Galil PlugIn for Mach3

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Overview:

The Galil PlugIn controls the popular Galil Motion Controllers. The Galil is a very powerful motion controller that will control up to 8 axes and provides I/O capabilities as well. When used with Mach, it provides a means of controlling a closed loop servo system as well as a stepper system. Stepper motor and servos can even be mixed.

For servos, the Galil controllers provide an industry standard +-10V motor command that works with most analogue servo amps. It is one of the few ways to run analogue amps with Mach.

For stepper motors, the Galil Controllers provide the standard pulse and direction interface. Unlike the parallel port stepper driver, the Galil controller can provide step pulse rates at up to 3 MHz.

The PlugIn works by taking the Mach step and direction signals that would normally go to the parallel ports and converting them into linear interpolated moves in the Galil command language. A spindle is also supported.

Galil axes can be mapped 1 to 1 with the Mach axes or mixed in any manner desired. Limit switches, home switches, general inputs, and general outputs are supported through the Mach "Ports and Pins" settings. And support for extended I/O is also provided.

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Controller Compatibility:

Accelera Series
- DMC-40x0 Ethernet
- DMC-18x6 PCI BUS

Optima Series
- DMC-17x0 ISA BUS
- DMC-18x0 PCI BUS
- DMC-21x0 Ethernet
- DMC-22x0 Ethernet

Econo Series
- DMC-21x2/3 Ethernet
- DMC-18x2 PCI

Single and Dual Axis
- DMC-14x5

The Optima DMC-20x0 USB controllers may work, but none have been tested.

Galil has versions of the above controllers that operate in distributed mode via Ethernet. They are the DMC-31x2/3 and the DMC-34x5. These controllers are not supported in their distributed form but can be loaded with the non-distributed mode firmware to effectively turn them into a DMC-21x2/3 or DMC-14x5.

Ethernet Controllers:

Galil Ethernet controllers have a few special items that need some consideration.

A good quality network is required. The Galil Controllers will answer just about any TCP/IP port and will open a "handle" when contacted by any remote machine. There is a limit of 8 handles, which can be used up rather quickly making your Galil controller unusable until it is reset. Obviously, a port sniffer running on the network will pretty much make a Galil Ethernet controller hose up pretty fast. So it is best to have the Galil controller on an isolated network along with your Mach machine.

In the Galil Controller Communication Parameters dialog, set the following items as described below:

- The "Primary Handle" drop down list should be set to "TCP".

- The "Unsolicited Messages" drop down list should be set to "Take no action".

- The Ethernet controllers also have a feature that allows them to listen to a Multicast address. This allows for one message to
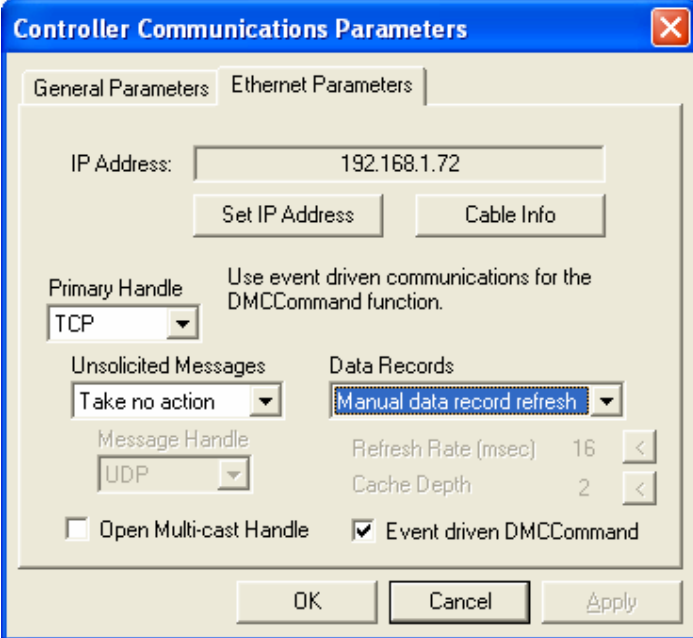
reach all controllers on a network. This is undesirable for the Mach/Galil combination. Uncheck the "Open Multi-cast Handle" check box.

▪ Data records for Ethernet controllers are handled differently than the bus based controllers. There are two modes for data records on Ethernet controllers. Either mode works with the Galil Plugin.

Manual mode:

Manual mode is where a command has to be sent to the controller to request a data record and then the controller will send one back.

