



**QUARTERLY NEWSLETTER
PUBLISHED BY
GALIL MOTION CONTROL**

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“ 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 SUPPORT TEAM



SERVO TRENDS

JAN 2009, VOL. 24 NO. 1



Galil Launches Newly Updated and Expanded Website

Check out Galil’s recently updated and expanded website at www.galilmc.com. It’s fully stocked with detailed product data and educational information designed to help you succeed in your motion control projects.

Easy Navigation

You can quickly and easily find the product and technical information you need with Galil’s new navigation and drop-down menus. The main navigation is divided into these sections: *Our Products*, *Learning Center*, *Support & Downloads*, and *About Galil*.

Complete Product Specifications and Pricing

The *Our Products* section has an easy-to-read, drop-down menu that lists all current Galil products including the Accelerera, Econo and Pocket PLC series. From the drop-down menu, you can quickly access individual product pages that include complete technical specifications and pricing.

Expanded Learning Center

At the *Learning Center*, you can access Galil’s full library of educational material, including online tutorials, support tools, training classes, technical articles and “Tech Talk”, a forum where Galil application engineers post their latest design tips. Engineers can further increase their motion control knowledge by viewing Galil’s growing library of over 20 online tutorials covering subjects such as servo tuning, motion programming, I/O control, motors, and drives. Online support tools also include MotorSizer for easy sizing of stepper and servo systems, and MotionCode, which is a step-by-step guide for developing common motion applications.

At the *Learning Center*, you’ll find Galil’s online, 4-hour motion control course which is available free with product purchase. Or, attend a live two-day, hands-on programming workshop held at Galil headquarters in Rocklin, CA.

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Quick Access to Support and Downloads

The **Support & Downloads** section provides quick access to a vast collection of Galil literature that can support your needs, including product manuals, application notes, example controller programs, the 2009 product catalog and Galil's quarterly ServoTrends newsletter.

Also available from this section are the latest firmware and software downloads, and Galil's collection of SmartMoves customer stories and videos which demonstrate the successful application of Galil motion controllers in a wide range of high-tech, industrial, medical and manufacturing industries.

Contact Galil or a Local Representative to Discuss Your Applications

Galil's highly trained application engineers are available to answer your questions and discuss your applications anytime from 8am to 5pm Pacific Standard Time, Monday through Friday. Just call Galil at 1-800-377-6329 or send an email to galil@galilmc.com. Galil also works with a network of factory-trained, independent technical representatives and distributors who stand by, ready to help address your motion control needs. To find the representative nearest you, please view our online Representative Finder at our website: www.galilmc.com/about/rep-finder.php. ■



Galil Now Offers Screw-Terminals and Expanded Memory for its RIO Pocket PLC

Introduced in early 2008, Galil's RIO Pocket PLC is a smart, compact and low-cost Ethernet controller that is packed with I/O. Now, Galil is offering two new additions to its popular RIO-47xxx PLC Series: The RIO-47200 with screw terminals and the RIO-471x2 with memory expansion.

RIO-471x2 with Memory Expansion

The RIO-471x2 PLC is the same as the RIO-471x0 except that it offers more memory, variables, array elements, programmable PID control loops and Ethernet handles. **Table 1** shows the expanded capabilities.



RIO-471x2 PLC with expanded memory, variables and control loops

Table 1: Comparison of RIO-471x2 and RIO-471x0

Number of:	RIO-471x2 Expanded Memory	RIO-471x0 Standard
Program Memory Lines	400	200
Symbolic Variables	254	126
Array Elements	1000	400
PID Control Loops	6	2
Ethernet Handles	5	3

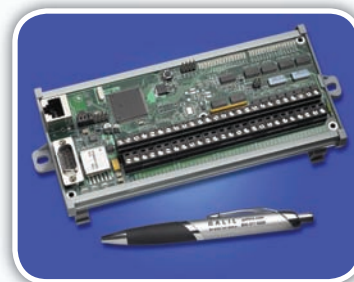
The RIO-471x2 PLC is ideal for customers that require more space for application programs or need to use additional variables or arrays in their programs. It also offers more PID process loops, which are ideal for temperature control.

