SERVOTRENDS

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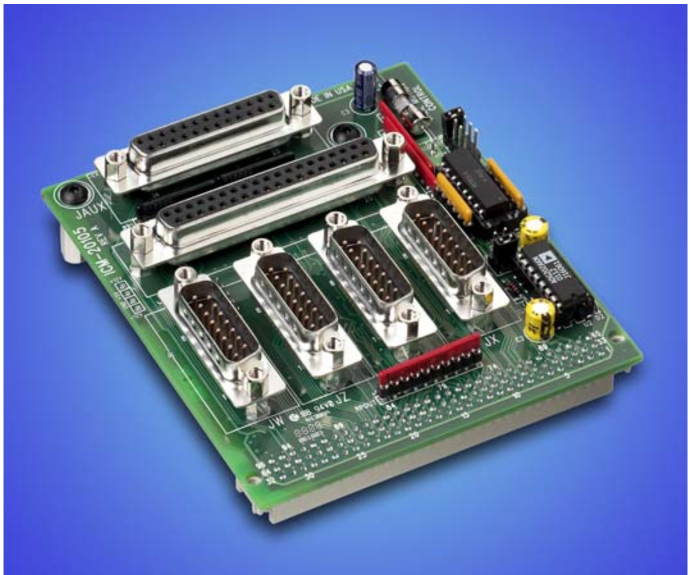
Galil's DMC-21x3 Controllers Now Available with Optical Isolation



Galil's ICM-20105 adds optical isolation to the DMC-21x3 controller

Galil announces a new ICM-20105 board that enables users to cost-effectively and easily add optical isolation to Galil's popular DMC-21x3 Ethernet controllers. The ICM-20105 attaches on top of the DMC-21x3 via a 96-pin DIN connector in order to optically isolate inputs and outputs including limits, home and general I/O. The connection is made without any additional cabling or hardware.

Measuring only 4.25" x 3.70", the ICM-20105 breaks out the DMC-21x3's 96-pin DIN connector into convenient D-sub connectors for easy interface to external amplifiers and I/O devices. These include four D-sub connectors with one for each of the four axes, a 37-pin D-sub for the digital I/O, home and limits; and a 25-pin D-sub for the auxiliary encoder signals.

Features also include:

- *Eight 500mA, high-side drive outputs for driving higher power external devices such as relays.*
- *Operates at up to 28 Volts.*
- *Interfaces to a wide range of external amplifiers*
- *User-configurable for: high or low amplifier enable, 5V or 12V logic, external supplies to 28 Volts, and sinking or sourcing.*

A single ICM-20105 is required for each set of four axes, and two ICMs can sit side-by-side on a DMC-2183 eight axis controller.

The ICM-20105 is a cost-effective solution for OEMs with its low price of $195 in single quantity and $145 in 100 quantities.

This new board represents the latest in a full line of Galil interconnect, amplifier and I/O options for the DMC-21x3, including:

- *SDM-20240 full- and half-step drives for four stepper motors*
- *AMP-20340 linear amplifiers for driving four 20-watt brush servo motors*
- *AMP-20440 PWM amplifiers for driving four 200-watt brush servo motors*
- *AMP-20540 PWM amplifiers for driving four 500-watt brushless servo motors*
- *ICM-20100 interconnect for interface to external amplifiers*
- *ICM-20105 interconnect with optical isolation*
- *DB-28040 for 40 additional digital I/O and 8 analog inputs*

Complete specifications, pin-out and pricing information for all DMC-21x3 interconnect options are available online at **http://www.galilmc.com/products/accessories/21x3 options.html**.

Galil's New AMP-19540 Multi-axis Drive for 500W Brushless Motors

Galil's AMP-19540 provides four 500W drives for brushless motors

In the July issue of ServoTrends, Galil introduced their powerful AMP-20540 four-axis amplifier designed for driving 500W brushless motors. It provides a cost-effective solution for multi-axis applications and eliminates the wiring between the controller and drives by attaching directly to Galil's DMC-21x3 controller.