Below is an example of how the controller's Communication Parameters should be set for manual data records.

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Automatic mode:

Automatic mode is where the controller will send a data record to the host PC at a predetermined interval. The automatic mode produces a smoother Mach interface because the PlugIn doesn't have the overhead of requesting a data record and waiting for it. Automatic mode will "feel" more like a bus based controller. However, the automatic data record mode uses UDP to transmit the stream of data records to the host. UDP is a connectionless protocol and there is no way of determining if there is a dropped packet. So if automatic mode is chosen, you must ensure that the network is in good shape. Or preferably, use a crossover cable between the controller and the Mach PC. If automatic mode is chosen and the data stream to the host PC is unreliable, Mach will crash from a lack of information from the Galil controller. In this case, simply choose the Manual data record refresh mode.

Below is an example of how the controller's Communication Parameters should be set for automatic data records. Set the Refresh Rate to 25 milliseconds and the Cache Depth to 2.
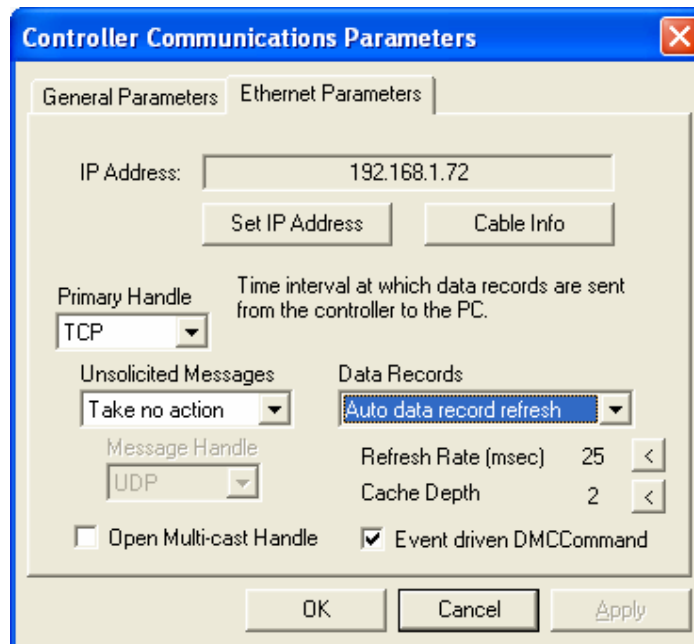
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Installing the PlugIn:

The PlugIn comes as an m3p file. Double clicking the m3p file should install the plug-In in the correct Mach location. The file is installed in the \Mach3\PlugIns directory. If the plug-in doesn't appear in the controller configuration menu at startup, check for the existence of Galil.dll in this directory. If it is not found here, then do a search for this file and copy and paste it manually into this directory.

Prerequisites:

While the setup and configuration of the Galil controller is beyond the scope of this manual, a few things are worth mentioning.

The Galil controller needs to be registered in the Galil SmartTerm software. Follow the instructions in Chapter 4 – Communications settings in the Galil User's Manual for your particular controller. Proper controller registration is required for the Mach3 Galil Plugin to communicate with the controller.

If you are running servos, the PID filter values should be set in the controller prior to running the Galil Plugin. This is known as tuning the servos. Also in Chapter 4 of the Galil User's Manual is a description of the Windows Servo Design Kit (WSDK) which is Galil's software that is capable of automatically tuning the servos. The full version of GalilTools can also be used as well. Manually tuning the servos is also possible via the KP, KI, and KD commands through SmartTerm.

After tuning the servos with whatever method you choose, the KP, KI, and KD values should be saved to the controller with the BN command.

All home and limit switches should be connected and verified. You can use the "Display Data Record" menu option in the "Tools" menu of SmartTerm to verify these switches.