The RIO-471x2 PLC features the same, compact packaging and D-type connectors as the standard RIO-471x0, and both contain the same amount of I/O: 8 analog inputs, 8 analog outputs, 16 digital inputs and 16 digital outputs. For all the expanded capabilities, the RIO-471x2 is just \$50 more than the RIO-471x0.

RIO-47200 with Screw Terminals

Galil's card level RIO-47200 PLC with DIN rail mount and screw terminals is ideal for customers who are prototyping or want to connect discrete wires to the RIO via screw terminals. As part of the RIO family, the RIO-47200 is an intelligent, cost-effective solution for I/O control. There are key differences with the RIO-47200 when compared to the RIO-47100

(See **Table 2**). ■



RIO-47200 PLC with screw terminals and DIN tray

Table 2: Comparison of RIO-47200 and RIO-47100

Feature:	RIO-47200 Screw Terminals	RIO-47100 Standard
Packaging	Card-level- DIN rail tray	Metal enclosure
Dimensions	7.19" x 3.52"	3.88" x 4.26" x 1.30"
Connections	Screw terminals	D-type
# Analog inputs	8	8
# Analog outputs	0 (available as option)	8
# Digital inputs	16	16
# Digital outputs	0 (available as option)	8
# Digital outputs, 500mA	16	8

For more information on these new RIO products, see www.galilmc.com/pocketplc

RIO Pocket PLC Video is now Online

Check out our new video highlighting the RIO Pocket PLC. Todd Shearer, one of our senior application engineers discusses the features and benefits of Galil's RIO Ethernet I/O controller in this dynamic, 2 minute video. Watch the video online at: www.galilmc.com/products/rio-47xxx.php

Features of Galil's RIO Pocket PLC

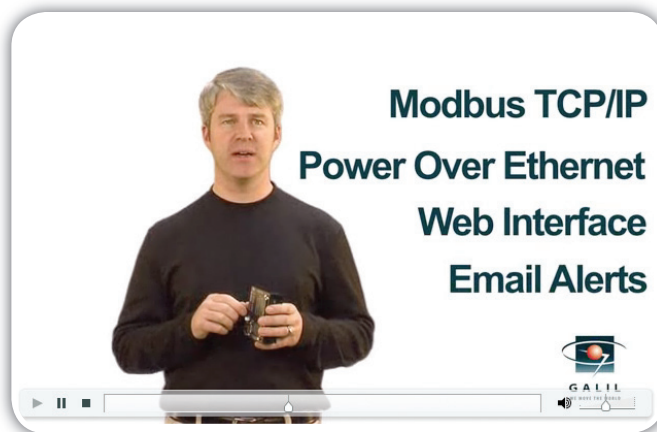
Packed with I/O

Each RIO is loaded with 8 analog inputs, 8 analog outputs, 16 digital inputs and 16 digital outputs. Network multiple units together for unlimited I/O.

Smart

The RIO is smart. It has a fast 32-bit processor, non-volatile memory for storing your programs and PID process control loops which are ideal for temperature control. Other features include data logging, counters and timers. The RIO allows communication via both Ethernet and

RS232. It also supports Modbus TCP/IP as both master and slave, Power-over-Ethernet, a web interface and the ability to send email alerts. Now you can easily interface to HMIs, PLCs, motion controllers and other I/O devices. Plus, the RIO is simple to program. You can program it with Galil's intuitive, two letter command language or Galil's Ladder Interface software. If the RIO Pocket PLC doesn't have it, Galil will work with you to create an affordable custom solution.



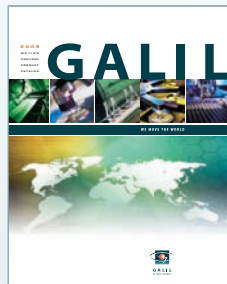
Compact

The compact RIO measures just 3.88" x 4.26" x 1.30" and provides reliable D-sub connectors. Or, use mating ICS boards which provide screw-terminals.