Now, Galil introduces a newer version of the same high-performance amplifier, the AMP-19540, which has been repackaged so that it can attach to Galil's DMC-18x2 or DMC-18x0 PCI bus, DMC-21x0 Ethernet or any other Galil Optima controller that uses the 100-pin SCSI connector and cable. Like the AMP-20540, the new AMP-19540 is a four axis amplifier that can drive up to four brush or brushless motors up to 500 Watts each.

The compact 6.8" x 8.75" x 1" AMP-19540 sits outside of the PC, interfacing to the PCI bus controller with a single, 100-pin high density SCSI cable. Signals for each axis are extracted via D-type connectors located on the AMP-19540.

The AMP-19540 also has similar power specifications as the AMP-20540. It contains four transconductance, PWM amplifiers, each of which can drive brush or brushless motors operating at 18V to 80 Vdc, up to 7 Amps continuous, 10 Amps peak. The gain setting is easily configured with jumpers, and the PWM switching frequency is 60 kHz.

Priced at $795 in single quantity and $495 in 100 quantities, the AMP-19540 is a cost-effective way for OEMs to get a high performance, multi-axis solution. When combined with a DMC-1842 four axis controller ($795 in 100 quantity), the amplifier/controller price per axis comes to less than $325. This combination provides a much lower cost alternative to using separate single axis drives. For applications with less than three axes, the AMP-19520 two-axis model is available. A shunt regulator option is also available (see Jacob Tal's article *"Using Shunt Regulators"* on page 5 in this issue of ServoTrends).

Complete specifications and pricing of the AMP-19540 is available on the web at: **http://www.galilmc.com/products/accessories/amp19540.html**.

Galil's Adds to Web-Tutorial Library to Help You Stay Current On Motion Control

Galil has built an extensive library of technical web-tutorials covering a variety of motion control subjects including servo tuning, dual loop control, and motor types. Recently, Galil has added two tutorials: "Using Shunt Regulators" and "Flexible-Distributed Control Systems". The "Flexible-Distributed Control Systems" tutorial presents a cost-effective, flexible method for distributed control by using multi-axis Ethernet controllers. Go to **http://www.galilmc.com/training/webconf.html** to view these new tutorials, as well as any other of the Galil tutorials listed below. Tutorials are available 24/7 and at no cost to registered viewers.

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"

Software Tools
"ActiveX Tool Kit"

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

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

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

New Distributed Control Option for DMC-21x3

One year ago, Galil introduced their central control solution, the DMC-21x3 Ethernet controller, and it has become one of the most popular controllers in Galil's 20 year history. Customers now have a cost-effective, multi-axis Ethernet control solution that sits outside of the PC.

One reason for its popularity is Galil's array of multi-axis amplifiers (also recently released) which connect directly to the DMC-21x3 controller to provide a complete controller/ drive solution that is cost-effective and dramatically reduces wiring. Additionally, the DMC-21x3 is a centralized multi-axis controller where motion control functions for all axes are handled on one central controller card. For example, an eight axis application is handled with a single DMC-2183 eight axis controller card. This type of a central control solution is very desirable because combining all axes onto a single card is far more economical than purchasing separate, single-axis controllers.

When Distributed Control is a Good Option

While a central control solution like the DMC-21x3 is the most economical choice for most applications, machine design often dictates that controllers be distributed throughout the system. For example, an eight axis machine may have all eight axes located far apart, resulting in long wiring when a central controller is used. Traditional distributed systems use single-axis controllers or drives in a network. While having the advantage of reduced wiring, these single-axis networks have several disadvantages. For starters, the coordination between the drives must be done by the host computer, resulting in significant programming for the user, especially when precise control is required. Also, the use of single axis drives significantly increases the cost. These disadvantages are eliminated with Galil's new Flexible-Distributed Control option for the DMC-21x3.

