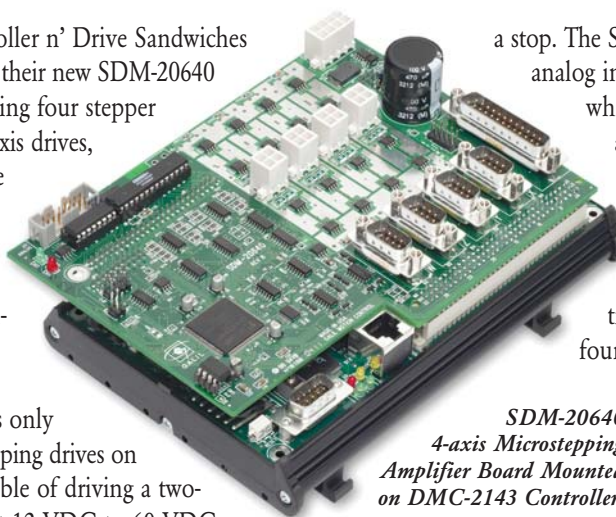


Galil's New Microstepping Drives for DMC-21x3 Controller n' Drive Sandwiches

Galil's family of DMC-21x3 Controller n' Drive Sandwiches continues to expand with the addition of their new SDM-20640 amplifier board designed for microstepping four stepper motors. Like all Galil DMC-21x3 multi-axis drives, the SDM-20640 attaches directly to the 96-pin DIN connector of the controller without any need for a cable. This gives OEMs a cost-effective, multi-axis controller-and-drive solution that eliminates any wiring between the controller and drives.

The compact SDM-20640 measures only 6.92" x 5.10" and contains four microstepping drives on a single board, with each amplifier capable of driving a two-phase bipolar stepper motor operating at 12 VDC to 60 VDC at up to 3.5 Amps. The drives produce 64 microsteps per full step or 256 steps per full cycle, resulting in 12,800 steps/rev for a standard 200-step motor. The maximum step rate generated by the controller is 3,000,000 microsteps/second.

The SDM-20640 has four user-selectable current settings: .5, 1, 2 and 3.5 Amps. In addition to these, it has a user-selectable low-current mode that reduces current power by 75% when the motor is at



*SDM-20640
4-axis Microstepping
Amplifier Board Mounted
on DMC-2143 Controller.*

a stop. The SDM-20640 also provides 8 uncommitted analog inputs with 12-bit ADC (16-bit optional), which allows inputs from joysticks or other analog sensors to be read by the DMC-21x3 motion controller.

Designed for value-conscious OEMs, the four-axis SDM-20640 is priced at only \$395 in 100 quantity. When combined with a DMC-2143 four-axis controller (\$795 in 100 quantity), the combined amplifier and controller price comes to less than \$300 per axis. Since the SDM-20640 attaches directly to the DMC-2143, there is no additional cabling or inter-connect hardware required, which provides even greater savings.

For applications requiring just two axes, Galil provides the SDM-20620 model. Due to space constraints, only one SDM-20620 or SDM-20640 can be used with a DMC-2183 eight-axis controller. However, Galil's lower power amplifier boards can be used on the second set of 4 axes. For complete specs go to: <http://www.galilmc.com/dmc21x3.html>.

PLUG-IN AMPLIFIER and I/O OPTIONS

MODEL NUMBER	MOTOR TYPE	# OF AXES	CURRENT	VOLTAGE	OTHER	U.S. PRICE (QTY 1/100)
ICM-20100	Interconnect for external drives	4	N/A	N/A		\$95/\$75
ICM-20105	Interconnect for external drives	4	N/A	N/A	Provides optical isolation of I/O	\$195/\$145
SDM-20240	Full and half step	4	Up to 1.4A/phase	12-30 VDC		\$195/\$175
SDM-20620	Microstep	2	Up to 3.5A/phase	12-60 VDC	Includes 8 analog inputs	\$545/\$345
SDM-20640	Microstep	4	Up to 3.5A/phase	12-60 VDC	Includes 8 analog inputs	\$695/\$395
AMP-20340	Brush DC	4	1A max	12-36 VDC	Linear drives	\$195/\$175
AMP-20420	Brush DC	2	3.3A max	20-60 VDC	PWM drives	\$395/\$245
AMP-20440	Brush DC	4	3.3A max	20-60 VDC	PWM drives	\$595/\$295
AMP-20520	Brush DC or brushless DC	2	7A cont 10A peak	18-60 VDC (160 VDC on request)	Includes 8 analog inputs, programmable gains and diagnostics	\$595/\$395
AMP-20540	Brush DC or brushless DC	4	7A cont 10A peak	18-60 VDC (160 VDC on request)	Includes 8 analog inputs, programmable gains and diagnostics	\$795/\$495
DB-28040	I/O expansion	N/A	N/A	N/A	40 digital I/O plus 8 analog inputs	\$295/\$195
Custom (Consult Galil)	Any	Any	Any	Any	Can specify special I/O, connector and size requirements	Nominal tooling fee. 25 unit minimum

Microstepping: Addressing The Performance Issues of Resolution, Accuracy and Repeatability

By Glen Garrettson, Galil Applications Engineer

Microstepping is a method for controlling stepper motors that improves performance by providing finer position steps, reduced vibration and smoother motion.