Low Price

The RIO starts at just \$295 in single quantity and \$195 in 100 qty. ■

Galil's New 2009 Motion Control Catalog Now Available for Free



Galil's product catalog has been updated for 2009 with comprehensive technical details, specifications and pricing on all our motion

controllers and drives. Go to: <http://www.galilmc.com/support/catalog.php> to download a PDF of the entire catalog, or download just the section of interest to you. You can also request to receive a hardcopy of the entire catalog by mail.

Galil's 2009 catalog provides extensive product and application information about our full line of controllers and

drives including the popular Accelera ultra high-speed controllers, Econo low-cost controllers and the RIO Pocket PLC series. Both the Accelera and Econo motion controllers are available as a standalone package with Ethernet/RS232 or in card-level format for the PCI bus.

Each series is available with your choice of Galil's growing family of multi-axis drives for stepper and servo motors. The drives attach directly to the controller without additional cables, providing a solution that minimizes wiring, cost and space.

Also included in the catalog is the RIO Pocket PLC which provides an intelligent, low-cost and compact solution for handling I/O. Each intelligent RIO unit contains numerous digital and analog I/O

and a RISC processor for fast processing of commands and I/O logic. The RIO includes an Ethernet 10/100Base-T port and RS232 port and can operate as a Modbus TCP/IP master or slave device.

The catalog also covers the new GalilTools software package which provides "one-button" PID servo tuning and an 8-channel scope for capturing data in real-time. A technical overview about motion control is also featured which gives many programming examples for various modes of motion, including point-to-point positioning, jogging, linear and circular interpolation, contouring and electronic gearing.

Get your free Galil 2009 catalog today by calling 800-377-6329 or visiting <http://www.galilmc.com/support/catalog.php> ■



Achieving Accurate Instantaneous Velocity Control with a Galil Motion Controller

By Andy Herum, Galil Senior Application Engineer

Introduction

Most motion control applications can be categorized as “move and settle” systems, where the objective is to move from one point to another and settle within a predefined time and position window. While velocity accuracy can be important for this type of application, it is the average velocity that matters and not maintaining a constant velocity on a microsecond by microsecond basis. However, some applications require that accurate control of the instantaneous velocity be maintained at all times, resulting in an extremely low velocity ripple. An example of this type of application is control of a precision, air-bearing spindle. This article discusses how accurate instantaneous velocity for a spindle application was achieved using a low-cost Galil motion controller with a simple firmware modification.

Application Description and Specifications

This velocity control application utilized an air-bearing spindle mounted on a granite base. The spindle motor was driven by a sinusoidally commutated amplifier operating in velocity mode. Because of the air bearings the spindle had virtually no frictional damping. It also had relatively low inertia that prevented it from counting on large inertia to dampen any velocity variations. The customer required a solution that was both lower cost than their current design

and produced even less velocity ripple especially at lower speeds.

The customer measured velocity accuracy by measuring the phase variation of the index pulse of the encoder installed on the spindle. This measurement was accomplished by overlaying the edges of the index pulses at a given speed and measuring any difference in the period from revolution to revolution. The customer specification was that the time variation between 2 index pulses must be less than ± 12 microseconds at 5.8 rev/sec (.007% ripple) and less than ± 200 nanoseconds at 333 rev/sec (.005% ripple). The specification also required that the controller accurately control all speeds within the given range shown in **Chart 1**.

Solution

The standard method for accurate velocity control is to use the position control loop of a motion controller to command an amplifier operating in the velocity mode. The controller PID filter is combined with a feed forward velocity (FV command) that produces an open-loop motor command that is proportional to the commanded velocity. This method produces accurate velocity control for most applications. However, the air-bearing spindle had extremely low mechanical damping and the standard method of control could not meet the stringent specifications for low instantaneous velocity ripple over the wide range of speeds.