DMC-31x3 is a Flexible-Distributed Control Solution

Galil's new DMC-31x3 provides a Flexible-Distributed Control option for the DMC-21x3. Unlike most distributed networks, which consist of single axis controllers or drives, the DMC-31x3 can be specified for one through eight axes. This allows the user to divide the system into islands, with each island having any number of axes according to the machine requirements. For example, an eight axis machine may consist of two 3-axis DMC-3133 controllers and one 2-axis DMC-3123 controller. Or, using two 4-axis DMC-3143 controllers may optimally suit the machine requirements. By allowing Flexible-Distribution, designers can choose the best combination for their machine. (See *Figures 1 and 2*)

DMC-31x3 Unburdens the Host Computer

In addition to providing flexibility, the DMC-31x3 distributed control system also frees the host computer from the time intensive task of motion coordination. This is accomplished because coordinated motion, such as linear and circular interpolation, is performed by each local, multi-axis DMC-31x3 controller. Alternative distributed systems that use single-axis controllers or drives will burden the host with the complex task of motion coordination.

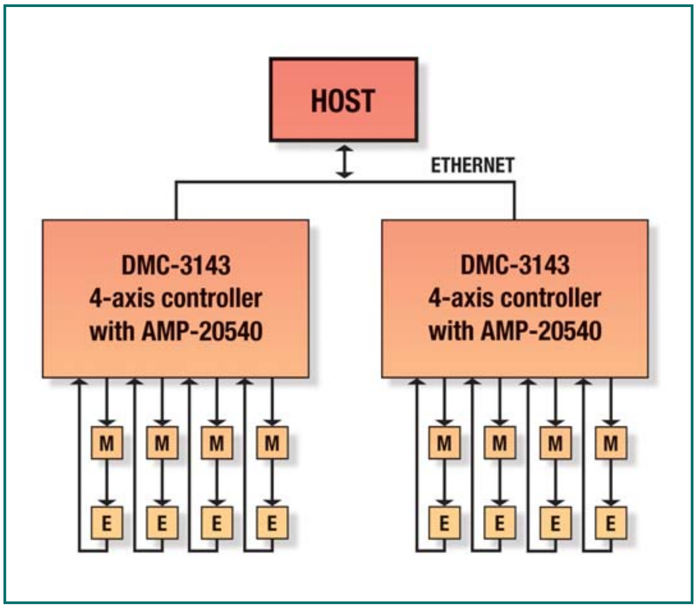


Figure 1. 8-axis Flexible-Distributed System using two 4-axis controllers

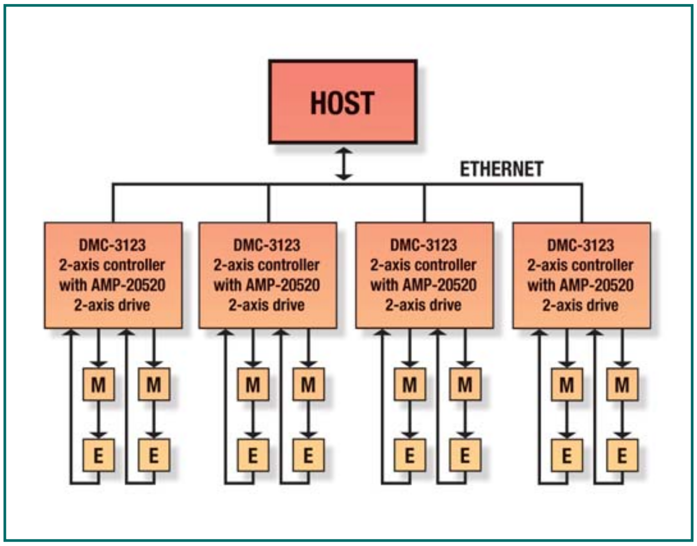


Figure 2. 8-axis Flexible-Distributed System using four 2-axis controllers

(Continued on Page 4)

New Distributed Control Option...

(Continued from Page 3)

The DMC-31x3 also minimizes the communication burden on the host computer as compared to single axis networks. It can do this because one DMC-31x3 controller is configured as the master controller and communicates directly with other DMC-31x3 controllers on the network (*see figure 3*). A set of special commands has been added to the standard Galil DMC-21x3 instruction set which allows for distributed control. For example, the command "HC" connects the Ethernet handle of a controller to the network. A complete list of commands is found in the DMC-31x3 user guide.

