RIO Firmware Command Reference

10/30/14

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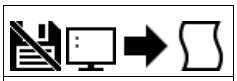
' *Comment*



```
' str
```

Description

The ' allows for a user to insert in a comment on a blank line after a command following a semicolon ";". See examples for valid uses of '.

Arguments

Argument	Value	Description	Notes
str	String	Comments added into program	Comment strings are restricted to the maximum row size for a program. This will vary per controller.

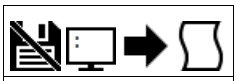
Remarks

- Comments will be downloaded to controller, thus taking up program space.
  - See REM for comments that will not download to controller

Examples

```
'Galil DMC Code Example
'Include an example like this one in the program.
SH AB;'Comments following a command MUST be proceeded by a semi-colon.
KP 10'This is NOT valid use of the '
```

- *Subtraction Operator*



n_0 - n_1

Usage	variable = (value1 - value2)	Performs an operation between two values or evaluated statements

Description

Subtraction operator. Takes as arguments any two values and returns a value equal to the difference of the arguments.

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
n_0	-2,147,483,648	2,147,483,647	N/A	1/65,536	Value to subtract from	
n_1	-2,147,483,648	2,147,483,647	N/A	1/65,536	Value to subtract	

Remarks

- An operator is not a command and is not valid individually.
- Evaluation occurs left to right. Use parenthesis for operator precedence.
- n_0 and n_1 may also be variables, array elements, operands, or @ functions (e.g. @SIN[]).

Examples

```
'Galil DMC Code Example
:var1 = 10-4
:var2 = var1 - 3
:MG var2 - 1
 2.0000
:
```

```
'Galil DMC Code Example
'It is recommended that parenthesis be used when more than one mathmatical operation is combined in one command.
'Example:
var = ((10*30)+(60/30));'      evaluates as 302
var = 10*30+60/30;'            evalutes as 12
```

Label Designator

#str

Description

Denotes the name of a program label. For example, #move. Labels can be up to seven characters long and are often used to implement subroutines or loops. Labels are either user-defined or are automatic subroutines that are run automatically by the firmware when a particular event occurs.

There is a maximum of 62 labels available on the RIO-47xx0.
There is a maximum of 126 labels available on the RIO-47xx2 and RIO-473xx.

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
str	1 char	7 chars	N/A	String	Name of label	

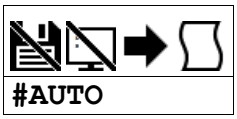
Remarks

- A label can only be defined at the beginning of a new line
- The number of labels available can be queried with MG _DL
- LL returns the current label table in the controller
- Galil recommends that at least the first character be lowercase to differentiate from Automatic subroutines.
- Label must be the first element on a line of code

Examples

```
'Galil DMC Code Example
'A simple example of iteration.  The loop will run 10 times
i= 0;'             Create a counter
#loop;'            Label
 i= i+1;'          Increment counter
JP #loop, i<10;'   Spin in #Loop until i >= 10
EN;'               End the subroutine or thread
```

#AUTO *Subroutine to run automatically upon power up*



Description

Defines the automatic entry point of embedded DMC code. When power is applied to the controller, or after the controller is reset, the program will automatically begin executing at this label. When no host software is used with the controller, #AUTO is required to run an application program on the controller stand-alone.

Arguments

Label must be the first element on a line of code.

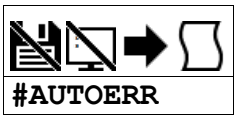
Remarks

- Use EN to end the routine
- Thread 0 is used to execute #AUTO on startup
- The BP command must be used to burn a program into EEPROM for the #AUTO to function.

Examples

```
'Galil DMC Code Example
'On startup, this code will create a 50% duty cycle square wave on output 1 with a period of 1 second.
#AUTO;'      Start on powerup
 SB 1;'      Set bit 1
 WT 500;'    Wait 500msec
 CB 1;'      Clear bit 1
 WT 500;'    Wait 500msec
JP #AUTO;'   Jump back to #AUTO
```

#AUTOERR *Bootup Error Automatic Subroutine*



Description

Automatic subroutine that runs code upon power up if the firmware detects errors. If the EEPROM is corrupted, #AUTOERR will run. The EEPROM is considered corrupt if the checksum calculated on the bytes in the EEPROM do not match the checksum written to the EEPROM.

For SSI and BiSS operation, #AUTOERR will also run if the time to acquire serial position data exceeds 90% of the hardware sample loop. This type of error is very rare and should never occur in normal operation.

Arguments

Label must be the first element on a line of code.

Remarks

- Use EN to end the routine
- The type of checksum error can be queried with MG_RS

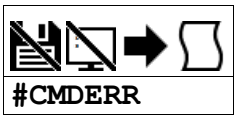
- For SSI and BiSS operation
  - In the event of a serial position acquisition timeout, the following will occur:
    - The controller will reset
    - The controller servo loop will not run, TM will be set to zero
    - TC1 will return "143 TM timed out"
    - The automatic subroutine #AUTOERR will run, if present
    - The Error output will be set
  - When using serial encoders (SSI or BiSS), the #AUTOERR should follow these guidlines
    - IF _TC=143 do not employ any trippoints in following code because the timer interrupt is suspended
    - Serial encoders can be disabled with the commands SIn=0 or SSn=0 where n is the axis indicator ABCDEFG or H
    - In order to re-enable the timer interrupt issue "TM n" where n is the servo update period in us (usually n=1000). See TM for more details

Examples

```
'Galil DMC Code Example
'Code detects a checksum error and notifies the user
#AUTOERR
 MG "EEPROM ERROR ",_RS
EN
```

```
'Galil DMC Code Example
'Use for BiSS and SSI only (-SER firmware)
'Distinguishing between a serial timeout
' condition and an EEProm condition
#AUTOERR
IF _TC=143
REM BiSS or SSI timeout
REM No trippoints in this clause
REM Print message to DMC-4020 LCD
 LU 0
 MG "BiSS"{L1}
 MG "Timeout"{L2}
 SSA= 0
 SSB= 0
ELSE
REM Checksum error
REM trippoints ok here
REM Print message to DMC-4020 LCD
 LU 0
 MG "EEProm:"{L1}
 MG {Z10.0}_RS{L2}
ENDIF
EN
```

#CMDERR *Command error automatic subroutine*



Description

Automatic subroutine that runs code when a DMC code error occurs. Without #CMDERR defined, if an error (see TC command) occurs in an application program running on the Galil controller, the program (and all threads) will stop.

Arguments

Label must be the first element on a line of code.

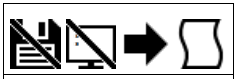
Remarks

- Use EN to end the routine
- #CMDERR will only run from errors generated within embedded DMC code, not from the terminal or host
- In a single threaded application (Thread 0 only), the EN command in the #CMDERR routine will restart thread 0 where it left off.
- In a multi-threaded application, the thread that has an error will be halted when a command error occurs. Thread 0 will be interrupted to run the #CMDERR routine but other threads will continue to run.
  - In order to restart the thread that encountered the error, see the example in Chapter 7 of the User Manual and the _ED operand.
- Thread 0 does not need to be running in order for the #CMDERR routine to execute.

Examples

```
'Galil DMC Code Example
'This example shows a bug in DMC code
'#CMDERR detects the bug at runtime and
' provides debugging info
'
#mysub;'user subroutine
xx;'Accidental typo, bad command
EN
'
#CMDERR;'runs if an error occurs
MG "An error occured at line",_ED
TC 1;'print type of error info
ZS;'Remove returns from the callback stack
EN;'End execution
```

#COMINT *Communication interrupt automatic subroutine*



Description

Automatic subroutine to provide interrupt driven communications from the serial port. #COMINT can be configured by the CI command to run either when any character is received, or when a carriage return is received over the com port. The auxiliary port is used if equipped.

Arguments

Label must be the first element on a line of code.

Remarks

- Use EN to end the routine
- #COMINT runs in thread 0, and an application must be running in thread 0 in order for #COMINT to be enabled.
- Code running in thread zero will be interrupted by the #COMINT subroutine.
- It is important to handle the interrupt condition and return without delay. The controller will continue to receive data and update the data operands (P1CH,P2CH, etc) while in #COMINT. This can lead to missed characters, numbers, and strings if #COMINT is unnecessarily delayed.

