SERVOTRENDS

GALIL
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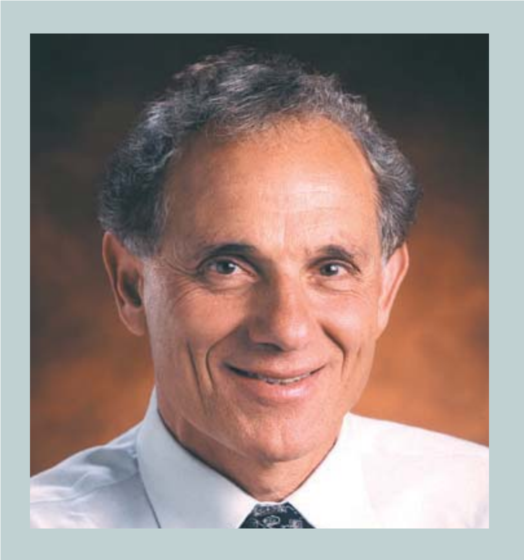
A Message from the President of Galil



After twenty years as president and CEO of Galil Motion Control, I have decided to reduce my management responsibility and focus on technical work for the company. As many of you know, I have always enjoyed research, writing and teaching, and I intend to keep doing that at Galil. Also, I have experienced great satisfaction over the years helping our customers with their motion projects, and that is something I will continue to do.

Although I will no longer be the President of Galil, I remain an active member of the Galil team, and will serve as its chairman of the board.

Effective immediately, Wayne Baron is promoted to the position of president and CEO. Wayne has done an exceptional job as Galil's Chief Technical Officer and Vice President of Engineering ever since its inception. In fact, Wayne and I founded Galil and for the last 20 years have guided the company with complete harmony. Therefore, you can expect no major changes in the operation and direction of the company.

As mentioned, my new position as chairman gives me more time to focus on technical subjects and customer applications. And, as usual, you are welcome to contact me to discuss any technical subject related to motion control.

Best regards,

Jacob Tal

Jacob Tal. Chairman of the Board

Enhanced Firmware Provides Ramp-to-Gearing and Position Tracking

Galil has introduced enhanced firmware for its Optima and DMC-21x3 controllers which provide new instructions that allow ramp-to-gearing in the electronic gearing mode, and an additional mode of motion for position tracking. Following is a detailed description of the new features, along with firmware revision information for each controller provided in *Table 1*.

1. Ramp-to-Gearing

Electronic gearing allows a slave axis to follow a master axis at the prescribed gear ratio. When the slave axis is engaged and commanded to follow the master, it is often desirable to gradually ramp up to the new gear setting. This results in smoother transitions in gearing and prevents abrupt changes when the gear ratio is changed. Even though a gradual engagement of gearing allows for smoother motion, there will be a position error accumulated during the engagement period that must be accounted for to keep the master and slave synchronized. Galil's enhanced firmware adds two new commands to the Electronic Gearing Mode: The GD command specifies

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the engagement distance while the GP command corrects the position difference.

GD sets the distance of the master axis over which the specified slave will be engaged, disengaged or changed to a new gear setting.

_GP contains the value of the lead or lag between the master and slave during the ramp-to-gearing. This value can be used to correct the position of the slave axis whenever the GD command is used.

In *Example 1*, the Y-axis is the master and the X-axis is the slave. The command GD 1000 is used to gradually ramp the slave axis, where the master will travel 1000 counts before the gearing is fully engaged. By using the GR command, the slave is commanded to start the motion and then gradually ramps to follow the master.

The term _GPX contains the value of the position error that has been accumulated during the gradual ramp-to-gearing. Once the master has moved the specified 1000 counts during the engagement period, the slave axis is then commanded to move by this amount with the Increment Position or IP command.

Example 1. *Ramp-to-Gearing Program*

INSTRUCTION	INTERPRETATION
GAY	Sets the Y-axis as the gearing master for the X-axis. This axis does not have to be under servo control. In this example, the axis is connected to a conveyor operating open loop.
GD1000	Set the distance that the master will travel to 1000 counts before the gearing is fully engaged for the X-axis slave.
AI-1	Wait for input 1 to go low. In this example, this input is representing a sensor that senses an object on a conveyor. This will trigger the controller to begin gearing and synchronize the master and slave axes together.
GR1	Engage gearing between the master and slave.
P1=_TPY	Sets the current Y-axis position to variable P1. This variable is used in the next command, because MF requires an absolute position.
MF, (P1+1000)	Wait for the Y-axis (master) to move forward 1000 encoder counts so the gearing engagement period is complete. Then, the phase difference can be adjusted accordingly. Note: This example assumes forward motion.
IP_GPX	Increment the difference to bring the master/slave in position sync from the point that the GR1 command was issued.