Ethernet is the Network of Choice for DMC-31x3

Of course, Ethernet is a very popular, cost-effective, highly supported network. There is one consideration when using Ethernet: it is a non-deterministic network in which commands sent faster than 1 msec might be delayed. This delay is not an issue with the DMC-31x3 distributed system. Because the DMC-31x3 is a full-featured motion controller that performs coordinated motion and executes complete motion programs, it need only receive high level instructions from the host computer. These instructions are sent at rates much slower than 1 msec, making the non-deterministic nature of Ethernet irrelevant for DMC-31x3 motion systems. (See Ethernet article on page 7)

DMC-31x3 Provides a Cost-effective Solution

Since the DMC-31x3 distributed controller uses the same hardware as the DMC-21x3 central controllers, all interconnect, amplifier and I/O options are available for the DMC-31x3. These include:

- *SDM-20240 full- and half-step drives for four stepper motors*
- *AMP-20340 linear amplifiers for driving four 20-watt brush servo motors*
- *AMP-20440 PWM amplifiers for driving four 200-watt brush servo motors*
- *AMP-20540 PWM amplifiers for driving four 500-watt brushless servo motors*
- *ICM-20100 interconnect for interface to external amplifiers*

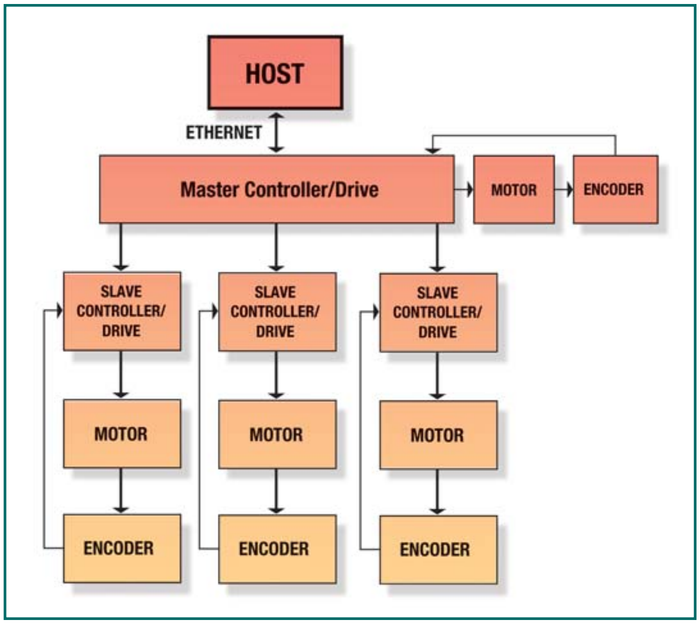


Figure 3. Galil's DMC-31x3 unburdens the host by allowing one DMC-31x3 master controller to talk to other DMC-31x3 slave controllers in the distributed system.

- *ICM-20105 interconnect with optical isolation*
- *DB-28040 for 40 additional digital I/O and 8 analog inputs*

These options allow for multi-axis controller/drive combinations to be connected on the distributed Ethernet network. Also, these controller and drive combinations offer a cost-effective solution as compared to networking single axis drives and controllers. For example, in an eight axis application, the designer may choose to network two DMC-3143 four-axis controllers with each sandwiched with an AMP-20540 four-axis drive. The price for each four-axis controller/drive combination is just $1,290 in 100 quantities or less than $325 per axis for both the controller and 500W drive. The resulting eight-axis solution is much more economical when compared to purchasing eight single axis controllers and eight individual drives.

In summary, Galil's new DMC-31x3 provides a powerful, cost-effective distributed control solution that's quite flexible. More information can be found at: **http://www.galilmc.com/products/econo/dmc21x3.html**.

New Technical Support Office Opened in the Northeast

Todd Shearer, a Galil application engineer for the past seven years, has established an office near Hartford, Connecticut, from which he will provide technical support for Galil's OEM customers in the Northeast. Lisa Wade, VP of Marketing and Sales at Galil, says "*Our customers in this region will appreciate having a senior technical specialist in their time zone. Please join us in welcoming Todd to his new home on the East Coast.*"

Using Shunt Regulators *By Jacob Tal, president/founder, Galil*

In motion control systems, energy changes its form from electrical to mechanical and vice versa. The change is done by the motor, which converts current to mechanical torque, and speed into voltage.