However, microstepping does have some limitations on performance, which we will discuss and analyze in order to predict realistic microstepping performance.

Performance

Resolution, Accuracy, and Repeatability are the three primary issues that define microstepping performance.

- **Resolution** is the commanded position increment.
- **Accuracy** is the absolute position error relative to commanded position.
- **Repeatability** is the relative position error over many commanded positions.

To clarify the terms, consider a simple system of a drive and motor that has a resolution of 12,800 microsteps/revolution, or 35.6 counts per degree. From here on, counts will be synonymous with microsteps. If a move of $\theta_o = 1000$ counts is commanded and the actual motor position ends up at $\theta_A = 950$, then there is a -50 count accuracy. After repetition, the position is observed to fluctuate 5 counts: $\theta_R = 945 - 955$.

Therefore,

$$\text{Resolution} = 1 \text{ count}$$

$$\text{Accuracy} = \pm 50 \text{ counts}$$

$$\text{Repeatability} = \pm 5 \text{ counts}$$

In general, resolution does not guarantee actual position accuracy. The true performance of a step motor and drive is reduced by many sources of error. The following table consolidates the performance errors:

Sources of Error That Effect Performance		
Source	Effects Accuracy	Error is Repeatable
Static Friction	Yes	No
Motor Torque Harmonics	Yes	Yes
Drive Bias	Yes	Yes
Quantization Effects	Yes	Yes

Table 1. Sources of Position error.

Two Types of Error: Non-Repeatable and Repeatable

There are two types of errors: non-repeatable and

repeatable. Non-repeatable errors are unpredictable, stay within a range, and have the greatest effect on accuracy. Repeatable errors produce predictable, repeatable effects upon accuracy.

Non-Repeatable

Non-repeatable position error is known as Absolute Position Error. This error cannot be improved upon by motor or drive resolutions that are better than the magnitude of the error, due to the non-repeatability of the torque of friction. After brief derivation, the calculated position error due to static friction is:

$$\theta_{NRE} = \pm [\text{Sin}^{-1}(T_F/KI_o)] \text{ (electrical degrees)} \text{ (Eq.1)}$$

Where T_F is the friction, I_o is the drive current and K is the motor torque constant.

Repeatable

Repeatable Position Error is known as Relative Position Error. Motor Torque Harmonics, Drive Bias and Quantization effects are the common repeatable sources of error. Essentially, drive component non-linearity and insufficient DAC resolution will cause deviations of the ideal sine and cosine current output waveforms to the motor, resulting in non-ideal sine and cosine torque curves from the motor. Because each motor and drive is unique, evaluating the individual error contribution from these sources is empirical per application and per axis.

Analysis: Effects on Performance

Consider now an example in which we use Galil's SDM-20640 Microstepping Drive with a resolution of 64 microsteps/step .

- Step Motor, 200 steps/revolution
- Nominal Current, $I_o = 1.4A$
- Motor Torque Constant, $K = 25 \text{ oz-in/A}$
- Resolution = 12,800 cnt/rev.
- Torque of Static Friction (Motor & Load), $T_F = 5 \text{ oz-in}$

Non-Repeatable Error

By first using Eq. 1 and converting the error to mechanical degrees, the absolute position error is:

$$\theta_{NRE} = 0.164^\circ / 0.028^\circ = \pm 5.9 \text{ counts}$$

(Continued on Page 3)