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Configuring the PlugIn:
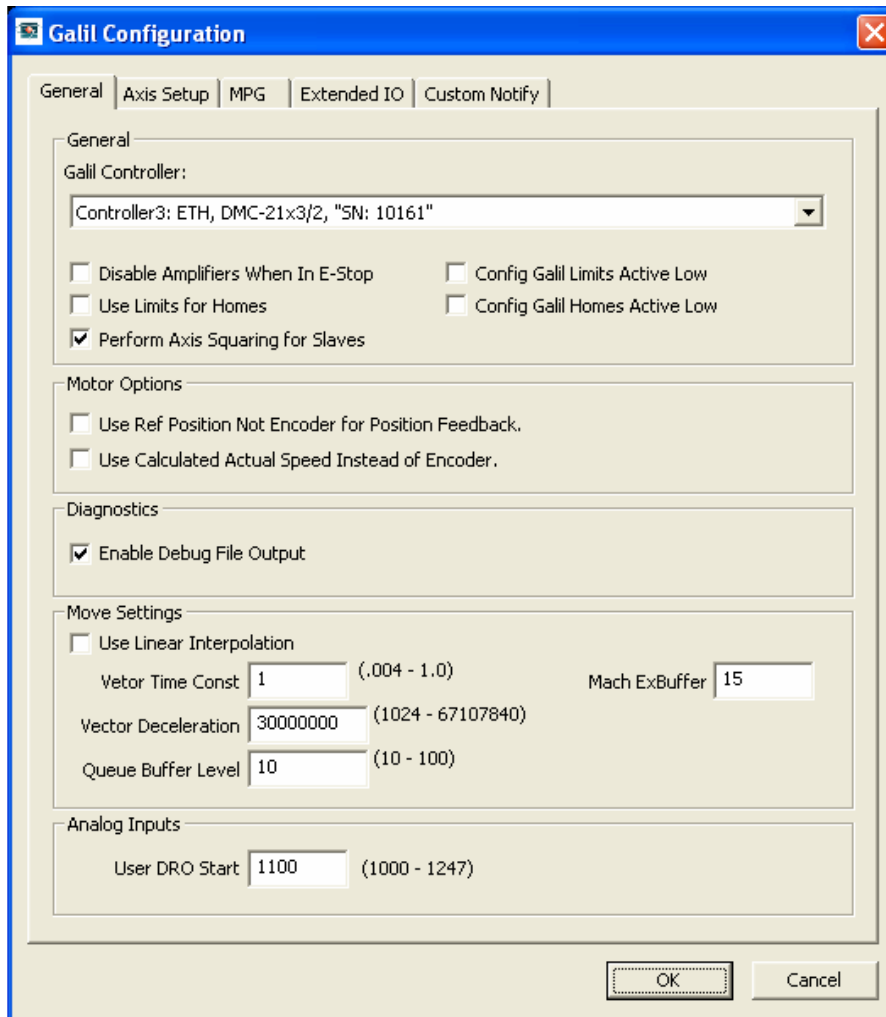
General:

> **Galil Controller:** When setting up communications with the Galil controller in the Galil SmartTerm software, you register the controller and provide information about it. This registration puts the controller into the Galil registry. This version of the PlugIn allows you to choose which registered controller to use for Mach. This allows different Mach profiles on the same machine to control different Galil controllers. This may be useful for people who wish to drive both a mill and a lathe from the same PC. (Not at the same time though!). Simply choose which controller you wish to use in this Mach profile from the dropdown list.
>
> **WARNING!!!** You must have previously registered a Galil controller in the SmartTerm software before any controllers will show up in the drop down list.

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Bus based controllers may require you to reboot the PC before a newly registered bus based controller will be visible.

Disable Amplifiers When in E-Stop: Disables the amplifiers when Mach is in an e-stop condition.

The Galil lets you control the active state of the limit switches. This allows for both normally open and normally closed switches to be used. It is popular to wire the limit switches with normally closed switches for safety reasons. In the event of a cable cut, the machine will stop. A normally closed switched system will be active low. A normally open switched system will be active high.

Config Galil Limits Active Low: If you have normally closed switches on your limits, then this checkbox should be enabled.

Config Galil Homes Active Low: Similarly, if your home switches are active low, enable this checkbox.

Unfortunately, you cannot have a mixture of normally closed and normally open limit switches. And you cannot have a mixture of switch types for the homes switches either. You must choose one switch type for the limits and one switch type for the home switches. However, you could mix switch types if you wire them with relays that do the right thing on the machine. The important thing is that the switch state that the Galil sees must be consistent.

Use Limits for Homes: For machines where no separate home switches are available, you will need to enable this checkbox. It is preferable to install home switches since there is a dedicated home switch input per axis on the Galil ICM.

Perform Axis Squaring for Slaves: Gantry style machines that have a slaved axis require special homing routines. The default way the plugin homes a gantry axis is that it first homes the master and slave axes together. It will then disconnect the slave and home it to square the gantry. If you do not wish to square the gantry, then uncheck this checkbox.