Examples

```
'Galil DMC Code Example
CI 2;'                    interrupt on any character
#loop
MG "Loop";'              print a message every second
WT 1000
JP #loop
#COMINT
MG "COMINT=",P1CH;'      print character received
EN 1,1
```

#COMINT applies to DMC40x0,DMC42x0,DMC41x3,DMC21x3,RIO,DMC30010,DMC50xx0

#ININT0 *Input interrupt automatic subroutine 0*

Description

Automatic subroutine that runs upon a state transition of digital inputs. The RIO provides an input interrupt function which causes the program to automatically execute the instructions following the #ININT0, #ININT1, #ININT2, and/or #ININT3 labels. This function is enabled using the II command. The thread for execution of each label can be chosen along with the input state conditions. Note that the specified thread needs to be executing at the time of the interrupt otherwise the automatic subroutine will be ignored.

Arguments

Label must be the first element on a line of code.

Remarks

- Use RI to exit the routine
- To make an unconditional jump from #ININT, there are two methods for re-enabling the interrupt capability
  - Issue a ZS and then re-issue the command II before the JP
  - or, use a "null" routine. The "null" routine allows for the execution of the RI command before the unconditional jump. For more information see Application Note #2418 http://www.galilmc.com/support/appnotes/optima/note2418.pdf

Examples

```
'Galil DMC Code Example
#a;                         'Program A
II 2,0,3&5&-10;             'Specify interrupt #2 on main thread when inputs 3 and 5 go high, and 10 goes low
#loop;JP #loop;             'Loop
EN;                         'End Program
#ININT2;                     'Interrupt subroutine number 2
MG "INTERRUPT";             'Print Message
#clear
JP #clear,@IN[1]=0;          'Check for 'reset' input 1 to clear interrupt
RI;                         'Return to main program
```

#ININT0 applies to RIO

#ININT1 *Input interrupt automatic subroutine 1*

#ININT1

Description

Automatic subroutine that runs upon a state transition of digital inputs. The RIO provides an input interrupt function which causes the program to automatically execute the instructions following the #ININT0, #ININT1, #ININT2, and/or #ININT3 labels. This function is enabled using the II command. The thread for execution of each label can be chosen along with the input state conditions. Note that the specified thread needs to be executing at the time of the interrupt otherwise the automatic subroutine will be ignored.

Arguments

Label must be the first element on a line of code.

Remarks

- Use RI to exit the routine
- To make an unconditional jump from #ININT, there are two methods for re-enabling the interrupt capability
  - Issue a ZS and then re-issue the command II before the JP
  - or, use a "null" routine. The "null" routine allows for the execution of the RI command before the unconditional jump. For more information see Application Note #2418 http://www.galilmc.com/support/appnotes/optima/note2418.pdf

Examples

```
'Galil DMC Code Example
#a;                     'Program A
II 2,0,3&5&-10;         'Specify interrupt #2 on main thread when inputs 3 and 5 go high, and 10 goes low
#loop;JP #loop;         'Loop
EN;                     'End Program
#ININT2;                 'Interrupt subroutine number 2
MG "INTERRUPT";         'Print Message
#clear
JP #clear,@IN[1]=0;      'Check for 'reset' input 1 to clear interrupt
RI;                     'Return to main program
```

#ININT1 applies to RIO

#ININT2 *Input interrupt automatic subroutine 2*

Description

Automatic subroutine that runs upon a state transition of digital inputs. The RIO provides an input interrupt function which causes the program to automatically execute the instructions following the #ININT0, #ININT1, #ININT2, and/or #ININT3 labels. This function is enabled using the II command. The thread for execution of each label can be chosen along with the input state conditions. Note that the specified thread needs to be executing at the time of the interrupt otherwise the automatic subroutine will be ignored.

Arguments

Label must be the first element on a line of code.

Remarks

- Use RI to exit the routine
- To make an unconditional jump from #ININT, there are two methods for re-enabling the interrupt capability
  - Issue a ZS and then re-issue the command II before the JP
  - or, use a "null" routine. The "null" routine allows for the execution of the RI command before the unconditional jump. For more information see Application Note #2418 http://www.galilmc.com/support/appnotes/optima/note2418.pdf

Examples

```
'Galil DMC Code Example
#a;                         'Program A
II 2,0,3&5&-10;             'Specify interrupt #2 on main thread when inputs 3 and 5 go high, and 10 goes low
#loop;JP #loop;             'Loop
EN;                         'End Program
#ININT2;                     'Interrupt subroutine number 2
MG "INTERRUPT";             'Print Message
#clear
JP #clear,@IN[1]=0;          'Check for 'reset' input 1 to clear interrupt
RI;                         'Return to main program
```

#ININT2 applies to RIO

#ININT3 *Input interrupt automatic subroutine 3*

Description

Automatic subroutine that runs upon a state transition of digital inputs. The RIO provides an input interrupt function which causes the program to automatically execute the instructions following the #ININT0, #ININT1, #ININT2, and/or #ININT3 labels. This function is enabled using the II command. The thread for execution of each label can be chosen along with the input state conditions. Note that the specified thread needs to be executing at the time of the interrupt otherwise the automatic subroutine will be ignored.

Arguments

Label must be the first element on a line of code.

Remarks

- Use RI to exit the routine
- To make an unconditional jump from #ININT, there are two methods for re-enabling the interrupt capability
  - Issue a ZS and then re-issue the command II before the JP
  - or, use a "null" routine. The "null" routine allows for the execution of the RI command before the unconditional jump. For more information see Application Note #2418 http://www.galilmc.com/support/appnotes/optima/note2418.pdf

Examples

```
'Galil DMC Code Example
#a;                     'Program A
II 2,0,3&5&-10;         'Specify interrupt #2 on main thread when inputs 3 and 5 go high, and 10 goes low
#loop;JP #loop;         'Loop
EN;                     'End Program
#ININT2;                 'Interrupt subroutine number 2
MG "INTERRUPT";         'Print Message
#clear
JP #clear,@IN[1]=0;      'Check for 'reset' input 1 to clear interrupt
RI;                     'Return to main program
```

#ININT3 applies to RIO

#MODERR *Modbus timeout automatic subroutine*

Description

Automatic subroutine which can be configured with the MH command to run when the RIO has not received a Modbus command within a certain period of time. #MODERR runs in thread 0 and will automatically run even if application code is not running on thread 0 at the time of the timeout.

Arguments

Label must be the first element on a line of code.

Remarks

- Use RE to end the routine.

Examples

```
'Galil DMC Code Example
#AUTO;'          Auto Start
MH 100;'         Set timeout at 100msec
#loop;'          Main loop
'                Loop code
JP #loop;'       Repeat loop
#MODERR;'        Modbus Timeout Automatic subroutine occurred
IHA= >-2;'       Close timed out handle
RE;'             Return from subroutine
```

#MODERR applies to RIO

#SERERR *Serial Encoder Error Automatic Subroutine*

Description

Automatic subroutine that allows user code to run when there is a serial encoder fault.
This subroutine is only used with controllers equipped with hardware featuring the -BiSS or -SSI encoder upgrade.

Arguments

Label must be the first element on a line of code.

Remarks

- Use the RE command to end this routine.
- #SERERR runs on thread 0
- The following are the fault conditions which will cause #SERERR to interrupt.

Serial Encoder Faults

BiSS
Encoder timeout (bit 0 of _SE)
CRC error (bit 1 of _SE)
Error bit* (bit 2 of _SE)
Warning bit* (bit 3 of _SE)

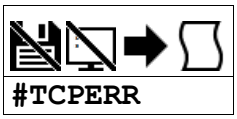
- The active level of the Error and Warning bits for BiSS must be configured with SY.
- For the encoder timeout condition, TC1 will also return "140 Serial encoder missing."
- Note: The encoder manufacturer may name the Error and Warning bits differently. Consult the encoder documentation for the naming convention.
  - See the SY command to define the polarity of these bits.
- Galil defines the Warning bit as the bit directly preceeding the CRC. The Error bit is defined as the bit directly preceeding the Warning bit.

Examples

```
'Galil DMC Code Example
#SERERR
MG "SERERR"
MG _SE0           ;' output status bits
SE 0,0              ;' disable encoder 0
RE
```

#SERERR applies to SER

#TCPERR *Ethernet communication error automatic subroutine*



Description

Automatic subroutine which allows execution of user code when an TCP error event occurs. #TCPERR allows the application programmer to run code (for example to reestablish the connection) when error code 123 occurs.

Arguments

Label must be the first element on a line of code.

Remarks

- Use RE to exit this subroutine.
- Error code 123 (TCP lost sync or timeout) occurs when a message is sent out a handle, and no acknowledgement is received.
  - When this occurs, the handle the message was sent out is closed.
  - #TCPERR can be used to reestablish the handle
- Code does not need to be running in thread 0 for #TCPERR to run.