The energy flow is shown in *Figure 1*. The electric power flows from the grid to the power supply and, via the amplifier, to the motor where it is converted to mechanical form. When the motor decelerates, its kinetic energy is converted back to electrical energy, which is transferred back to the supply.

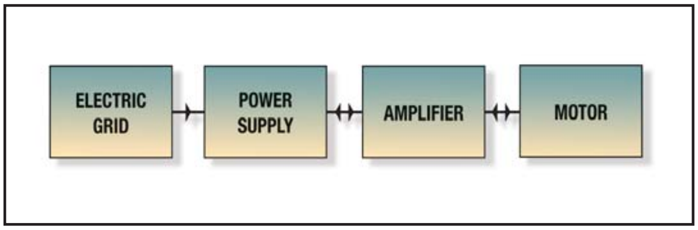


Figure 1. Power Flow

A unique feature of the power flow system is that the flow from the grid to the power supply is unidirectional. That means power cannot flow back from the power supply to the grid. Consequently, when electrical energy is regenerated by the motor, it is stored in the power supply, resulting in increased supply voltage.

Increased voltage beyond a permitted range can cause damage to the system. First, the amplifier may stop functioning, resulting in loss of control. Higher voltage will also cause damage to the components.

There are several options to avoid this scenario. First, one can increase the capacitance of the power supply, thereby, allowing it to store more energy. Secondly, one can start with a lower supply voltage, allowing a wider voltage margin for regenerative energy. Finally, one can use a shunt regulator, which discharges excess energy above a certain voltage, thereby assuring that the voltage is limited.

The operation of a shunt regulator is illustrated by *Figure 2*. The switch S is turned on when the supply voltage exceeds a threshold. This causes the excess charge to bleed through the resistor R. Once the voltage drops to a desired level, the switch S is open.

Who needs it?

Due to the potential damage, every designer must evaluate the need for a shunt regulator. In general, a shunt regulator is needed when a relatively large amount of mechanical energy is converted to electrical form. Most likely, scenarios include a heavy inertia, rotating at high speed, coming to a stop, or a large mass moving down. If there are some doubts regarding the need for a shunt regulator, it is highly recommended to perform the analysis shown that follows.

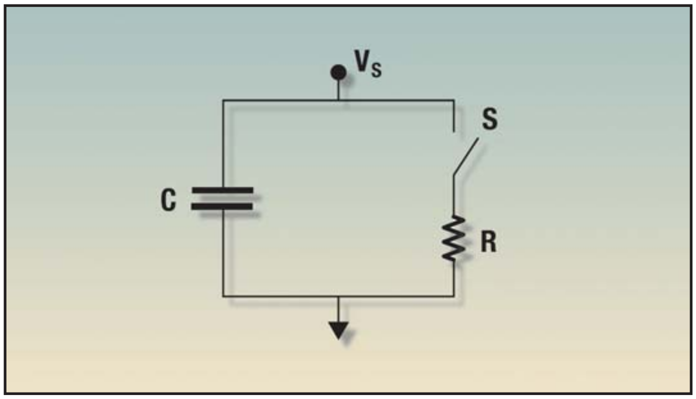


Figure 2. Shunt Regulator

The Power Transfer

As energy flows back and forth between electrical and mechanical forms, there are some losses associated with the conversion. The two major elements of energy loss are friction loss E_F and I^2R losses E_L. The energy flow is illustrated in *Figure 3*.