The primary difficulty in maintaining the low instantaneous velocity ripple came from

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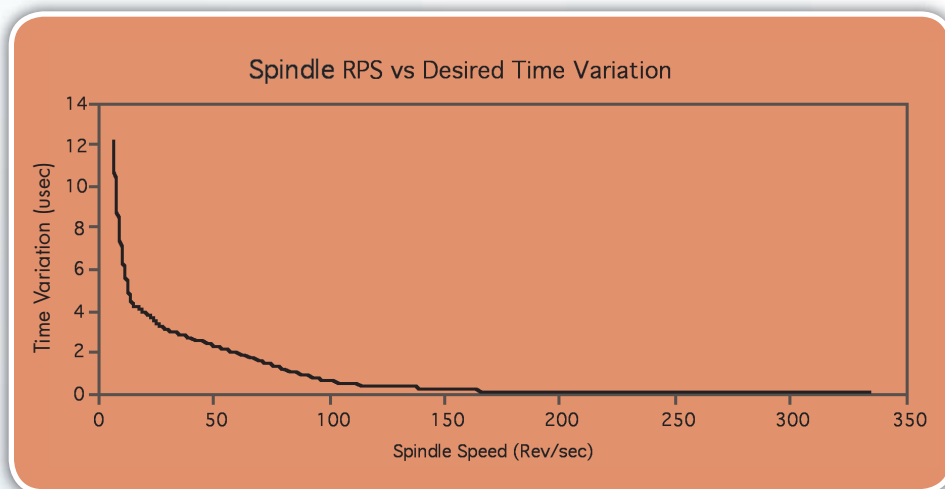


Chart 1: Specifications for Velocity Ripple from Customer



the encoder resolution and the resulting quantization of the encoder reads. Even at constant speeds, the controller will read a different number of encoder counts from sample to sample depending upon when the encoder increments in the servo loop. For any speed that does not have an integral number of encoder counts per sample there will be some samples with a different number of counts than others. For example, the controller might read 10 counts/sample for 5 samples, then read 11 counts in one sample, then back to 10 counts/sample for the next 5 samples, then 11 counts again, etc. While the spindle is actually moving at a constant velocity, the controller will interpret the 11 count samples as an increase in velocity and try to make the appropriate modification to the motor command output. The PID values required to overcome external perturbations, such as changes in air pressure, will result in an injection of torque causing a slight ripple in the velocity.

One solution to the quantization problem is to use a much higher resolution encoder but the extra cost involved was not an option for this application. Another option is to use a sine/cosine encoder and interpolate the signals into higher resolution. However, this also introduces additional costs and potential errors due to analog-to-digital conversion delays at very high speeds.

To meet the low cost and precise performance objectives, Galil proposed a cost-effective, custom firmware solution to the DMC-18x2 Econo series PCI Motion Controller in order to simulate a higher resolution encoder. Use of the Econo series controller and existing, lower resolution, purely digital encoder allowed the customer to reduce the overall cost of the controller compared to their prior controller solution. Plus, the Galil

controller solution offered the added benefit of improved performance.

Speed Range (RPS)	KP	KD
5.8 to 17	2	200
17 to 33	3	225
33 to 333	.05	100

Table 1: PID values chosen

System Performance

To optimize the performance, different control parameters were used for different velocity ranges. The proportional (KP) and derivative (KD) gains of the DMC-18x2 controller were tuned for 3 ranges of velocities as shown in **Table 1**. The update rate on the controller was set at 500usec for each velocity range. Note that the integral gain (KI) is not needed for this application

because velocity accuracy is the goal and zeroing the steady state position error has no effect on a constant velocity output. For the slower speeds ranging from 5.8 rev/sec to 33 rev/sec, a larger proportional gain was used to quickly react to mechanical changes such as changes in air pressure, and a larger derivative gain was used to quickly dampen any possible oscillations that might occur from the fast adjustments. For higher speeds ranging from 33 rev/sec to 333 rev/sec, the inertia of the spindle added an additional level of damping which allowed for lower proportional and derivative gains. The settings allowed for a highly responsive system with very good instantaneous velocity control over a wide speed range, achieving less than .001% velocity ripple. The results are shown in **Chart 2**.