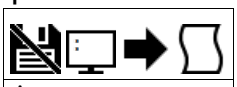
Examples

```
'Galil DMC Code Example
#loop
 MG {EA} "L"
 WT 1000
JP #loop

#TCPERR
 MG {P1} "TCPERR.  Dropped handle", _IA4
RE
```

```
'Galil DMC Code Example
'example of reestablishing connection after TCPERR
'
#main
IHE= 192,168,1,30;'    connect to 192,168,1,30
WT 100;'               wait for handle to be established
ipe= _IHE0;'           save IP for reconnection use
n= 0;'                 connection counter
#loop;'               endless message loop
MG "hello"
WT 1000
JP #loop
EN

#TCPERR
IHE= >-3;'             make sure handle E is clear
JP #TCPERR,_IHE2<>0;' wait for clear handle
IHE= ihe;'             set handle with saved IP var
WT 100
n= n+1;'               increment counter
JP #end,n>5;'          try at least 5 times
JP #TCPERR,_IHE2<>-2;'repeat if handle failed
#end
IF (n>5)
 MG "failed connection"
 HX 0;'                stop code if connection lost
ELSE
 MG "Reconnected"
 n = 0;'              reset connection counter
ENDIF
RE
```

#TCPERR applies to DMC40x0,DMC42x0,DMC41x3,DMC21x3,RIO,DMC30010,DMC50xx0

$ *Hexadecimal*



$n

Description

The $ operator denotes that the following string is in hexadecimal notation.

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
n	$80000000.0000	$7FFFFFFF.FFFF	N/A	$0.0001	Value of hexadecimal number	32 bits of integer and 16 bits of fraction in total

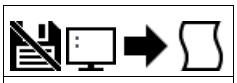
Remarks

- None

Examples

```
'Galil DMC Code Example
x = $7fffffff.0000              ;'store 2147483647 in x
y = x & $0000ffff.0000          ;'store lower 16 bits of x in y
z = x & $ffff0000.0000 / $10000 ;'store upper 16 bits of x in z
```

% *Modulo Operator*



n % n

Usage	variable = (value1 % value2)	Performs an operation between two values or evaluated statements

Description

The % symbol is the modulo operator. It takes as arguments any two values, variables, array elements, operands, or At functions (@SIN[]) and returns a value equal to the modulo of the arguments.

Mathmatical operations are calculated left to right rather than multiplication and division calculations performed prior to addition and subraction.
Example:
1+2*3 = 9, not 7

It is recommended that parenthesis be used when more than one mathmatical operation is combined in one command.
Example:
var = ((10*30)+(60/30));' evaluates as 302
var = 10*30+60/30;' evalutes as 12

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
n	-2,147,483,648	-2,147,483,647.9999	N/A	1/65,536	Value to use in modulo operation	

Remarks

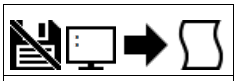
- This is a binary operator (takes two arguments and returns one value). The result of this operation is a value, which is not valid on its own. It must be coupled with a command. See examples below.
- Mathmatical operations are calculated left to right rather than multiplication and division calculations performed prior to addition and subraction.
  - Example: 1+2*3 = 9, not 7
- It is recommended that parenthesis be used when more than one mathmatical operation is combined in one command.
  - Example: var = ((10*30)+(60/30));' evaluates as 302
  - var = 10*30+60/30;' evalutes as 12

Examples

```
'Galil DMC Code Example
'Determine the day of week in n days
DM name[7];'Strings for day of week
name[0]= "SUN"
name[1]= "MON"
name[2]= "TUE"
name[3]= "WED"
name[4]= "THU"
name[5]= "FRI"
name[6]= "SAT"
today= 2;'Tuesday
days= 123;'Days from now
dow= ((days + today)%7);'calculate future day of week
MG "The day of week in ",days{Z10.0}," days will be ", name[dow]{S3.0}
EN

REM Code Returns: The day of week in  123 days will be SAT
```

% applies to DMC40x0,DMC42x0,DMC41x3,RIO,DMC18x6,DMC30010,DMC50xx0

& *Bitwise AND Operator*



n & n

Usage	variable = (value1 & value2)	Performs an operation between two values or evaluated statements

Description

The & symbol is the bitwise AND operator used with IF, JP, and JS decisions, and also to perform bitwise ANDING of values.

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
n	-2,147,483,648	2,147,483,647	N/A	1/65,536	Value to use with AND operator	

Remarks

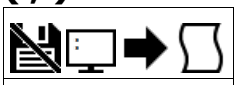
- The result of this operation is a value, which is not valid on its own. It must be coupled with a command. See examples below.
- For IF, JP, and JS, the values used for n are typically the results of logical expressions such as (x > 2) & (y=8)

Examples

```
'Galil DMC Code Example
'Bitwise use
:var1= $F;'00001111
:var2= $F0;'1111000
:MG (var1 & var2)
0.0000
:MG var1
15.0000
:MG var2
240.0000
:
```

```
'Galil DMC Code Example
'Conditional Use
var1= $F;'00001111
var2= $F0;'1111000
IF (var1 = $F) & (var2 = $F1)
 MG "True"
ELSE
 MG "False"
ENDIF
EN

REM Returned: False
```

(,) *Parentheses (order of operations)*



(n)

Description

The parentheses denote the order of math and logical operations.

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
n	-2,147,483,648	2,147,483,647.9999	N/A	1/65,536	Math or logical expression for evaluation	

Remarks

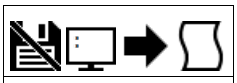
- Note that the controller evaluates expressions from left to right, and does **not** follow academic algebraic standards (e.g. multiplication and division first, followed by addition or subtraction)
- It is required to use parentheticals to ensure intended mathematical precedence

Examples

```
'Galil DMC Code Example
:MG 1+2*3
 9.0000
:MG 1+(2*3)
 7.0000
```

```
'Galil DMC Code Example
:var1= $1F
:var2= $F
:MG var1&var2/$10
0.9375       ($0.F000)
:MG var1&(var2/$10)
0.0000       ($0.0000)
```

* *Multiplication Operator*



n * n

Usage	variable = (value1 * value2)	Performs an operation between two values or evaluated statements

Description

The * symbol is the multiplication operator. It takes as arguments any two values, variables, array elements, operands, or At functions (@SIN[]) and returns a value equal to the product of the arguments.

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
n	-2,147,483,648	-2,147,483,647	N/A	1/65,536	Value to use in multiplication operation	

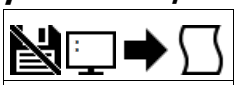
Remarks

- This is a binary operator (takes two arguments and returns one value). The result of this operation is a value, which is not valid on its own. It must be coupled with a command. See examples below.
- Mathmatical operations are calculated left to right rather than multiplication and division calculations performed prior to addition and subraction.
  - Example: 1+2*3 = 9;' not 7
- It is recommended that parenthesis be used when more than one mathmatical operation is combined in one command.
  - Example: var = ((10*30)+(60/30));' evaluates as 302
  - var = 10*30+60/30;' evalutes as 12

Examples

```
'Galil DMC Code Example
:var1 = (2 + 3) * 2
:var2 = var1 * 10
:MG var2 * 0.5
 50.0000
:
```

/ *Division Operator*



n_0 / n_1

Usage	variable = (value1 / value2)	Performs an operation between two values or evaluated statements

Description

The / symbol is the division operator. It takes as arguments any two values, variables, array elements, operands, or At functions (@SIN[]) and returns a value equal to the quotient of the arguments.

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
n_0	-2,147,483,648	2,147,483,647	N/A	1/65,536	Numerator of divide operation	
n_1	-2,147,483,648	2,147,483,647	N/A	1/65,536	Denominator of divide operation	

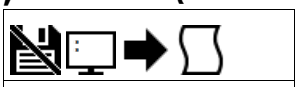
Remarks

- This is a binary operator (takes two arguments and returns one value). The result of this operation is a value, which is not valid on its own. It must be coupled with a command. See examples below.
- Mathmatical operations are calculated left to right rather than multiplication and division calculations performed prior to addition and subraction.
  - Example: 1+2*3 = 9;' not 7
- It is recommended that parenthesis be used when more than one mathmatical operation is combined in one command.
  - Example: var = ((10*30)+(60/30));' evaluates as 302
  - var = 10*30+60/30;' evalutes as 12

Examples

```
'Galil DMC Code Example
:var1 = 100/10
:var2 = var1/2
:MG var2 + 1
 6.0000
:
```

; *Semicolon (Command Delimiter)*



```
arg;arg;arg;arg
```

Description

The semicolon operator allows multiple Galil commands to exist on a single line.

