a powerful, 32-bit RISC-based microcomputer that delivers much higher speed and processing power than previous-generation controllers. Sizzling speed specifications include acceptance of encoder inputs of up to 22 MHz, servo sample periods as low as 32 microseconds, and command processing times as low as 40 microseconds for application programs.

While the DMC-18x6 controller resides in a PCI slot of a PC, the DMC-40x0 is a packaged controller unit that is designed to operate standalone or interfaced to a PC via its Ethernet or RS232 ports. The DMC-40x0 accepts either Ethernet 10Base-T or 100Base-T and provides two RS232 ports up to 115 kbaud.

Galil's DMC-40x0 is offered in one- through eight-axis formats and, like all Galil controllers, the user need only purchase the number of axis required. For example, a DMC-4030 would be specified for a 3-axis project and the DMC-4050 would be used for a 5-axis project. Multiple controllers can be synchronized for applications with more than eight axes. Each axis is user-configurable for stepper or servo motor operation, enabling the user to easily mix-and-match motor types in an application.

Like the highly successful DMC-21x3 series of controller n' drive sandwiches, the DMC-40x0 is available with mating multi-axis amplifiers. These amplifiers mount directly to the controller and eliminate wiring between the controller and drives. The first multi-axis drive product available for the DMC-40x0 is the AMP-43040 which is a 4-axis amplifier for driving servo motors. Two AMP-43040 4-axis drives install conveniently on a DMC-4080 8-axis controller. Each amplifier drives brush or brushless servo motors operating at up to 7 Amps continuous, 10 Amps peak, 20VDC to 80VDC. Future product releases will include drives for stepper motors.

DMC-4040 4-axis controller and DMC-4080 8-axis controller.

The DMC-40x0 provides optically isolated inputs and outputs for enhanced noise immunity. Standard, optically-isolated inputs for each axis include a forward limit, reverse limit and homing input. The controller also features 8 uncommitted isolated inputs and 8 uncommitted isolated, high-power outputs for the 1-through 4-axis models, and 16 inputs and 16 outputs for the 5- through 8- axis models. In addition, the DMC-40x0 has 8 uncommitted analog inputs, which allow the controller to interface with analog sensors such as joysticks and temperature sensors. Inputs from two separate encoders are available for each servo axis.

Standard servo loop features include advanced PID compensation, velocity feedforward, acceleration feedforward, integrator limits, notch filter, low-pass filter, and backlash compensation. Servo update rates as high as 32 kHz can be achieved.

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Galil Products are Available in RoHS

All Galil catalogued products are now available in RoHS. These RoHS boards are marked with a no-lead symbol.

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Also, the DMC-40x0 can be used with Galil's popular WSDK servo design software, which simplifies system set-up with "one-button" servo tuning and real-time display of position and velocity information.

The DMC-40x0 provides expanded memory for up to 510 symbolic variables, 16,000 array elements in 30 arrays, and application program space for up to 2000 lines x 80 characters. The controller also allows multitasking for simultaneously running up to eight programs and fast I/O processing for precisely synchronizing motion with external events. Modes of motion include point-to-point positioning, position tracking, jogging, linear and circular interpolation, contouring, electronic gearing and ECAM. Advanced commands for coordinated motion include ellipse scaling, slow-down around corners, infinite segment feed and feedrate override.

Like all Galil controllers, the Accelera series use Galil's popular, English-like command language which makes them very easy to program. Communication drivers are available for all current versions of Windows, Linux and .NET.

The DMC-40x0 controller is a box-level controller which internally consists of a stack of multiple circuit boards: (1) CPU board, (1) CMB communications board, (1 or 2) ICM interconnect boards, and (1 or 2) optional AMP amplifier boards. 1-axis thru 4-axis versions of the DMC-40x0 use one ICM and one AMP board, while the 5-axis through 8-axis versions use two ICM boards and two AMP boards. The default CMB board for the DMC-40x0 is the CMB-42012 which provides one Ethernet port and two RS232 ports. Future CMB boards will be available with other communication interfaces. The default ICM board for the DMC-40x0 is an ICM-42000 interconnect module which provides a 15-pin D-type connector for each axis. Future ICM boards will be available with screw-terminals and other configurations.

The stacked boards are packaged in a compact metal enclosure with dimensions of 8.1" x 7.25" x 1.72" for the 1-through 4-axis models and 11.5" x 7.25" x 1.72" for the 5-through 8-axis models. The DMC-40x0 controller operates from a single supply voltage from 20VDC to 80VDC.