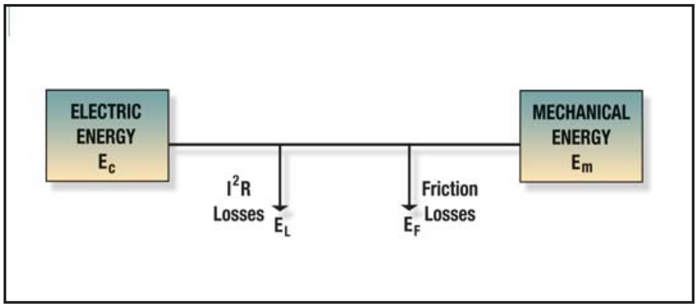


Figure 3. Energy Conversion and Losses

To analyze the voltage increase, note that if the mechanical energy is E_m, the regenerated energy E equals:

$$E = E_m - E_L - E_F$$

As the initial supply voltage is V_S, its starting energy is

$$E_S = \tfrac{1}{2} C V_S^2$$

The addition of E increases the voltage to V, where

$$\tfrac{1}{2} C V_S^2 + E = \tfrac{1}{2} C V^2$$

or

$$V = \sqrt{V_S^2 + 2E/C}$$

The following discussion illustrates the analysis for a rotary system.

(Continued on Page 6)

Using Shunt Regulators...

(Continued from Page 5)

Analysis – Rotary System

Consider a rotary load with the following parameter, stopping over a time interval T.

J	Inertia
ω	Speed
R	Armature Resistance
T_F	Friction
K_T	Torque Constant
V_S	Supply Voltage
C	Supply Capacitance
T	Deceleration Time

Assuming that the deceleration rate is uniform, the stopping angle, θ, equals

$$\theta = \frac{\omega T}{2}$$

This implies that the friction losses are

$$E_F = T_f \theta$$

As the motor deceleration rate is

$$\theta = \frac{\omega}{T}$$

The motor current required to stop the motor at the presence of the friction is

$$I = \left(\frac{J\omega}{T} - T_F\right)/K_T$$

Resulting in energy losses of

$$E_L = I^2RT = \left(\frac{J\omega}{T} - T_F\right)^2 RT/K_T^2$$

As the mechanical energy is kinetic

$$E_m = \frac{1}{2} J\omega^2$$

The net regenerated energy is

$$E = E_m - E_L - E_F$$

Resulting in a supply voltage of

$$V = \sqrt{V_s^2 + 2E/C}$$

Note that the analysis can be simplified if the user takes a conservative approach by assuming that both E_L and E_F are zero.

Next, we illustrate the process with an example:

Example – Rotary System

Consider a rotary system with the following parameters coming to a stop. Then, determine the final supply voltage.

It is highly advised to perform all the calculations in mks units, as shown below.

$J = 0.003$ oz-in-s^2 $= 2.1 \cdot 10^{-5}$ kg*m^2

ω = 6000 rpm = 628 Rad/s

R = 1.2Ω

T_F = 10 oz-in = 0.07 Nm

K_T = 29 oz-in/A = 0.2 Nm/A

V_S = 60 Volts

C = 0.2 Farad

T = 1 sec.

The kinetic energy of the system equals,

$$E_m = \frac{1}{2} J\omega^2 = 591 \text{ Joules}$$

The stopping angle, θ, is

$$\theta = \frac{1}{2}\omega T = 314 \text{ Rad}$$

Resulting in friction losses of

$$E_F = 0.07*314 = 22 \text{ Joules}$$

The motor current during the deceleration equals

$$I = (0.003*628 - 0.07)/0.2 = 9A$$

Resulting in

$$E_L = 9^2*1.2 = 97 \text{ Joules}$$

This leads to a regenerated energy of

$$E = 591-22-97 = 472 \text{ Joules}$$

And a final voltage of

$$V_S = \sqrt{60^2 + 2*472/0.2} = 91 \text{ Volts}$$

If the resulting voltage of 91 volts is unacceptable, the designer must increase the capacitance or use a shunt regulator.

Conclusion

The analysis method given above describes the case of a rotary system. The same method can be easily extended to linear systems and, with some efforts, to vertical systems as well.

For additional information, watch a free web tutorial *"Using Shunt Regulators"* at **http://www.galilmc.com/training/webconf.html**.

The Suitability of Ethernet for Motion Control

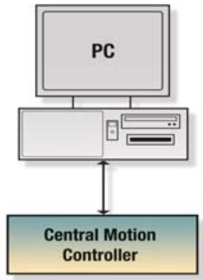
By Robin C. Riley, Senior Applications Engineer

Systems engineers are frequently tasked with determining the appropriate network for optimizing the performance of their motion control system. Usually, the two competing protocols are TCP/IP over Ethernet or a Fieldbus architecture such as CanOPEN, SERCOS, or DeviceNet.