Arguments

arg represents any valid Galil command

Remarks

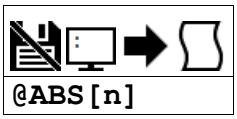
- The semicolon operator is used for the following reasons:
  1. To put comments on the same line as the command (STX ;'stop)
  2. To compress DMC programs to fit within the program line limit (Note: use a compression utility to do this. Do not program this way because it is hard to read.)
  3. To give higher priority to a thread. All commands on a line are executed before the thread scheduler switches to the next thread.

Examples

```
'Galil DMC Code Example
SB 1;WT 500;CB 1;' multiple commands separated by semicolons with a comment
```

```
'Galil DMC Code Example
#high;'      #High priority thread executes twice as fast as
 a = a + 1; b = b + 1
JP #high

#low;'       #Low when run in parallel
 c = c + 1
 d = d + 1
JP #low
```

@ABS *Absolute value*



Usage	variable = @ABS[value]	Performs a function on a value or evaluated statement and returns a value

Description

The @ABS[] operation takes the absolute value of the given number. Returns the value if positive, and returns -1 times the value if negative.

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
n	-2,147,483,648	2,147,483,647	N/A	1/65,535	Number to display as absolute value	

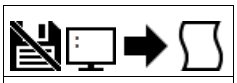
Remarks

- @ABS[] is an operand, not a command. It can only be used as an argument to other commands and operators

Examples

```
'Galil DMC Code Example
:MG @ABS[-2147483647]
 2147483647.0000
```

@ACOS *Inverse cosine*



@ACOS [n]

Usage	variable = @ACOS[value]	Performs a function on a value or evaluated statement and returns a value

Description

The @ACOS operator returns in degrees the arc cosine of the given number.

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
n	-1	1	N/A	1/65,536	Value used for arc cosine operation	

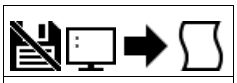
Remarks

- @ACOS[] is an operand, not a command. It can only be used as an argument to other commands and operators
- @ACOS[] is also referred to as the inverse cosine function

Examples

```
'Galil DMC Code Example
:MG @ACOS[-1]
 180.0000
:MG @ACOS[0]
 90.0000
:MG @ACOS[1]
 0.0001
```

@AN *Analog Input Query*



@AN[n]

Usage	variable = @AN[value]	Performs a function on a value or evaluated statement and returns a value

Description

The @AN[] operator returns the value of the given analog input in volts.

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
n	0	7	N/A	1	Analog input to query	

Remarks

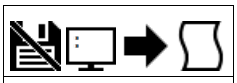
- @AN[] is an operand, not a command. It can only be used as an argument to other commands and operators

Examples

```
'Galil DMC Code Example
:MG @AN[1] ;'print analog input 1
 1.7883
:x = @AN[1] ;'assign analog input 1 to a variable
```

@AN applies to DMC40x0,DMC42x0,DMC41x3,DMC21x3,RIO,DMC18x6,DMC30010,DMC50xx0

@AO *Analog Output Query*



@AO[n]

Usage	variable = @AO[value]	Performs a function on a value or evaluated statement and returns a value

Description

The @AO[n] operator is used to query the value of an Analog Output.
On the RIO-4712x, use the DQ command to specify the voltage output range. Note - The RIO-472xx does not have any analog outputs by default.

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
n	0	7	N/A	1	Analog output to query	See Remarks

Remarks

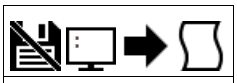
- @AO[] is an operand, not a command. It can only be used as an argument to other commands and operators
- On the RIO-4712x, use the DQ command to specify the voltage output range.
- The RIO-472xx does not have any analog outputs by default.

Examples

```
'Galil DMC Code Example
MG @AO[1];'       Displays status of Analog output 1
temp= @AO[1];'    Sets variable Temp to the value of Analog output 1
```

@AO applies to RIO,DMC30010

@ASIN *Inverse sine*



@ASIN[n]

Usage	variable = @ASIN[value]	Performs a function on a value or evaluated statement and returns a value

Description

The @ASIN operator returns in degrees the arc sine of the given number.

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
n	-1	1	N/A	1/65,536	Value used for arc sine operation	

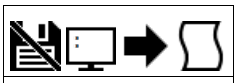
Remarks

- @ASIN[] is an operand, not a command. It can only be used as an argument to other commands and operators
- @ASIN[] is also referred to as the inverse sine function

Examples

```
'Galil DMC Code Example
:MG @ASIN[-1]
 -90.0000
:MG @ASIN[0]
 0.0000
:MG @ASIN[1]
 90.0000
```

@ATAN *Inverse tangent*



@ATAN[n]

Usage	variable = @ATAN[value]	Performs a function on a value or evaluated statement and returns a value

Description

The @ATAN operator returns in degrees the arc tangent of the given number.

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
n	-2,147,483,638	2,147,483,647	N/A	1/65,536	Value used for arc tangent operation	

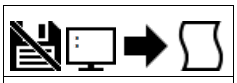
Remarks

- @ATAN[] is an operand, not a command. It can only be used as an argument to other commands and operators
- @ATAN[] is also referred to as the inverse tangent function

Examples

```
'Galil DMC Code Example
:MG @ATAN[-10]
 -84.2894
:MG @ATAN[0]
 0.0000
:MG @ATAN[10]
 84.2894
```

@COM *Bitwise complement*



@COM[n]

Usage	variable = @COM[value]	Performs a function on a value or evaluated statement and returns a value

Description

The @COM[] operation performs the bitwise complement (NOT) operation to the given number.

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
n	-2,147,483,648	2,147,483,647	N/A	1	Value to perform bitwise complement operation.	Integer interpreted as a 32-bit field

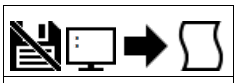
Remarks

- @COM[] is an operand, not a command. It can only be used as an argument to other commands and operators

Examples

```
'Galil DMC Code Example
:MG {$8.0} @COM[0]
$FFFFFFFF
:MG {$8.0} @COM[$FFFFFFFF]
$00000000
```

@COS *Cosine*



@COS[n]

Usage	variable = @COS[value]	Performs a function on a value or evaluated statement and returns a value

Description

The @COS[] operation returns the cosine of the given angle in degrees

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
n	-32,768	32,767	N/A	1/65,536	Value in degrees to use for cosine operation	

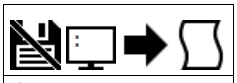
Remarks

- @COS[] is an operand, not a command. It can only be used as an argument to other commands and operators

Examples

```
'Galil DMC Code Example
:MG @COS[0]
 1.0000
:MG @COS[90]
 0.0000
:MG @COS[180]
 -1.0000
:MG @COS[270]
 0.0000
:MG @COS[360]
 1.0000
```

@FLOT *Convert Galil 4.2 to Floating Point*



@FLOT[n]

Usage	variable = @FLOT[value]	Performs a function on a value or evaluated statement and returns a value

Description

The @FLOT operation returns the 32bit floating representation of a number

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
n	-2,147,483,648	2,147,483,647	N/A	1/65,536	Value to use for floating point conversion	

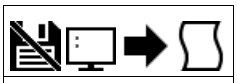
Remarks

- @FLOT[] is an operand, not a command. It can only be used as an argument to other commands and operators
- A useful utility for determining the 32 bit floating point value for a given fractional number can be found here: http://babbage.cs.qc.cuny.edu/IEEE-754/index.xhtml

Examples

```
'Galil DMC Code Example
:MG @FLOT[2.5] {$8.0}
$40200000
:MG @REAL[$40200000]
 2.5000
:
```

@FRAC *Fractional part*



@FRAC[n]

Usage	variable = @FRAC[value]	Performs a function on a value or evaluated statement and returns a value

Description

The @FRAC operation returns the fractional part of the given number

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
n	-2,147,483,648	2,147,483,647	N/A	1/65,536	Value to use in fractional operation	

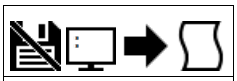
Remarks

- The sign of the number input to the operation will be maintained in the fractional output.
- @FRAC[] is an operand, not a command. It can only be used as an argument to other commands and operators

Examples

```
'Galil DMC Code Example
:MG @FRAC[1.2]
 0.2000
:MG @FRAC[-2.4]
 -0.4000
```

@IN *Read digital input*



@IN[n]

Usage	variable = @IN[value]	Performs a function on a value or evaluated statement and returns a value