Please call Galil at ***800-377-6329*** or go to ***http://www.galilmc.com/products/accelera/dmc40x0.html*** for more information about the powerful, new DMC-40x0 Accelera Series controller.

Galil's C-language API for Linux 2.6

The GNU/Linux operating system provides an alternative to Microsoft® Windows® for developing host applications and graphical user interfaces for motion control applications. This article introduces Galil's open-source communication library (dmclnx.a) for Linux, which is useful for those developing a Linux application that communicates with a Galil controller.

The library facilitates communication with Galil's DMC-14x5, 21xx, 22x0, and 3xxx Ethernet controllers; as well as their DMC-18x0 and 18x6 PCI controllers.

Figure 1 shows the architecture of the communication library (dmclnx.a) containing the Galil API (application programming interface). Your application program makes calls to the API such as DMCOpen() and DMCCommand(), which in turn make calls to the Linux operating system. If you are using a Galil Ethernet controller, dmclnx.a will make calls to the BSD Sockets API to access the Ethernet hardware. If you are using a Galil PCI controller (DMC-18x0/6), dmclnx.a will make calls to the Galil PCI driver (galilpci.ko), which is a module that is loaded into the Linux kernel and handles the hardware communication across the PCI bus. Note that setting up a PCI controller may require that you are logged in as root and have installed the kernel development package for your Linux distribution.

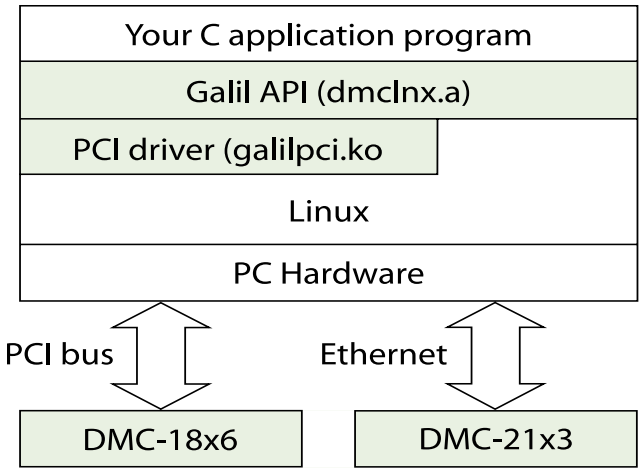


Figure 1. Architecture of Galil's communication library for Linux (Galil components are in green)

The library can be downloaded from Galil's website here: ***http://www.galilmc.com/support/download.html#linux***

After downloading, detailed API documentation can be found in dmclnx/dmclnx.h.

Detailed instructions for getting started with the library can be found in application note 4425. ***http://www.galilmc.com/support/appnotes/software/note4425.pdf***

Nanopositioning with ALIO Ceramic Stages and Galil Controllers

By John Hayes, Senior Applications Engineer, Galil Motion Control

When dealing with high precision, high-resolution applications where positioning down to sub-micron resolution is critical, a ceramic stage coupled to a Galil controller provides an effective motion control solution. This article describes the hardware that was used for nanometer-level positioning and the tips and tricks used to achieve optimum results.

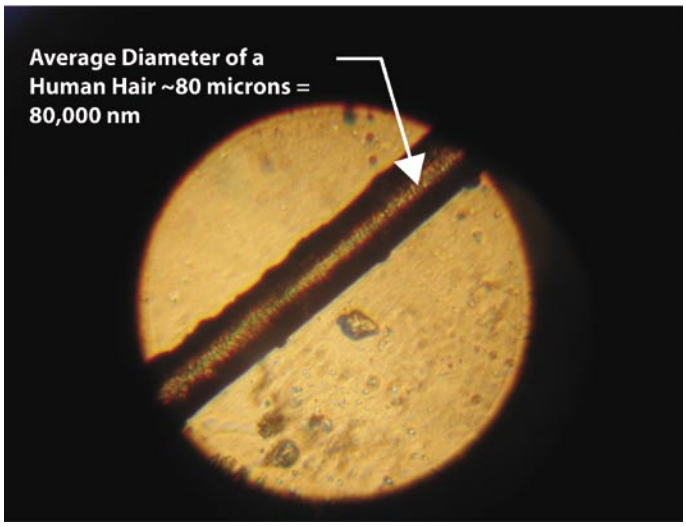
Introduction

There are many industries that require sub-micron positioning, including:

- *Semiconductor*
- *Measurement and Metrology*
- *Medical and Biotechnology*
- *Photonics and Laser Systems*
- *Microscopy*

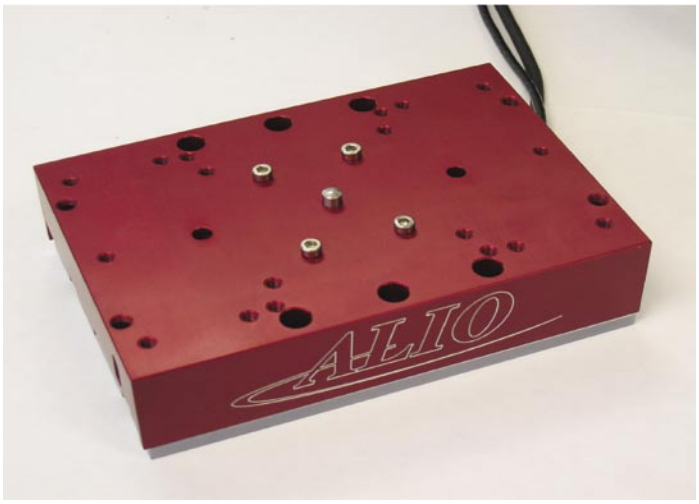
To demonstrate the scale of what it means to position to sub-micron accuracy, a photo of a human hair with 750X magnification is shown below. Note that the width of an average hair is approximately 80 µm (micrometers) or 80,000 nm (nanometers). By using a controller/stage/encoder combination with a resolution of 80 nanometers/count, you can slice a hair into 1,000 lengthwise sections and still hold a stable and repeatable position to one of those slices.

750X Magnification

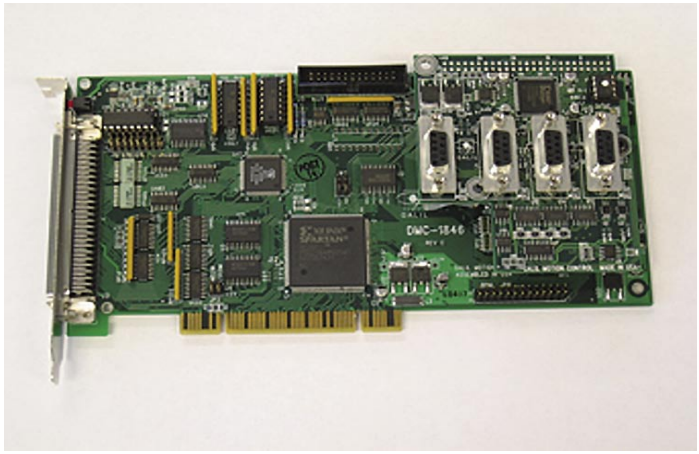


Hardware Elements

The critical components used for the precision positioning system include an ALIO stage with a ceramic motor, Renishaw encoder, Nanomotion driver, and Galil's DMC-18x6-DB-28104 motion controller.



ALIO stage with ceramic motor.



Galil DMC-18x6-DB-28104.

ALIO Stage

ALIO Industries offers a comprehensive line of nanometer resolution linear and rotary stages. These stages are modular in design so that multi-axis applications can be achieved by stacking them in various ways to achieve the desired motion. Ceramic servomotors are used to achieve high speeds and low settling times. Contact ALIO Industries directly for more information at ***http://www.alioindustries.com***

Encoder Feedback

The encoder feedback for this test used a 20 µm Renishaw Sine/Cosine Encoder (see details at ***http://renishaw.com***). Galil's DB-28104 is an analog interpolator

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Nanopositioning with ALIO Ceramic Stages and Galil Controllers *(Continued from Page 3)*

board that reads the 1 Vpk-pk sine/cosine signal from the encoder and converts it into a position. The AFx=n command determines the amount of interpolation, where n is in terms of 2^n counts per cycle. Thus, at AFx=8, the resolution is:

$$\frac{20\ \mu m}{256} = 78\ nm$$

Table 1: The following table shows the resolution for different values of AF

AF Value	Resolution	Stable?
AFx=8	78 nm	YES
AFx=9	39 nm	YES
AFx=10	19.5 nm	YES
AFx=11	9.76 nm	YES

Since the starting resolution of the encoder is 20 µm, the highest stable resolution achieved is 9.76 nm when using AFx=11. To get to higher resolutions, it is recommended that a higher starting resolution of the encoder be used so that the AF value can be as low as possible. Stability was determined by the ability of the system to hold position and perform repeatable motion at the desired resolution.