Refer to Jacob Tal's article *"Gradual Shift Into Gear"* in this issue of ServoTrends for more information about the ramp-to-gearing feature.

2. Position Tracking

Many applications require an axis to precisely follow a randomly generated position target. Absolute position commands are typically specified at random by the host computer whether or not the axis is in motion. The axis under control must be ready to move to the new position in a controlled fashion. To accommodate this requirement, a new mode of motion called Position Tracking has been added to the enhanced firmware. In this mode, a new absolute position may be specified even if the axis is in motion. The controlled axis is commanded to move to the new position following a trapezoidal velocity profile.

The PT command places the controller in the position-tracking mode, which allows the host to issue absolute position commands on-the-fly. The axis moves to the new position and waits until a new position target is specified and given by the PA command. The ST Stop command is used to exit the Position Tracking mode.

The example program shown below enables the position-tracking mode for the X-, Y-, Z- and W-axes with the PT1,1,1,1 command. A new position target is specified with the PA command where the variables containing the absolute position for each of the axes V1, V2, V3, and V4 are generated by the host.

Example 2. *Position Tracking Program*

INSTRUCTION	INTERPRETATION
PT1, 1,1,1	Enable the position-tracking mode for X-, Y-, Z-, and W-axes.
#A	Create label A in a program. This small program will update the absolute position at 100 Hz. Note that the user must update the variables V1, V2, V3, and V4 from the host PC, or another thread operating on the controller.
PAV1, V2, V3, V4	Command X-, Y-, Z-, and W-axes to move to absolute positions. Motion begins when the command is processed. BG is not required to begin motion in this mode. In this example, it is assumed that the user is updating the variables at a specified rate. The controller will update the new target position every 10 milliseconds (WT10).
WT10	Wait 10 milliseconds
JP#A	Repeat by jumping back to label A

Table 1. *Enhanced Firmware Revision Information*

Controller Model	Form Factor	Firmware Revision
DMC-20x0	RS232, USB - box	1.0n
DMC-22x0	RS232, Ethernet - box	1.0n
DMC-21x2 and 21x3	RS232, Ethernet - card	1.0n
DMC-18x2	PCI	1.0o
DMC-18x0	PCI	2.0o
DMC-17xx	ISA	2.2o
DMC-16xx	cPCI	2.0o
DMC-13xx	VME	2.0o
DMC-12xx	PC/104	2.0o

Jacob Tal Presents New Web-Tutorial on Microstepping

Jacob Tal, co-founder of Galil and one of the most highly regarded innovators in motion control, presents a new web-tutorial on Microstepping. Ready for viewing at **http://www.galilmc.com/support/library/tutorials.html**, the tutorial features Jacob first reviewing step motor technology including full- and half-step modes, and then providing a detailed analysis on the theory of operation, performance advantages and limitations of microstepping. Jacob also gives clear, step-by-step instructions for configuring Galil's microstepping drives for optimum stepmotor operation.

This new Microstepping presentation is now part of Galil's extensive, growing library of over 20 free web-tutorials, which are available 24/7 to registered viewers. Galil's library helps engineers keep current with the latest on servo tuning, motion programming, motor and drive technology, and more.

Current web-tutorial topics include:

MOTION CONTROLLER DEMONSTRATION

- ***Motion Controller Demonstration***. In this 15-minute video, Jacob demonstrates PID tuning and motion programming using a Galil controller, WSDK servo design software and a servo motor with encoder.

TUNING

- ***Tuning Servo Systems for Optimum Performance***. Adjustment of PID filter parameters for fast and stable performance of servo systems is covered.
- ***Advanced Tuning Methods***. Discusses notch filter, low-pass filter and feedforward control techniques.
- ***Dual Loop Compensation Methods***. Various methods of eliminating backlash are discussed including dual loop.

SYSTEM DESIGN

- ***Modes of Motion***. Various modes are discussed including jogging, point-to-point positioning, linear and circular interpolation and contouring.
- ***Control of Load Sharing Systems***. Talks about using electronic gearing with automatic correction for control systems with a shared load.
- ***Tension Control of Web Processing Systems***. Learn about using electronic gearing to precisely control tension.
- ***Optimal Design of Motion Control Systems***. Covers optimization of velocity profile, optimization of mechanical couplings and method for selecting best motor for minimum power dissipation.

ETHERNET

- ***DMC-21x3 Ethernet Controller n' Drive Sandwiches***. Introduces Galil's low-cost, Ethernet motion controllers and attached multi-axis drives.
- ***Flexible-Distributed Control Systems***. Discussion of flexible, Ethernet-based distributed control where motion controllers need to be distributed throughout the machine to minimize wiring.
- ***Ethernet and Motion Control***. Learn about Ethernet and Modbus terminology, advantages, and special commands for motion control.