Description

The @IN operand returns the value of the given digital input (either 0 or 1)

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
n	0	15	N/A	1	Digital input to query	RIO-471xx and RIO-472xx
	0	23	N/A	1	Digital input to query	RIO-473xx
	24	47	N/A	1	Digital input to query	RIO-473xx with -24ExIn option
n	1,000	3,999	N/A	1	Read Modbus slave bit	For RIO-47xx0. See Remarks
	1,000	5,999	N/A	1	Read Modbus slave bit	For RIO-47xx2 and RIO-473xx. See Remarks

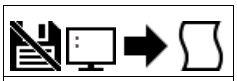
Remarks

- @IN[] is an operand, not a command. It can only be used as an argument to other commands and operators
- n = (SlaveAddress*10000) + (HandleNum*1000) + ((Module-1)*4) + (Bitnum-1)
  - Slave Address is used when the ModBus device has slave devices connected to it and specified as Addresses 0 to 255. Please note that the use of slave devices for modbus are very rare and this number will usually be 0.
  - HandleNum is the handle specifier where A is 1, B is 2 and so on.
  - Module is the position of the module in the rack from 1 to 16.
  - BitNum is the I/O point in the module from 1 to 4

Examples

```
'Galil DMC Code Example
:MG @IN[1]
1.0000
:x = @IN[1]
:x = ?;'  print digital input 1
1.000
```

@INT *Integer part*



@INT[n]

Usage	variable = @INT[value]	Performs a function on a value or evaluated statement and returns a value

Description

The @INT operation returns the integer part of the given number. Note that the modulus operator can be implemented with @INT (see example below).

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
n	-2,147,483,648	2,147,483,647	N/A	1/65,536	Value to use in integer operation	

Remarks

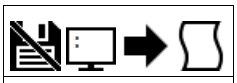
- @INT[] is an operand, not a command. It can only be used as an argument to other commands and operators

Examples

```
'Galil DMC Code Example
:MG @INT[1.2]
 1.0000
:MG @INT[-2.4]
 -2.0000
```

```
'Galil DMC Code Example
#AUTO;'        modulus example
 x = 10;'      prepare arguments
 y = 3
 JS #mod;'      call modulus
 MG z;'        print return value
EN

'subroutine: integer remainder of x/y (10 mod 3 = 1)
'arguments are x and y. Return is in z
#mod
 z = x - (y * @INT[x/y])
EN
```

@OUT *Read digital output*



@OUT[n]

Usage	variable = @OUT[value]	Performs a function on a value or evaluated statement and returns a value

Description

Returns the value of the given digital output (either 0 or 1)

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
n	0	15	N/A	1	Digital output to query	RIO-471xx and RIO-472xx
	0	23	N/A	1	Digital output to query	RIO-473xx
	24	47	N/A	1	Digital output to query	RIO-473xx with -24ExOut option
n	1,000	3,999	N/A	1	Read Modbus slave bit	For RIO-47xx0. See Remarks
	1,000	5,999	N/A	1	Read Modbus slave bit	For RIO-47xx2 and RIO-473xx. See Remarks

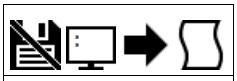
Remarks

- @OUT[] is an operand, not a command. It can only be used as an argument to other commands and operators
- n = (SlaveAddress*10000) + (HandleNum*1000) + ((Module-1)*4) + (Bitnum-1)
  - Slave Address is used when the ModBus device has slave devices connected to it and specified as Addresses 0 to 255. Please note that the use of slave devices for modbus are very rare and this number will usually be 0.
  - HandleNum is the handle specifier where A is 1, B is 2 and so on.
  - Module is the position of the module in the rack from 1 to 16.
  - BitNum is the I/O point in the module from 1 to 4

Examples

```
'Galil DMC Code Example
:MG @OUT[1];'     print state of digital output 1
1.0000
:x = @OUT[1];'    assign state of digital output 1 to a variable
```

@REAL *Convert Floating Point to Galil 4.2*



@REAL[n]

Usage	variable = @REAL[value]	Performs a function on a value or evaluated statement and returns a value

Description

The @REAL operation returns the Galil 4.2 equivalent of a 32 bit floating point number

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
n	-2,147,483,648	2,147,483,647	N/A	1	32 bit floating point number to convert to Galil 4.2 integer	

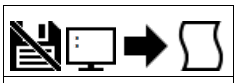
Remarks

- @REAL[] is an operand, not a command. It can only be used as an argument to other commands and operators
- A useful utility for determining the 32 bit floating point value for a given fractional number can be found here: http://babbage.cs.qc.cuny.edu/IEEE-754/index.xhtml

Examples

```
'Galil DMC Code Example
:MG @FLOT[2.5] {$8.0}
$40200000
:MG @REAL[$40200000]
 2.5000
:
```

@RND *Round*



@RND[n]

Usage	variable = @RND[value]	Performs a function on a value or evaluated statement and returns a value

Description

The @RND operation rounds the given number to the nearest integer.

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
n	-2,147,483,648	2,147,483,647	N/A	1/65,536	Value to use in rounding operation	

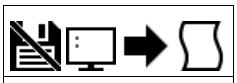
Remarks

- @FRAC[] is an operand, not a command. It can only be used as an argument to other commands and operators
- The sign of the number input to the operation will be maintained in the rounded output.

Examples

```
'Galil DMC Code Example
:MG @RND[1.2]
 1.0000
:MG @RND[1.6]
 2.0000
:MG @RND[-1.2]
 -1.0000
:MG @RND[5.7]
 6.0000
:MG @RND[-5.7]
 -6.0000
:MG @RND[5.5]
 6.0000
:MG @RND[-5.5]
 -5.0000
```

@SIN *Sine*



@SIN[n]

Usage	variable = @SIN[value]	Performs a function on a value or evaluated statement and returns a value

Description

The @SIN[] operation returns the sine of the given angle in degrees

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
n	-32,768	32,767	N/A	1/65,536	Value in degrees to use for sine operation	

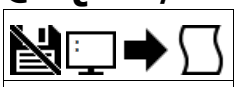
Remarks

- @SIN[] is an operand, not a command. It can only be used as an argument to other commands and operators

Examples

```
'Galil DMC Code Example
:MG @SIN[0]
 0.0000
:MG @SIN[90]
 1.0000
:MG @SIN[180]
 0.0000
:MG @SIN[270]
 -1.0000
:MG @SIN[360]
 0.0000
```

@SQR *Square Root*



@SQR[n]

Usage	variable = @SQR[value]	Performs a function on a value or evaluated statement and returns a value

Description

The @SQR operation takes the square root of the given number.

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
n	-2,147,483,648	2,147,483,647	N/A	1/65,536	Value to use in square root operation	If n < 0, the absolute value is taken first.

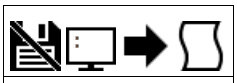
Remarks

- @SQR[] is an operand, not a command. It can only be used as an argument to other commands and operators

Examples

```
'Galil DMC Code Example
:MG @SQR[2]
 1.4142
:MG @SQR[-2]
 1.4142
```

@TAN *Tangent*



@TAN[n]

Usage	variable = @TAN[value]	Performs a function on a value or evaluated statement and returns a value

Description

The @TAN[] operation returns the tangent of the given angle in degrees.

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
n	-32,768	32,767	N/A	1/65,536	Value in degrees to use for tangent operation	

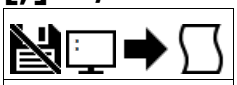
Remarks

- @TAN[] is an operand, not a command. It can only be used as an argument to other commands and operators

Examples

```
'Galil DMC Code Example
:MG @TAN[23]
 0.4245
:
```

[,] *Square Brackets (Array Index Operator)*



`str[n]`

Description

The square brackets are used to denote the array index for an array, or to denote an array name.

They are also used to designate the argument to a function, such as @ABS[n].

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
str	1 char	8 chars	N/A	String	Name of array to access	Must be a valid dimensioned array name.
n	0	399	N/A	1	Element of array to query	For RIO-47xx0
	0	999	N/A	1	Element of array to query	For RIO-47xx2 and RIO-473xx

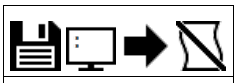
Remarks

- None

Examples

```
'Galil DMC Code Example
DM a[50]          ;'define a 50 element array
a[0] = 3          ;'set first element to 3
MG a[0]           ;'print element 0
```

^L^K *Lock program*



^L^K str,n

Usage	^L^K n ...	Arguments specified with an implicit, comma-separated order

Description

Locks user access to the application program. When locked, the ED, UL, LS, and TR commands will give privilege error #106. The application program will still run when locked. Once the program is unlocked, it will remain accessible until a lock command or a reset (with the locked condition burned in) occurs.