Motor Options:

These check boxes determine how Mach gets the position feedback and speed. Most of the time, these should remain unchecked. If stepper motors are configured, using the "SM" jumpers, checking the boxes may be necessary to display position in the DRO displays.

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Diagnostics:

Enable Debug File Output: Enabling this checkbox creates a GalilDebug.txt file in the PlugIn's directory. This output may be useful for the developers if you are running into problems. Leave it unchecked for normal operation.

Move Settings:

Use Linear Interpolation: The Plugin is capable of using two modes of motion; linear interpolation and contour mode. Linear Interpolation works with all Galil controllers and thus, is the default. However, if have an Accelera controller, you may wish to uncheck this checkbox to enable Contour mode.

The Vector Time Constant and **Vector Deceleration** are effective in the liner interpolation mode only.

For most situations, set the Vector Time Constant to 1. Setting this to a lower value will have the effect of smoothing the moves. The Vector Time Constant is a velocity filter. Setting the value progressively lower increases the filtering to attempt to maintain a more constant velocity over the move sequences.

The Galil is a very powerful motion controller in its own right and it is capable or performing its own trajectory planning. But Mach is doing the same thing! So the Vector Deceleration should be set to a range that allows Mach to take the lead in this department. Start with 30,000,000. That's thirty million!

Queue Buffer Level: The PlugIn uses an internal buffer to stream the commands to the Galil controller. This is the Queue Buffer Level and it can be tweaked to suit the speed of the Mach PC. If you are experiencing motor stutters in mid moves, then start incrementing this value by one until the stutter is gone. The default value is 10 and it will go as high as 100. A side effect of increasing this number is that feed rate overrides and feed holds will be slower, so start low and increase it only to the point where your problem disappears.

Mach ExBuffer: For external motion PlugIns, Mach maintains a buffer for the move sequences. This value impacts the response time of the feed rate override and the feed hold. Lower the value yield the better the responses. However, setting the value too low will cause the plugin to cease producing moves. 15, the default value is "safe". Faster Mach machines may be able to use a value of 11 or 12.

Analog Inputs:

User DRO Start: This is the starting User DRO OEM code for the range of 8 analog inputs that are available on some Galil controllers.

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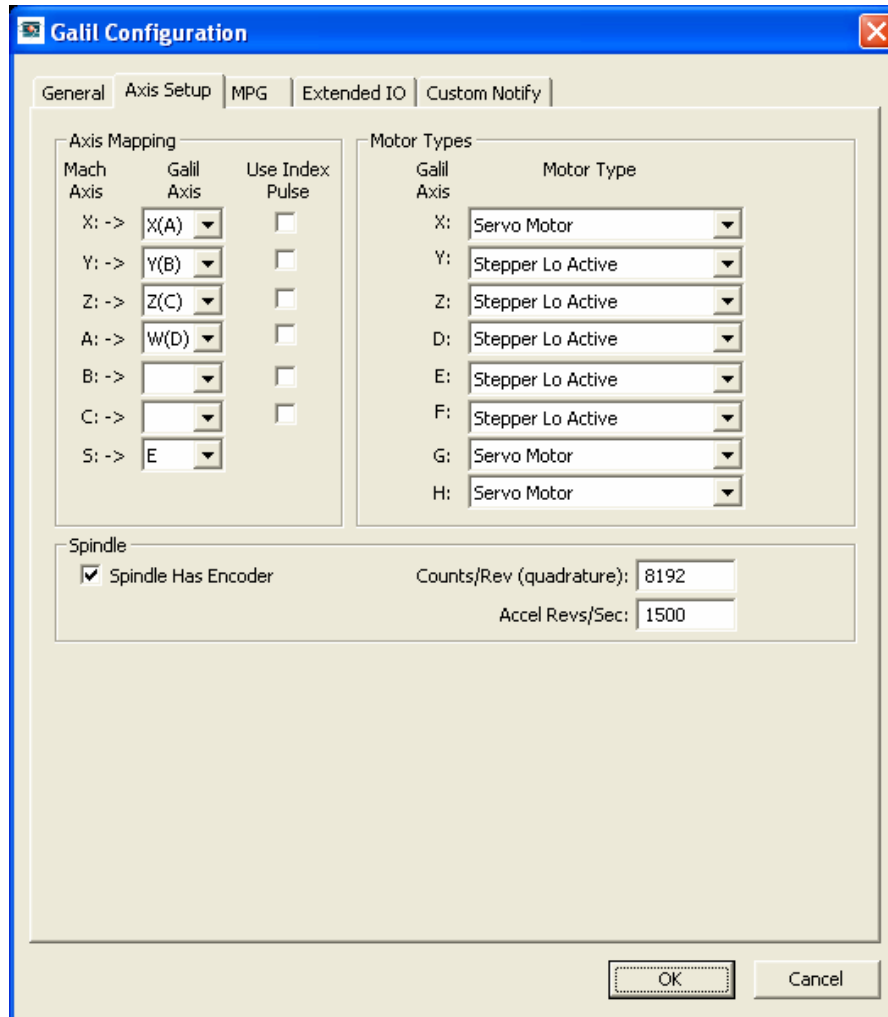
Axis Mapping:

You can map axes in a different order than the standard XYZABC order that Mach provides. For instance, you may wish to drive your Mach X axis with the Galil G axis. Simply choose the Galil G axis in the dropdown list for the Mach X axis.

The limit switches travel with the Galil axis, so in the example above, you would wire your limits to the Galil G axis but they would appear as Mach X axis signals.

The Mach Spindle can be mapped to any unused Galil axis.

It is important not to map more axes than you have configured in Mach. This is to allow unused Galil axes to remain independent and is handy if you are using the Galil to drive brushless motors that require an extra axis to perform the sinusoidal commutation. Since the Galil controller will automatically map these sinusoidal axes to the last unused axes on the Galil controller, we don't want Mach trying to send movement information to these axes. For example, if the X (A), Y (B), and Z(C)

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Galil axes are driving brushless motors, the Galil maps the commutation axes to F, G, and H on an 8-axis controller. In this case, it is very important not to map the F, G, and H axes to any Mach axes. If any Mach axis is unused, just leave it blank as in the example above and don't try to map it to a Galil axis.

It is also useful to hide Galil axes from Mach so that the axis can be controlled from a thread running on the Galil controller. This is useful in cases where the hidden axis is used as a drive for semi continuously running devices such as a sewing machine motor, which are controlled through the Galil thread, and not Mach.

If you wish to have the Galil home and then look for an index pulse, check the appropriate "**Use Index Pulse**" checkbox. (Using index pulses requires use of encoders that are capable of providing an index pulse!).

Motor Type:

The Motor Type drop down boxes allows setup of the Galil "MT" and "CE" values from within Mach. The options include:

```
Servo Motor                         (MT1, CE0)
Servo Reverse                       (MT-1, CE0)
Step Motor Hi active                (MT-2, CE4)
Step Motor Lo active                (MT2, CE4)
Step Motor Reverse Hi active        (MT-2.5, CE12)
Step Motor Reverse Lo active        (MT2.5, CE12)
```

The step motor options require that the "SM" jumper is placed on the appropriate Galil axis jumpers for non Accelera models.

Spindle:

Spindle has Encoder: If your spindle has an encoder and you wish to use it to allow the Galil controller to keep the spindle speed constant, then enable this checkbox.

Counts/Rev: This value is the number of counts per revolution for the spindle encoder. The value should be in quadrature counts. e.g. If your encoder has 512 counts per revolution, the Galil will see it as 2048 counts per revolution. In this example, 2048 is what you should enter in this field.

Accel Revs/Second: This is the acceleration and deceleration value for the encoder based spindle in revolutions per second.