Nanomotion AB1A Driver

Nanomotion offers a ceramic motor and drive combination that provides motion for the stage. The ceramic motor works off of the piezoelectric effect in which a piezoelectric crystal is excited by an external voltage, resulting in the crystal changing its shape by a small amount. By harnessing this movement, Nanomotion motors provide smooth continuous motion with an unlimited amount of travel. Find more information at ***http:/www.nanomotion.com***

Galil DMC-18x6 Motion Controller

For this example, Galil's Accelera series DMC-18x6 controller is used. The update rate was set at TM 125 (125 µsec or 8 kHz) and Galil's special ceramic firmware was used. The Accelera series is not required to control ceramic motors since both the Optima and Econo series controllers can go down to 8 kHz sample rates (depending on the number of axes). However, even lower sample rates are possible on the Accelera and the command processing is ~10 times faster than Optima and Econo series controllers. This allows for higher throughput of commands that can lead to higher throughput on the final system.

Tuning the System

Combining high quality hardware is only part of the package. The next step is tuning the system and creating a program to tell the motor what to do.

While there are a number of settings that can be adjusted in the firmware to tune the controller, it is important to know the goal of the specific application. In this example system, high speed and low settling times were the desired constraints. In order to get the correct tuning parameters, a series of tests were run to get a baseline set of parameters. The tests and special firmware commands are explained in detail in AppNote #5426 which can be found at ***http://www.galilmc.com/support/appnotes/miscellaneous/note5426.pdf***

The key parameters used in this system are:

- **ZP & ZN (Anti-Friction Bias).** A ceramic motor inherently has a high static friction, so there is a "breakaway" command voltage at which there is no motion until that specific voltage is reached. The ZP and ZN commands account for this by allowing for an open loop bias voltage to overcome this static friction when there is position error present.
- **Two sets of PID values.** This allows the user to enter one set of PID's that are active when holding position and another set of PID's that are active during motion. The end result is the ability to have more aggressive PID values that would otherwise cause instability during motion.
- **FC and FN Feedfoward.** For improved settling time, Galil has included the FC and FN commands that help prevent overshoot at the end of the move. A bias voltage that is proportional to the velocity is enabled when a specific distance from the end of the move is reached.
- **Deadband with Hysteresis.** The DS and DB commands allow the user to set a deadband for the motor. This is especially important for high-resolution ceramic systems where the motor provides holding torque on the stage even when the drive is disabled. Once the desired position is reached (i.e., inside the deadband), the drive is disabled and the mechanics of the ceramic motor will hold the position of the stage without shifting its position.

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Nanopositioning with ALIO Ceramic Stages and Galil Controllers *(Continued from Page 4)*

A full list of parameters that were used is shown here:

COMMAND	FUNCTION	VALUE
KP	Proportional Gain (While Holding Position)	10
KI	Integral Gain (While Holding Position)	1.5
KD	Derivative Gain (While Holding Position)	50
IL	Integrator Limit to prevent KI from causing saturation	2
FA	Feedforward Acceleration – Add voltage proportional to Accel rate	0
FV	Feedforward Velocity – Add voltage proportional to velocity	0
ZP	Positive Bias – voltage to break positive direction static friction	0.75
ZN	Negative Bias – voltage to break negative direction static friction	0.75
DS	Deadband – number of counts within which to shut off amp	2
DB	Deadband – number of counts above which to turn amp back on	5
K1	Proportional Gain (While Moving)	5
K2	Integral Gain (While Moving)	0
K3	Derivative Gain (While Moving)	40
FC	Distance Selectable Velocity Feedforward Gain	100
FN	Distance from end of move before FC is engaged	100
AF	Analog Feedback – Value of Interpolation 2^n	9
TM	Update Rate of controller	125

Last, but not least, is creating a program to make the motor move. This is done by downloading the following application directly onto the controller and then executing it from the host PC.

```
#MAIN
'Program to move ALIO stage 500cts back
and forth
DPX=0;   'Define X axis position to zero
#LOOP
PAX=500; 'Position Absolute Move of 500cts
BGX;     'Begin Motion
AMX;     'Wait for motion to complete
WT500;   'Delay 500msec
PAX=0;   'Return to zero position
BGX;
AMX;
WT500;
JP#LOOP; 'Repeat from #LOOP label
```