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
str	0 char	8 chars	""	String	Controller password string	Password assigned with the PW command.
n	0	1	0	1	Set lock/unlock state for controller	n = 1 locks the application program. n = 0 unlocks the application program.

Remarks

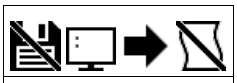
- The PW command can only be set while the application program is unlocked.

Examples

```
'Galil DMC Code Example
:PW test,test;'              Set password to "test"
:^L^K test,1;'               Lock the program
:LS;'                        Attempt to list the program
?
:TC 1
106 Privilege violation
:
```

^L^K applies to DMC40x0,DMC42x0,DMC41x3,RIO,DMC18x6,DMC30010,DMC50xx0

^R^S *Master Reset*



^R^S

Usage	^R^S	Command takes no arguments

Description

The Master Reset command resets the controller to factory default settings and erases EEPROM. A master reset can also be performed by installing a jumper at the location labeled MRST and resetting the board (power cycle or pressing the reset button). Remove the jumper after this procedure.

Arguments

^R^S has no parameters

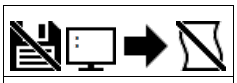
Remarks

- Sending a ^R^S over an Ethernet connection will cause the IP address to be cleared from the controller and will result in a timeout.

Examples

```
'Galil DMC Code Example
REM Example burns-in a non-default value for KP, does a standard reset with
REM the RS command, then performs a master reset with ^R^S.

:KP ?
 6.00
:KP 10
:BN
:RS

:KP ?
 10.00
:^R^S

:KP ?
 6.00
:
```

^R^V *Revision Information*



^R^V

Usage	^R^V	Command takes no arguments

Description

The Revision Information command causes the controller to return the firmware revision information.

Arguments

^R^V has no arguments

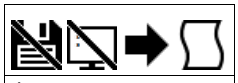
Remarks

- Do not use ^ symbols to send ^R^V command. ^ symbols denote using the control (Ctrl) key when pressing the characters.

Examples

```
'Galil DMC Code Example
:^R^V
RIO47100 Rev 1.0e1
:
```

` *Line Continuation Character*



`

Description

The ` (ASCII 96) character allows a command in an application program to extend beyond the maximum line length of 40 characters. This is especially useful for code compression, long MG statements, or multiple conditions in an IF,JP or JS statement. A continued line can be a maximum of 80 characters total.

Arguments

See Examples for usage.

Remarks

- When multiple lines are joined using the line continuation character the first line number is the line number used for any errors.
  - For example, if lines 5,6,7 are joined and a syntax error occurs on your 7th line the controller will actually report a problem on line 5.
- The lines following the Line Continuation Character (`) will not be displayed in the trace output (TR1).

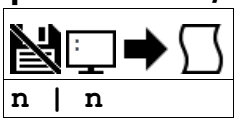
Examples

```
'Galil DMC Code Example
#a
a= 123`
456;'not displayed with TR1 output
EN
```

```
'Galil DMC Code Example
IF ((var100=1000)&(var101=50));MG "GO";EL`
SE;MG "STOP";ENDIF ;
```

` applies to RIO,DMC30010

| *Bitwise OR Operator*



n | n

Usage	variable = (value1 | value2)	Performs an operation between two values or evaluated statements

Description

The | symbol is the bitwise OR operator used with IF, JP, and JS decisions, and also to perform bitwise ORING of values.

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
n	-2,147,483,648	2,147,483,647	N/A	1/65,536	Value to use with OR operator	

Remarks

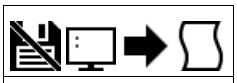
- For IF, JP, and JS, the values used for m are typically the results of logical expressions such as (x > 2) | (y=8)
- The result of this operation is a value, which is not valid on its own. It must be coupled with a command. See examples below.

Examples

```
'Galil DMC Code Example
'Bitwise use
var1= $F;'00001111
var2= $F0;'1111000
MG (var1 | var2)
EN

REM Returned: 255.0000 (same as 11111111)
```

```
'Galil DMC Code Example
'Conditional Use
var1= $F;'00001111
var2= $F0;'1111000
IF (var1 = $F) | (var2 = $F1)
 MG "True"
ELSE
 MG "False"
ENDIF
EN

REM Returned: True
```

+ *Addition Operator*



n + n

Usage	variable = (value1 + value2)	Performs an operation between two values or evaluated statements

Description

The + symbol is the addition operator. It takes as arguments any two values, variables, array elements, operands, or At functions (@SIN[]) and returns a value equal to the sum of the arguments.

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
n	-2,147,483,648	2,147,483,647	N/A	1/65,536	Value to use in addition operation	

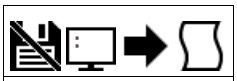
Remarks

- This is a binary operator (takes two arguments and returns one value). The result of this operation is a value, which is not valid on its own. It must be coupled with a command. See examples below.
- Mathmatical operations are calculated left to right rather than multiplication and division calculations performed prior to addition and subraction.
  - Example: 1+2*3 = 9;' not 7
- It is recommended that parenthesis be used when more than one mathmatical operation is combined in one command.
  - Example: var = ((10*30)+(60/30));' evaluates as 302
  - var = 10*30+60/30;' evalutes as 12

Examples

```
'Galil DMC Code Example
:var1 = 1+2
:var2 = var1 + 1
:MG var2 + 2
 6.0000
:
```

< *Less than comparator*



$n_0 < n_1$

Usage	variable = (value1 < value2)	Performs an operation between two values or evaluated statements

Description

"Less than" comparator for testing if one value is less than another. Comparators are used in mathematical expressions, IFs, and in conditional jumps. The result is a boolean.

Comparators in DMC Code

Symbol	Comparator
<	Less than
>	Greater than
=	Equal to
<=	Less than or equal to
>=	Greater than or equal to
<>	Not equal to

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
n0	-2,147,483,648	2,147,483,647	N/A	1/65,536	Value to test	
n1	-2,147,483,648	2,147,483,647	N/A	1/65,536	Value to test	

Remarks

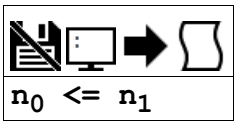
- A comparator is not a command and is not valid individually. Instead, the above expression would be used as part of a jump (JP,JS), IF expression, or assignment. See examples below.
- If $n_0 < n_1$, the expression will evaluate to 1.0000. If the comparision is false, it will evaluate to 0.0000.
- Evaluation occurs left to right. Use parenthesis for operator precedence.

Examples

```
'Galil DMC Code Example
:bool= (1<2)
:MG bool
 1.0000
:bool= (1<0)
:MG bool
 0.0000
:
```

```
'Galil DMC Code Example
REM Example to find the largest
REM value in an array
REM
REM ****************************
REM Create an array and fill it
len= 5
DM array[len]
array[0]= 5
array[1]= 100.0001
array[2]= 42
array[3]= 3.14
array[4]= 100
JS #max;' call max subroutine
MG "Max value is ", max
EN
REM
REM ****************************
REM Find max element in array
#max
i= 0
max = -2147483648;' start at min
#max_h
IF (array[i] > max)
 max = array[i]
ENDIF
i= i+1
JP #max_h, (i < len)
EN
REM
REM ****************************
REM Program output
REM :XQ
REM :
REM Max value is 100.0001
```

<= *Less than or Equal to comparator*



Usage	variable = (value1 <= value2)	Performs an operation between two values or evaluated statements

Description

"Less than or Equal to" comparator for testing if one value is less than or equal to another. Comparators are used in mathematical expressions, IFs, and in conditional jumps. The result is a boolean.

Comparators in DMC Code

Symbol	Comparator
<	Less than
>	Greater than
=	Equal to
<=	Less than or equal to
>=	Greater than or equal to
<>	Not equal to

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
n0	-2,147,483,648	2,147,483,647	N/A	1/65,536	Value to test	
n1	-2,147,483,648	2,147,483,647	N/A	1/65,536	Value to test	

Remarks

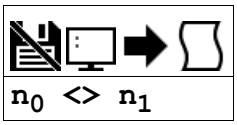
- A comparator is not a command and is not valid individually. Instead, the above expression would be used as part of a jump (JP,JS), IF expression, or assignment. See examples below.
- If n_0 <= n_1, the expression will evaluate to 1.0000. If the comparision is false, it will evaluate to 0.0000.
- Evaluation occurs left to right. Use parenthesis for operator precedence.