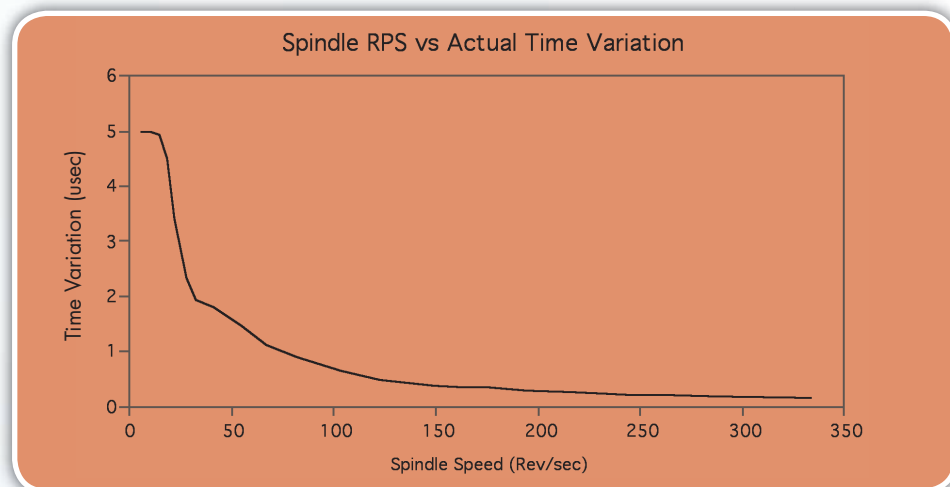


Chart 2: Performance with DMC-1842

Conclusion

Galil's DMC-18x2 Econo motion controller with a custom firmware modification to simulate a higher resolution encoder provided a solution that achieved the cost and greatly exceeded the performance objectives for this velocity control application. Please contact Andy Herum, Senior Applications Engineer, at: andyh@galilmc.com or 800-377-6329 to discuss this article further. See specifications about the DMC-18x2 motion controller at <http://galilmc.com/products/dmc-18x2.php> ■



Galil. We Move the World.

With over 500,000 controllers installed worldwide, Galil is the leading supplier of motion controllers. Galil's legacy of innovation began in 1983 with the introduction of the first microprocessor-based servo motion controller. Today, Galil continues its leadership by offering the most powerful, cost-effective and easy-to-use controllers to accommodate all your motion and I/O needs.

Galil offers a broad array of motion controllers in a variety of formats: single and multi-axis, card-level and box-level, bus-based and stand-alone. Galil's Ethernet/RS232 and PCI controllers are available in an Econo version for lowest cost and Accelera version for ultra high-speed performance. Plug-in, multi-axis drives for steppers and servos save space, cost and wiring. For intelligent I/O control, the RIO Pocket PLC is compact, low-cost and packed with analog and digital I/O.

At Galil, we share our expertise with our customers. You will find a wealth of information on our website at <http://www.galilmc.com>. Here, you can view any of Galil's free web-tutorials, read an application note or white paper, post a question on our bulletin board, or download the latest software and manuals.

Exceptional application support is a top priority at Galil. Call Galil today at 800-377-6329 to discuss your project with one of our highly-trained applications engineers.



ACCELERA CONTROLLERS AND DRIVES

DMC-40x0 Ethernet/RS232
DMC-18x6 PCI

ECONO CONTROLLERS AND DRIVES

DMC-21x3 Ethernet/RS232
DMC-18x2 PCI

SINGLE-AXIS CONTROLLERS AND DRIVES

DMC-1415 Ethernet/RS232
CDS-3310 Ethernet/RS232

POCKET PLC I/O CONTROLLER

RIO-47xxx Ethernet/RS232

SOFTWARE TOOLS

GalilTools. Servo Tuning and analysis software

Ladder Interface. Converts Ladder program into code for RIO Pocket PLC.



FREE Online Support Tools

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