SOFTWARE TOOLS

- ***ActiveX Toolkit***. An introduction to Visual Basic and Galil's ActiveX Toolkit. Examples of incorporating polling windows and action buttons into a Visual Basic form.

MOTORS & DRIVES

- ***Servo Amplifier Basics***. Reviews servo amplifiers such as linear and PWM drives and voltage and current drives. Power supply and commutation considerations are discussed.
- ***Using Shunt Regulators***. Describes shunt regulators and when they are used. Calculations for both rotary and linear systems are provided.
- ***Piezo Ceramic and Ultrasonic Actuators***. Discusses the advantages and disadvantages of these actuators. Compensation methods for optimum tuning are presented.
- ***Step Motor Control***. Discusses step motor operation including full-, half- and micro-step; and tells how to configure Galil controllers for proper operation with step motors.
- ***Microstepping***. Discusses microstepping operation, and performance advantages and limitations. Includes guide for configuring Galil's microstepping drives.
- ***Brushless Motor Control***. Covers the operation of brushless motors, including sinusoidal commutation. Also discusses how to use brushless motors with Galil controllers.

MISCELLANEOUS

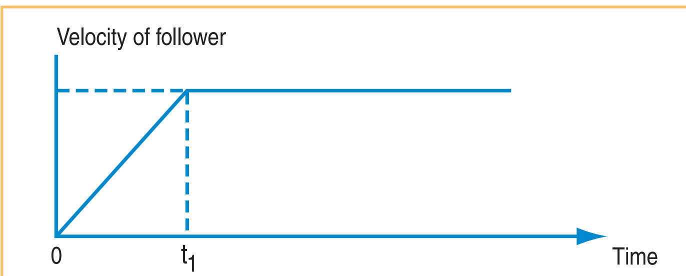
- ***Connecting Galil I/O***. Explains TTL and optoisolated I/O and how to connect to it.
- ***Controller Upgrade Options***. Various upgrades are presented including absolute and SSI encoder interfaces, backlash and lead screw compensation, antifriction bias, two sets of PID and more.
- ***Overview Of Galil Motion Control***. Presents Galil and its products.

Gradual Shift Into Gear *By Jacob Tal*

The gearing function, which is commonly used in automation processes, enables synchronization between two motions by forcing a controlled motor to follow a master motor at a specified ratio.

The standard operation of the gearing function is that the follower instantly locks up to the master. In those cases where the master has been moving at a high speed, such a transition, requiring instant velocity change, results in a mechanical impact that may cause mechanical vibrations and, therefore, may not be acceptable.

To address this concern, Galil has modified the gearing function to allow for a gradual engagement, where the user specifies the distance that the master travels, over which the gearing is gradually engaged. The resulting velocity of the follower is shown below:



At the time t=0, the gradual gearing command is issued; and at t_1, the gearing is fully engaged.

While this feature reduces the mechanical impact on the motor, it creates a problem with synchronization. Between the time t=0 and t_1, the follower does not run at the desired speed, thereby resulting in "Lost Distance". This lost distance, which is the difference between the follower position under normal gearing and gradual gearing, L, can be shown to equal approximately:

$$L = \frac{1}{2} GD$$

Here, G is the gear ratio and D is the distance that the master travels during the gearing engagement interval.

For applications that require exact synchronization, like cutting and registration, Galil offers the data needed for precise motion. Since the lost distance L may vary slightly due to changing master velocity and numerical quantization, the Galil controller precisely records the value of L for the specific move and makes the result available for the user. If necessary, an application program can be used to determine the synchronization error and to correct for it. The process is illustrated by the following example:

Design Example:

Let's consider a gearing application where the master moves at a velocity near 10,000 ct/s, and the follower needs to be geared at the ratio of 0.5. For a gradual gearing engagement time of approximately 0.1 seconds, we select the master engagement distance, D, as 1000 counts.

During the gear engagement phase, the lost distance, L, is expected to be nearly 250 counts. This can be taken into account by engaging the gearing function at a master position that is 500 counts prior to the effective engagement point.

As the actual lost distance, L, may differ more than 250, it is possible to perform an additional correction as shown in the following program:

INSTRUCTIONS	INTERPRETATION
GAY	set Y as master of X
GD 1000	set the gearing engagement distance
GR 0.5	set gear ratio
P=_TPY	record current master position
MFY (P+_GDX)	wait until master traveled engagement distance
V1=250-_GPX	find variation in lost distance
IPV1	correct for variation
EN	End

"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, co-founder 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."

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