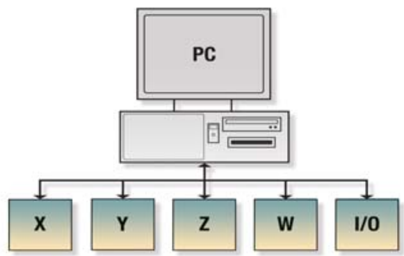
Such Fieldbus networks rely on small, deterministic packets of data that are transferred between a single master and multiple slaves. This method works very well when the information is repetitive, short, and required at regular intervals. The data could include streaming position commands for each axis of motion.

Ethernet protocol provides the engineer with a flexible, scalable network, where large packet size and collision recovery allow intelligent devices to seamlessly communicate with one another. Since any device with an Ethernet network can generate messages, the potential for a collision exists. TCP/IP recovers from a collision by re-transmitting the packet after a small, randomly generated delay. This effect leads to non-determinism of less than 1 millisecond. However, because all the servo loop and coordinated motion profiles occur off-network, multi-axis controllers are insensitive to non-determinism. In addition, with the lighter network traffic, the chance of a collision occurring at all is far less likely than with a fully loaded network.

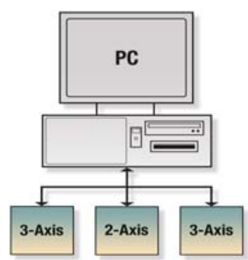
The following diagrams detail three control schemes that the designer may choose–each with benefits and drawbacks. Here, the network depends on the devices in the system.



Scenario 1 *In this scheme, a host PC sends high-level commands to a centralized controller, where all loop closure, coordinated motion, and I/O handling are performed on the controller. This architecture is best suited for either Ethernet or RS-232.*



Scenario 2 *This scheme shows a host PC sending real-time position trajectory commands to a network consisting of several single-axis drives. This data is regular and repetitive. If the system requires loop closure such as SERCOS to occur over the network, then a deterministic network is necessary. If the system contains intelligent drives capable of closing the servo loop internally, then either a Fieldbus or Ethernet network is acceptable.*



Scenario 3 *Here a host PC sends high-level motion commands to a network consisting of multi-axis motion controllers and I/O. In addition, text messages and irregular (unsolicited) data will be transmitted from one device to another. All servo loop closure, coordinated motion, and I/O handling is performed inside the controller. For this architecture, Ethernet is the best option.*

Galil Motion Control has developed the *flexible-distributed* network, (see scenario 3), which lets the user configure the system so that axes that are in close physical proximity to each other are controlled by a multi-axis motion controller (see DMC-31x3 article on page 3 of this issue of ServoTrends). Also, each of these multi-axis nodes can, in turn, communicate with a master controller or the host PC. This keeps all time-critical operations such as servo loop closure, coordinated motion, and I/O handling local to the node. Plus, the network is used to merely transmit high-level supervisory commands, such as "Execute a process" or "Tell the master the current I/O status". Because of the flexibility of TCP/IP packets, Ethernet is the network protocol of choice.

Because of the vast popularity of the Internet, almost all PC users are familiar with some form of TCP/IP. By relying on the local loop closure and motion profiling inherent to all Galil motion controllers, a systems engineer can create a robust control network with off-the-shelf commercial products and a user-friendly, popular, open-source serial data protocol.

For additional in-depth information on various networks, see Galil's latest application bulletin *"The Suitability of Ethernet for Motion Control"*, at **http://www.galilmc.com/literature/technotes.html**.

"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.

Galil Technical Support Team

Top Row-left to right- Chris Richtsmeier, Chris Cortopassi

3rd Row- left to right- Kaushal Shah (Group Mgr.), Glen Garettsson, Robin Riley

2nd Row-left to right- Eric Kelley, Todd Shearer (northeast region)

Front- John Hayes

Galil. We Move the World.

With over 300,000 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-21x0. 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.