Examples

```
'Galil DMC Code Example
:bool= (1 <= 2)
:MG bool
 1.0000
:bool= (2 <= 2)
:MG bool
 1.0000
:bool= (3 <= 2)
:MG bool
 0.0000
:
```

```
'Galil DMC Code Example
max= 2.05
min= 1.47
value = 0.025
JS #check
value = 1.471
JS #check
EN
REM
REM ********************************
REM Determine if in range
#check
inrange= 0
IF ((value >= min) & (value <= max))
 inrange= 1
ENDIF
IF (inrange)
 MG "Value ",value," in range"
ELSE
  MG "Value ",value," NOT in range"
ENDIF
EN
REM
REM ********************************
REM Program output
REM :XQ
REM :
REM  Value 0.0250 NOT in range
REM  Value 1.4710 in range
```

<> *Not Equal to comparator*



Usage	variable = (value1 <> value2)	Performs an operation between two values or evaluated statements

Description

"Not Equal to" comparator for testing if one value is not equal to another. Comparators are used in mathematical expressions, IFs, and in conditional jumps. The result is a boolean.

Comparators in DMC Code

Symbol	Comparator
<	Less than
>	Greater than
=	Equal to
<=	Less than or equal to
>=	Greater than or equal to
<>	Not equal to

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
n0	-2,147,483,648	2,147,483,647	N/A	1/65,536	Value to test	
n1	-2,147,483,648	2,147,483,647	N/A	1/65,536	Value to test	

Remarks

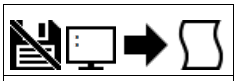
- A comparator is not a command and is not valid individually. Instead, the above expression would be used as part of a jump (JP,JS), IF expression, or assignment. See examples below.
- If n_0 <> n_1, the expression will evaluate to 1.0000. If the comparision is false, it will evaluate to 0.0000.
- Evaluation occurs left to right. Use parenthesis for operator precedence.

Examples

```
'Galil DMC Code Example
:bool= (1 <> 2)
:MG bool
 1.0000
:bool= (2 <> 2)
:MG bool
 0.0000
```

```
'Galil DMC Code Example
REM Lock out code until
REM a particular digital
REM input pattern is detected
#AUTO
JS #lock;'block until pattern
REM
REM
REM Rest of code here
REM
REM
EN
REM
REM ************************
#lock
JP #lock, (_TI0 <> 170)
EN
```

= *Assignment Operator*



```
str = n
```

Description

The = operator is the assignment operator for the controller. The assignment operator is used for three reasons:
(1) to define and initialize a variable (x = 0) before it is used
(2) to assign a new value to a variable (x = 5)
(3) to print a variable or array element (x= which is equivalent to MG x). MG is the preferred method of printing.

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
str	1 char	8 chars	N/A	String	Variable name to access	
n	-2,147,483,648	2,147,483,647	see Notes	1/65,536	Value to assign to specified variable	Default n, or n = null results in a query of the value of variable

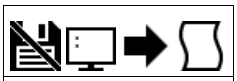
Remarks

- None

Examples

```
'Galil DMC Code Example
:x= 5
:x= ?
 5.0000
:MG x
 5.0000
'define and initialize x to 5
'print x two different ways
```

= *Equal to comparator*



$n_0 = n_1$

Usage	variable = (value1 = value2)	Performs an operation between two values or evaluated statements

Description

"Equal to" comparator for testing if one value is equal to another. Comparators are used in mathematical expressions, IFs, and in conditional jumps. The result is a boolean.

Comparators in DMC Code

Symbol	Comparator
<	Less than
>	Greater than
=	Equal to
<=	Less than or equal to
>=	Greater than or equal to
<>	Not equal to

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
n0	-2,147,483,648	2,147,483,647	N/A	1/65,536	Value to test	
n1	-2,147,483,648	2,147,483,647	N/A	1/65,536	Value to test	

Remarks

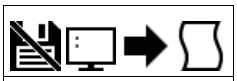
- A comparator is not a command and is not valid individually. Instead, the above expression would be used as part of a jump (JP,JS), IF expression, or assignment. See examples below.
- If $n_0 = n_1$, the expression will evaluate to 1.0000. If the comparision is false, it will evaluate to 0.0000.
- Evaluation occurs left to right. Use parenthesis for operator precedence.

Examples

```
'Galil DMC Code Example
:bool= (1=0)
:MG bool
 0.0000
:bool= (3.14=3.14)
:MG bool
 1.0000
:
```

```
'Galil DMC Code Example
REM Checks for a digital
REM input pattern and
REM sets a bit if matched
#loop
IF (_TI0 = 170)
 SB 1
ELSE
 CB 1
ENDIF
JP #loop
```

> *Greater than comparator*



$n_0 > n_1$

Usage	variable = (value1 > value2)	Performs an operation between two values or evaluated statements

Description

"Greater than" comparator for testing if one value is greater than another. Comparators are used in mathematical expressions, IFs, and in conditional jumps. The result is a boolean.

Comparators in DMC Code

Symbol	Comparator
<	Less than
>	Greater than
=	Equal to
<=	Less than or equal to
>=	Greater than or equal to
<>	Not equal to

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
n0	-2,147,483,648	2,147,483,647	N/A	1/65,536	Value to test	
n1	-2,147,483,648	2,147,483,647	N/A	1/65,536	Value to test	

Remarks

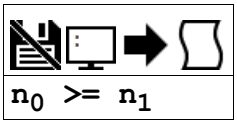
- A comparator is not a command and is not valid individually. Instead, the above expression would be used as part of a jump (JP,JS), IF expression, or assignment. See examples below.
- If $n_0 > n_1$, the expression will evaluate to 1.0000. If the comparision is false, it will evaluate to 0.0000.
- Evaluation occurs left to right. Use parenthesis for operator precedence.

Examples

```
'Galil DMC Code Example
:bool= (1>2)
:MG bool
 0.0000
:bool= (1>0)
:MG bool
 1.0000
:
```

```
'Galil DMC Code Example
REM Example to find the largest
REM value in an array
REM
REM ****************************
REM Create an array and fill it
len= 5
DM array[len]
array[0]= 5
array[1]= 100.0001
array[2]= 42
array[3]= 3.14
array[4]= 100
JS #max;' call max subroutine
MG "Max value is ", max
EN
REM
REM ****************************
REM Find max element in array
#max
i= 0
max = -2147483648;' start at min
#max_h
IF (array[i] > max)
 max = array[i]
ENDIF
i= i+1
JP #max_h, (i < len)
EN
REM
REM ****************************
REM Program output
REM :XQ
REM :
REM Max value is 100.0001
```

>= *Greater than or Equal to comparator*



Usage	variable = (value1 >= value2)	Performs an operation between two values or evaluated statements

Description

"Greater than or Equal to" comparator for testing if one value is greater than or equal to another. Comparators are used in mathematical expressions, IFs, and in conditional jumps. The result is a boolean.

Comparators in DMC Code

Symbol	Comparator
<	Less than
>	Greater than
=	Equal to
<=	Less than or equal to
>=	Greater than or equal to
<>	Not equal to

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
n0	-2,147,483,648	2,147,483,647	N/A	1/65,536	Value to test	
n1	-2,147,483,648	2,147,483,647	N/A	1/65,536	Value to test	

Remarks

- A comparator is not a command and is not valid individually. Instead, the above expression would be used as part of a jump (JP,JS), IF expression, or assignment. See examples below.
- If n_0 >= n_1, the expression will evaluate to 1.0000. If the comparision is false, it will evaluate to 0.0000.
- Evaluation occurs left to right. Use parenthesis for operator precedence.

Examples

```
'Galil DMC Code Example
:bool= (1 >= 2)
:MG bool
 0.0000
:bool= (2 >= 2)
:MG bool
 1.0000
:bool= (3 >= 2)
:MG bool
 1.0000
:
```

```
'Galil DMC Code Example
max= 2.05
min= 1.47
value = 0.025
JS #check
value = 1.471
JS #check
EN
REM
REM ********************************
REM Determine if in range
#check
inrange= 0
IF ((value >= min) & (value <= max))
 inrange= 1
ENDIF
IF (inrange)
 MG "Value ",value," in range"
ELSE
  MG "Value ",value," NOT in range"
ENDIF
EN
REM
REM ********************************
REM Program output
REM :XQ
REM :
REM  Value 0.0250 NOT in range
REM  Value 1.4710 in range
```

AA *After Analog*

AA n_0,n_1,n_2

Usage	AA n ...	Arguments specified with an implicit, comma-separated order

Description

AA is a trippoint that halts program execution until a voltage on a particular analog input has been reached.