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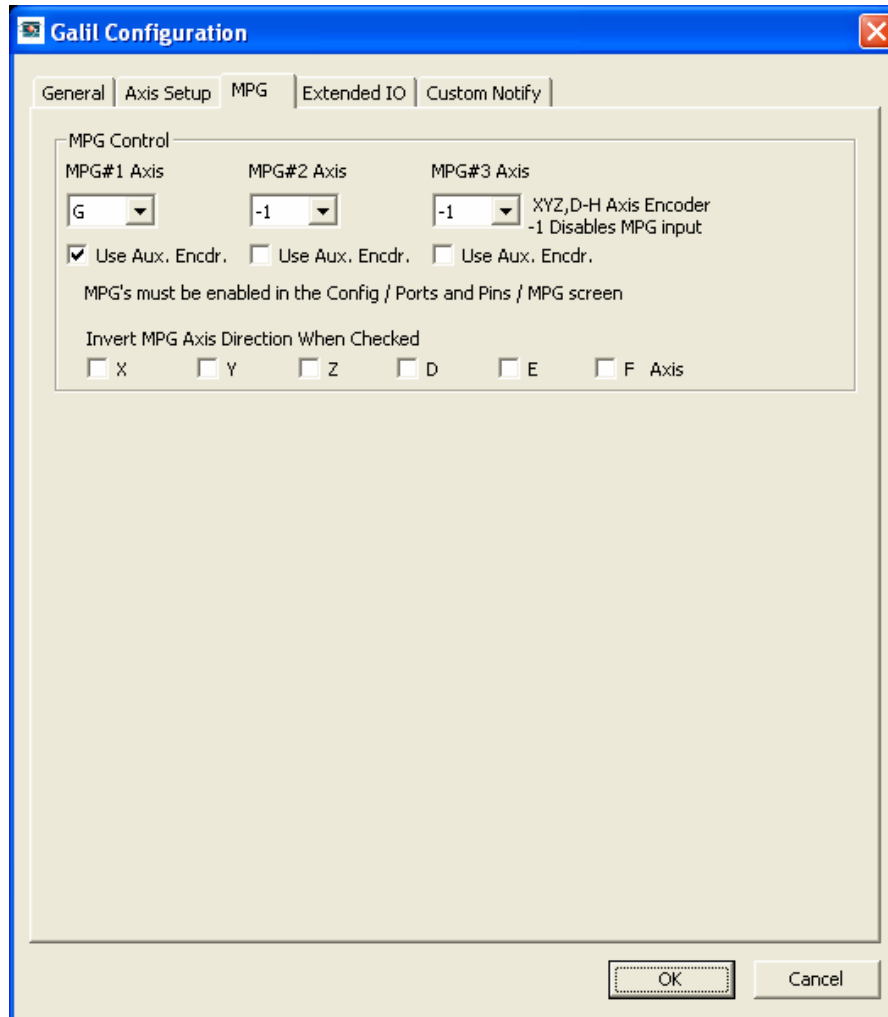
MPG Control:

The Galil PlugIn provides a way to drive the axes directly with MPGs via Galil axis gearing. This dramatically smoothes the MPG response since it is not pulsed from Mach's 100ms update loop.

There are several possible MPG configurations. You can use an MPG pendant with a pulse generator wheel and selector switches to choose controlled axis and increment per pulse. With this setup, the inputs from the pendant need to be wired into the Galil inputs, and a "brain" file used in Mach to map inputs to the MPG.

Alternatively, An MPG pulse generator wheel can be connected to an unused Galil encoder input and the tab-out MPG screen can direct output and amount to the proper axis.

A third method uses 1 to 3 MPG encoders wired to unused Galil encoder inputs. The first MPG can control Mach's X axis, the second can control Mach's Y axis, and the third can control Mach's Z axis. Axis selection is controlled with the tab-out MPG screen menu. In any case,

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to use an MPG requires that the MPG is enabled through the "Ports and Pins" screen and the MPG page by checking the enable box.

The MPGs use either an un-configured Galil axis (meaning Mach is not using it and it is not mapped in the axis mapping) or one of the Galil axes' secondary encoders. For example, if Mach is configured to use X, Y, and Z axes and they are mapped to the Galil A, B, and C axes respectively, you could choose the Galil D axis to drive your first MPG. You would then hook the MPG encoder to the Galil D main encoder terminals on the ICM.

If you have used all of your Galil axes for Mach, you can then choose the Galil axis A and check the "Use Aux Encdr." check box to drive your first MPG. You would then hook the MPG encoder to the Galil A secondary encoder terminals on the ICM.

Follow this method for each MPG you wish to connect.

WARNING!!!! It is very important that if you don't have an MPG configured in Mach then you must not configure the MPG setting in the Galil PlugIn configuration. Otherwise, you may get weird axis movements. X tied to Y, etc…