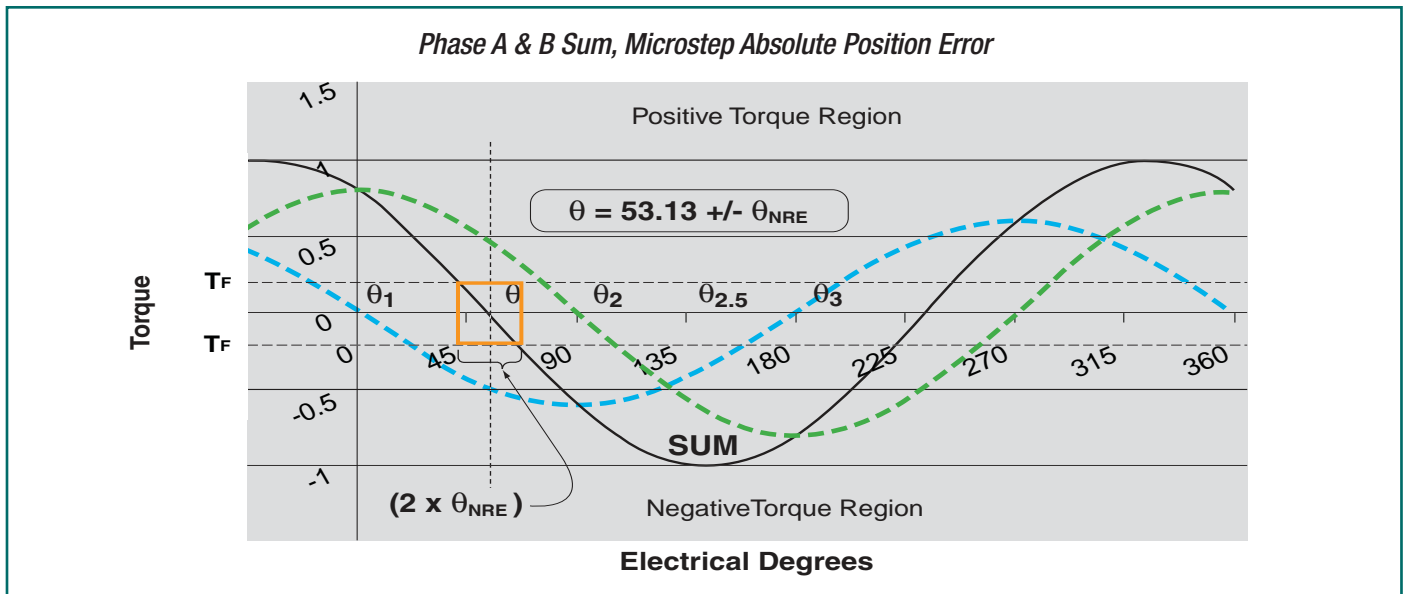


Figure 1. Absolute Error: Motor Torque vs. Static Friction Torque.

Repeatable Error

The relative position error per move is observed as:

$$\theta_{RE} = \pm 0.06^\circ = \pm 2.1 \text{ counts error}$$

Therefore, even though the system has a resolution of 0.028° per count, the actual position could be ± 8 counts (microsteps) or greater around the commanded position with just the motor and drive.

Conclusion

It is important to understand what the performance goal is when considering the performance of an application. This is because some applications require absolute positional accuracy, whereas others are less concerned with accuracy and more with repeatability. It is equally important to consider the effects of all mechanical components associated with each axis. Lead screws, couplings and other mechanics will add to the repeatable error

through coupling non-linearity, and to the non-repeatable error through tolerance.

The microstepping control method offers improved performance potential for stepper motor axes. However, resolution is no guarantee of actual position accuracy. For an in-depth analysis of microstepping performance and more information about step motor control, please visit the following links.

Application Note 5452

<http://www.galilmc.com/support/appnotes/miscellaneous/note5452.pdf>

Monitoring Step Motor Operation

<http://www.galilmc.com/support/appnotes/optima/note2417.pdf>

Backlash Compensation with Closed Loop Steppers

<http://www.galilmc.com/literature/servotrends/closedloopstepper.pdf>

View Free Web Tutorials on Motion Control

Available 24/7 and free to registered viewers, Galil has an extensive, growing library of web-tutorials covering a variety of motion control subjects including servo tuning, dual loop control, and motor types. Go to <http://www.galilmc.com/training/webconf.html> to view any of the twenty Galil tutorials listed below.



Video Demonstration by Jacob Tal

"Motion Controller Demonstration"

Tuning

"Tuning Servos for Best Performance"
 "Advanced Tuning Methods"
 "Dual Loop Compensation Methods"

System Design

"Modes of Motion"
 "Control of Load Sharing Systems"
 "Tension Control of Web Processing Systems"
 "Optimal Design of Motion Systems"

Ethernet

"Flexible-Distributed Control Systems"
 "DMC-21x3 Ethernet Controllers & Drive Options"
 "Ethernet & Motion Control"

Software Tools

"ActiveX Tool Kit"

Motors & Drives

"Servo Amplifier Basics"
 "Using Shunt Regulators"
 "Piezo Ceramic & Ultrasonic Actuators"
 "Step Motor Control"
 "Brushless Motor Control"

Miscellaneous

"Connecting to Galil I/O"
 "Controller Upgrade Options"
 "Overview of Galil Motion Control"

“Live” Tech Support for Fast Answers to Your Questions

Galil has a full team of dedicated application engineers in residence and ready to support your project. They are motion control specialists, each personally trained by Jacob Tal, President of Galil and renowned expert in motion control. To receive prompt service from a “live” Galil engineer, just call Galil at **800-377-6329** Mon-Fri 8am-5pm Pacific Standard Time. Or, email support@galilmc.com. They’re at your service.

“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.”

Galil Technical Support Team

Top Row-left to right- Chris Richtsmeier, Chris Cortopassi, Robin Riley
3rd Row- left to right- Kaushal Shah (Group Mgr.), Glen Garrettson, Enoch Wall
2nd Row-left to right- Eric Kelley, Todd Shearer (northeast region)
Front- John Hayes



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-18x0. PCI, 1-8 axes
DMC-18x2. PCI, 1-4 axes
DMC-1417. PCI, 1 axis

Motion Controllers – Ethernet/RS232

DMC-20x0. USB/RS232, 1-8 axes
DMC-22x0. Ethernet/RS232, 1-8 axes
DMC-21x2/x3. Ethernet/RS232, 1-8 axes
DMC-14x5. Ethernet/RS232, 1-2 axes
DMC-34x5. 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

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>.