Conclusion

With a combination of the right high quality components from ALIO, Renishaw, Nanomotion and Galil, precise positioning down to the nanometer scale is not as daunting as it might seem. The resulting system was able to move and settle with repeatable positional accuracy down to sub 100 nm levels. To see a video of a 50µm move, go to ***http://www.galilmc.com/ftp/pub/appnotes/note5475/ceramic_014.mov***

Call **1-800-377-6329** for more information or to discuss your project with a Galil Applications Engineer.

Galil. We Move the World.

With over 350,000 controllers installed worldwide, Galil is the #1 leading supplier of motion controllers. Galil's legacy of innovation began in 1983 when they introduced the first microprocessor-based servo motion controller. Today, Galil continues its leadership by offering the most powerful, cost-effective and easy-to-use motion controllers to accommodate all your motion needs.

Galil provides you with the widest choice of single or multi-axis, bus-based or stand-alone, and box-level or card-level controllers. Interface options include PCI, ISA, PC/104, VME, cPCI, USB, RS232 and Ethernet. Select from 1-, 2-, 3-, 4-, 5-, 6-, 7- and 8-axis controllers, and configure them to run stepper or servo motors on any combination of axes.

Additionally, Galil provides various accessories that enable you to complete your project quickly. These include servo motors, amplifiers and software tools for quick set-up and "one-button" servo tuning.

Motion Controllers – PCI

DMC-18x6.	PCI, 1-8 axes. Accelera
DMC-18x0.	PCI, 1-8 axes. Optima
DMC-18x2.	PCI, 1-4 axes. Econo
DMC-1417.	PCI, 1 axis

Motion Controllers – Ethernet/RS232

DMC-40x0.	Ethernet/RS232, 1-8 axes
DMC-20x0.	USB/RS232, 1-8 axes
DMC-22x0.	Ethernet/RS232, 1-8 axes
DMC-21x2/x3.	Ethernet/RS232, 1-8 axes
CDS-3310.	Ethernet/RS232, 1 axis controller and servo drive unit
DMC-14x5.	Ethernet/RS232, 1-2 axes
IOC-7007.	Ethernet I/O controller

Motion Controllers – Other

DMC-12x0.	PC-104, 1-8 axes
DMC-13x8.	VME, 1-4 axes
DMC-16x0.	cPCI, 1-4 axes
DMC-17x0.	ISA, 1-8 axes
DMC-1410.	ISA, 1 axis
DMC-1411.	PC/104, 1 axis
DMC-1412.	RS232, 1 axis

Plug-In, Multi-axis Drives

AMP-20341.	4 axis, 20W servo drives
AMP-204x0.	2 & 4 axis, 200W servo drives
AMP-205x0.	2 & 4 axis, 500W servo drives
SDM-20240.	4 axis, full/half stepper drives
SDM-206x0.	2 & 4 axis, microstep drives

Software Tools

Communication Drivers. For DOS, QNX, Linux and all current versions of Windows

SmartTerm. Provides a friendly interface to all Galil controllers

WSDK. Servo Tuning and analysis software

ActiveX Toolkit. Custom controls for Visual Basic or other ActiveX software

CAD-to-DMC. Translates AutoCAD DXF files into DMC controller files

For complete specifications and pricing on all Galil products, please go to www.galilmc.com. Request a free catalog at http://www.galilmc.com/products/catalog.html

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✓	Over 20 tutorials about servo tuning, motion programming, & motors and drives http://www.galilmc.com/training/webconf.html
✓	MotionCode™ Toolkit, step-by-step solutions with downloadable code http://www.galilmc.com/support/motioncode/index.html
✓	MotorSizer™ Tool for quick sizing of stepper and servo motion systems http://www.galilmc.com/support/motorsizer/index.html
✓	Interactive bulletin board with knowledge base for fast answers to your questions http://www.galilmc.com/cgi-bin/ubb/ultimatebb.cgi
✓	Extensive motion controller and drive product catalog with specs and prices http://www.galilmc.com/products/catalog.html

"The mission of Galil's experienced Applications Department is to provide prompt and accurate technical assistance to help OEMs successfully deliver their products to market"