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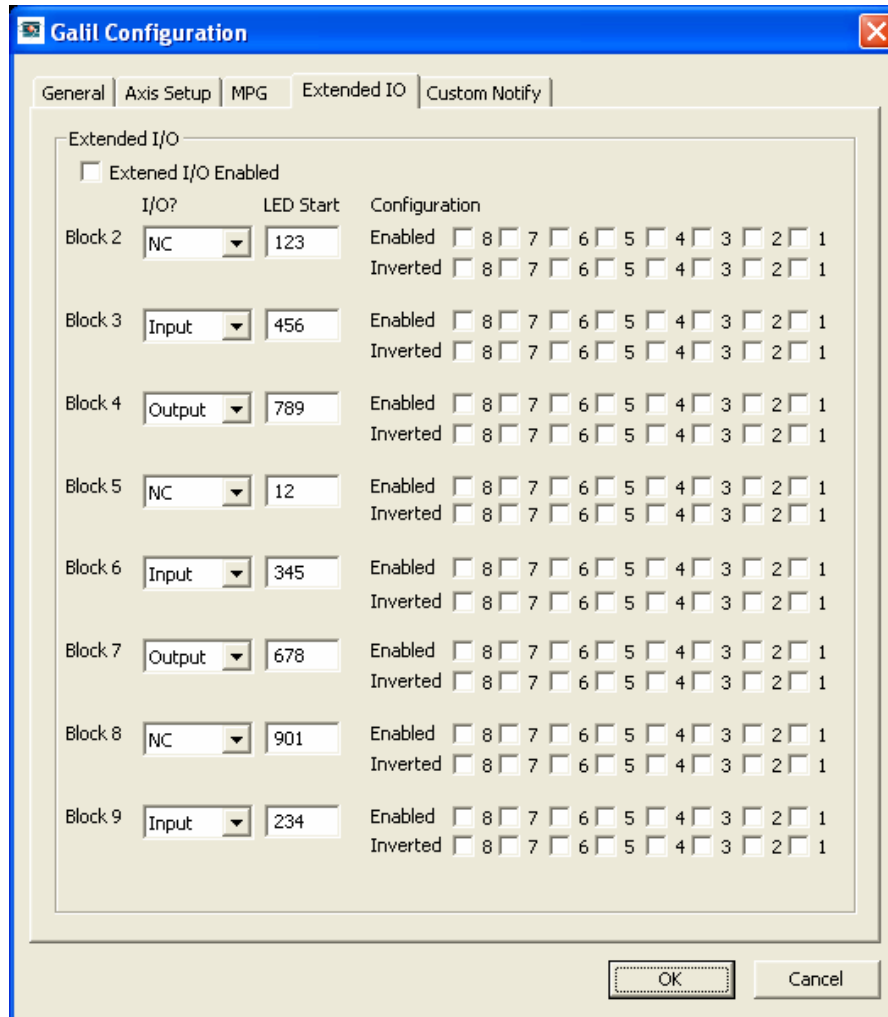
Extended I/O:

Extended I/O is not available on the Econo Series PCI controllers. It is an option on the Optima Series bus controllers and the Econo Ethernet controllers. It is standard on the Optima Ethernet and USB controllers. For the Optima controllers, there are 64 bits of configurable extended I/O. However, the Econo Ethernet controllers only provide 40 bits of configurable extended I/O. The extended I/O is configurable, in blocks of eight, as either inputs or outputs.

Extended I/O Enabled: To enable extended I/O, this checkbox must be enabled.

I/O ?: You must explicitly enable each block as either and Input or Output blocks, or leave it in the not configured state (NC).

LED Start: Each block must be configured with a range of Mach user LEDs. Since each block consists of 8 I/O points, each block will use 8 Mach user LEDs. This filed is the number of the first Mach user LED in the block.

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Enabled: Each I/O bit can be enabled or disabled depending on the state of its associated "Enabled" checkbox.

Inverted: The state of the I/O point (active high or active low) can be configured with its associated "Inverted" checkbox.

Leave extended I/O disabled if you do not have extended I/O or do not wish to use it.

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Custom Notify Messages:

The Galil PlugIn allows the user to make use of the powerful Galil command set via custom notify messages. There are 24 possible messages that can be configured.

Enable: Enable this message.

Message ID: The Mach message ID. This is the ID that Mach sends the PlugIn.

Commands: The Galil commands to send to the controller when the PlugIn receives its corresponding message ID. More than one command can be sent provided that they are separated by semicolons. The entire command string can be no longer than 80 characters (the Galil command line length). There is support for limited substitutions in the command string. DROxxxx will substitute the value of the Mach DRO with OEM code xxxx. LEDxxxx will substitute the values of the Mach LED with OEM code xxxx. For instance, if you wanted to set a Galil variable to the value of a Mach DRO, then the cammand string would look like this: "SPI=DRO55". This will set the Galil variable SPI equal to the value in the Mach DRO #55.

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Configuring Mach:

Limit \ Home connections:

Limit and home switches are configured on the ports & pins inputs screen.

They are wired to the Galil inputs and configured as in the table below:

All use port #1

```
X +limit ----- pin #1    A +limit ----- pin #4
X -limit ----- pin #9    A -limit ----- pin #12
X home    ----- pin #17  A home    ----- pin #20
Y +limit ----- pin #2    B +limit ----- pin #5
Y -limit ----- pin #10   B -limit ----- pin #13
Y home    ----- pin #18  B home    ----- pin #21
Z +limit ----- pin #3    C +limit ----- pin #6
Z -limit ----- pin #11   C -limit ----- pin #14
Z home    ----- pin #19  C home    ----- pin #22
```

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General I/O:

Galil controllers of 1-4 axes usually have 8 inputs and 8 outputs available. 5-8 axis controllers have a total of 16 inputs and 16 outputs available.

It is now necessary to configure the I/O in ports & pins to enable Mach to access and control the Galil I/O. Prior to this release, the Galil inputs were mapped to port1 and the pin number was the Galil input number. The same was true of the outputs. While this was simple, problems were found in the implementation that necessitated change. With this release, the I/O must be configured in Mach using the pin numbers from the table below. The I/O must also be identified as active low or high.

Inputs: 1-4 axis control	**5-8 axis control only**

All use port #1

```
Input 1 ----- pin #25        Input 9  ----- pin #33
Input 2 ----- pin #26        Input 10 ----- pin #34
Input 3 ----- pin #27        Input 11 ----- pin #35
Input 4 ----- pin #28        Input 12 ----- pin #36
Input 5 ----- pin #29        Input 13 ----- pin #37
Input 6 ----- pin #30        Input 14 ----- pin #38
Input 7 ----- pin #31        Input 15 ----- pin #39
Input 8 ----- pin #32        Input 16 ----- pin #40
```

Outputs: 1-4 axis control	**5-8 axis control only**

All use port #1

```
Output 1 ----- pin #41       Output 9  ----- pin #49
Output 2 ----- pin #42       Output 10 ----- pin #50
Output 3 ----- pin #43       Output 11 ----- pin #51
Output 4 ----- pin #44       Output 12 ----- pin #52
Output 5 ----- pin #45       Output 13 ----- pin #53
Output 6 ----- pin #46       Output 14 ----- pin #54
Output 7 ----- pin #47       Output 15 ----- pin #55
Output 8 ----- pin #48       Output 16 ----- pin #56
```

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Probing:

The Galil PlugIn is capable of using a probe for various probing functions. This is accomplished using the Galil high speed position latch functions. Unfortunately, the latch inputs share general purpose inputs on the Galil ICM. Galil axes A, B, C, and D use inputs 1, 2, 3, and 4 and Galil axes E, F, G, and H use inputs 9, 10, 11, and 12 for the latch inputs.

IMPORTANT!!!! A probe should be wired to **ALL** latch inputs for any moving axis on your machine! For example, if you have a 3 axis mill and you are using Galil axes A, B, and C to drive them, then the probe's output should be wired to inputs 1, 2, and 3. This is because the G31 probe command will move in all 3 dimensions.   If you have 3 axis mill with a 4th axis rotary driven from Galil axes A, B, C, and D, then the probe's output should be wired to inputs 1, 2, 3, and 4.

When setting up Mach for probing, it is imperative that the "Probe" signal is enabled in "Ports and Pin" on the "Input Signals" tab and the port and pin should be mapped to one of the Galil latch input pins. For example, if your 3 axis mill uses Galil axes A, B, and C to drive Mach axes X, Y, and Z, then the probe's output signal should be wired to Galil inputs 1, 2, and 3 and the Mach Probe signal should be enabled and mapped to port 1, and one of pins 25, 26, or 27. Which pin is mapped really does not matter since all of the inputs will be active upon a probe hit.

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Credits:

Brian Barker: brianb@machsupport.com
> Thanks go to Brian for feeling adventurous and writing the Galil PlugIn. Without Brian, the Galil PlugIn would not have materialized at all.

Jeff Birt:
> Jeff added the Extended I/O support.

Kenny Crouch: kcrouch@cruises4fun.com
> Kenny added the MPG support and improved the flow of the Galil command to the controller. He also made it possible to run Galil threads while under Mach control. He was able to smooth things out tremendously.

Steve Murphree: smurph@smcomp.com
> Steve added the following:
> - The ability to control registered Galil controllers other than the first registered controller.
> - Axis mapping.
> - Contour Mode movement control.
> - He originated this manual and continues to maintain version control of the plug-in software.
> - Encoder controlled Spindle.
> - Analog Input support.
> - Custom Notify Messages
> - Use Limits for Homes.