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
n_0	0	7	N/A	1	Selects analog input	
n_1	0	5	6		Selects the trippoint voltage	Range dependent on hardware and AQ setting. See Remarks.

Argument	Value	Description	Notes
n_2	0	Trippoint to clear when voltage is greater than n_1	
	1	Trippoint to clear when voltage is less than n_1	

Remarks

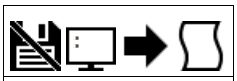
- The range of n_1 is dependant on RIO hardware:
  - 0-5V for RIO-47x0x
  - Range dependent on AQ command for RIO-47x2x
    - See the AQ command for more info

Examples

```
'Galil DMC Code Example
#a
'Wait for analog input 3 to go above 2.5V
AA 3,2.5,0
MG "Analog input 3 reached 2.5V"
EN
```

AA applies to RIO

AB *Abort*



AB
AB n

Usage	AB n ...	Arguments specified with an implicit, comma-separated order
Operands	_ABm	Operand has special meaning, see Remarks

Description

The AB command is a command to issue an abort to controller operation.
The AB command aborts any application code running in any thread on the RIO.

Arguments

AB is a command with no arguments.

Remarks

- _AB gives state of Abort Input, 1 inactive and 0 active.

Examples

```
'Galil DMC Code Example
AB;'            Abort application program
```

AF *Analog Feedback Select*

AFm= n

AF n,n,n,n,n,n,n,n

Usage	AFm= n	Arguments specified with a single axis mask and an assignment (=)
	AF n ...	Arguments specified with an implicit, comma-separated order
Operands	_AFm	Operand holds the value last set by the command

Description

The AF command configures analog feedback mode for the PID filter.

If a control loop is desired, AF is used to select which analog input channel will be used for feedback on each process control loop channel.

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
m	A	F	N/A	Axis	Axis to configure	RIO-47xx2 and RIO-473xx
	A	B	N/A	Axis	Axis to configure	RIO-47xx0
n	-1	7	-1	1	Selects the analog input channel for feedback.	n=-1 to disable control loop
	-1	-1	0	0	The analog hardware sampled in the servo interrupt	This provides evenly sampled data for both the data record and the RA/RD/RC function.

Remarks

- Below is the feedback in counts decoded by the controller hardware when reading in analog feedback for certain analog input ranges.

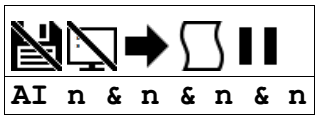
	12 Bit ADC	16 Bit ADC
+/-5 V, +/-10 V	-2048 to 2047 counts	-32768 to 32767 counts
0-5 V, 0-10 V	0 to 4095 counts	0 to 65535 counts

- For RIO-47x0x, the analog voltage range is hardset at 0-5V with 12bit resolution.
- For RIO-47x2x, the analog voltage range is set using the AQ command. AQ must be set prior to setting AF
- The analog feedback is decoded by a 12-bit A/D converter. An upgrade option is available for 16-bits.
- See the User manual for more information on the Process loop mode.

Examples

```
'Galil DMC Code Example
AF 0;'    Use input 0 as the Process loop input
AZ 0;'    Use output 0 as the Process loop output
KP 1;'
KD 10;'
KI 0.5;'
PS 2.5;'
```

AI *After Input*



Usage	AI n ...	Arguments specified with an implicit, comma-separated order

Description

The AI command is a trippoint used in motion programs to wait until after a specified input has changed state. This command can be configured such that the controller will wait until the input goes high or the input goes low.

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
n	0	15	N/A	1	Input to use for trippoint	+n = High trigger. -n = Low trigger. Up to 4 input conditions may be AND'd together.

Remarks

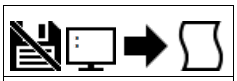
- The AI command actually halts execution until specified input is at desired logic level. Use the conditional Jump command (JP) or input interrupt (II) if you do not want the program sequence to halt.
- AI functions only on local input points. See Example below for network based digital inputs.
- Only inputs [0-15] may be used in the trippoint expression with the RIO-473xx

Examples

```
'Galil DMC Code Example
#a;'                Begin Program
AI 7&15&-1&-12;'    Wait until inputs 7 & 15 are high, and inputs 1 & 12 are low
MG "DONE";'         Send message 'DONE' when conditions are satisfied
EN;'                End Program
```

```
'Galil DMC Code Example
REM When using a remote I/O device (e.g. the RIO), the following provides
REM a similar function as AI. Assume that the remote device is already
REM configured on handle C (see IH)
'code before
JS #remote;' this call blocks and waits for the remote logic to return
'code after
EN
'***** The example subroutine *****
#remote
WT 10;' wait a reasonable interval so we don't flood the network
JP #remote,(@IN[3001] = 1);'loop while input 1 on the remote device is high
EN;' return to calling code.
```

AO *Analog Output*



AO n_0,n_1

Usage	AO n ...	Arguments specified with an implicit, comma-separated order

Description

The AO command sets the analog outputs on the Galil or for a Modbus Slave.

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
n_0	0	7	N/A	1	Set Local Analog Output	See Remarks
n_0	1,000	3,999	N/A	1	Set Analog Output on Modbus Slave	For RIO-47xx0. See "Using AO with a Modbus Slave" in Remarks
	1,000	5,999	N/A	1	Set Analog Output on Modbus Slave	For RIO-47xx2 and RIO-473xx. See "Using AO with a Modbus Slave" in Remarks
n_1	-9.9998	9.9998	N/A	20/65,536	Analog Output Voltage	See Remarks

Remarks

- RIO-4712x
  - The output voltage range can be adjusted using the DQ command. Use the ID command to check your model number and I/O configuration.
- RIO-472xx
  - Analog outputs are not standard, must be ordered with AO option.

Using AO with a Modbus Slave

- RIO as Modbus Slave
- 3rd Party Modbus Slave Device

- n_0 is the I/O number calculated using the following equations:
- n_0 = (HandleNum*1000) + ((Module-1)*4) + (Bitnum-1)
  - HandleNum is the handle specifier from A to H.
    - Handle must be assigned to port 502 for Modbus comms (See IH)
  - Module is the position of the module in the rack from 1 to 16.
  - BitNum is the I/O point in the module from 1 to 4

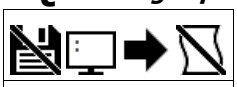
Examples

```
'Galil DMC Code Example
AO 3005,3.2;'          Outputs 3.2 Volts on Channel 5 of the Device connected to Handle C
```

```
'Galil DMC Code Example
AO 2,1.324;'         Outputs 1.324 Volts on Channel 2
```

AO applies to DMC40x0,DMC42x0,DMC41x3,DMC21x3,RIO,DMC30010,DMC50xx0

AQ *Analog Input Configuration*



AQ n_0,n_1

Usage	AQ n ...	Arguments specified with an implicit, comma-separated order
Operands	_AQ0 _AQ1 _AQ2 _AQ3 _AQ4 _AQ5 _AQ6 _AQ7	Operand has special meaning, see Remarks

Description

The AQ command is used to set the behavior of the analog inputs. This command will set the analog range and operation for the specified input.

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
n_0	0	7	N/A	1	Analog input channel	
n_1	0	1	0	1	Single Ended or Differential Input	RIO-47x0x (0-5V inputs), 0=Single ended, 1=differential
	1	4	2	1	Analog range setting	RIO-47x2x, RIO-472xx-(AI_10vxxbit) (+/-10V analog inputs), See Table Below
	-4	-1	N/A	1	Specify analog input is differential	valid only for n_0=0,2,4,6, See Remarks

Remarks

RIO-47x2x, RIO-472xx-(AI_10vxxbit)

Argument	Value	Description	Notes
n_1	1	+/- 5v	
	2	+/- 10v	Default
	3	0-5v	
	4	0-10v	

- Setting a negative n_1 for inputs 0,2,4 or 6, configures those inputs as the differential input relative to input 1,3,5 and 7 respectively.
- Operands _AQ0 through _AQ7 return the setting for the specified input
  - Default resolution for analog inputs is 12bits. 16 bit is optional.

Differential Input Mapping (-n_1)

Differential Input Mapping (negative n_1)

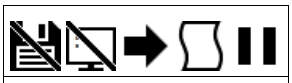
Input (n_0)	Compliment (n_0 + 1)
0	1
2	3
4	5
6	7

Examples

```
'Galil DMC Code Example
:AQ 2,1;'      Sets Analog input 2 and 3 to be differential inputs on the RIO-47100
:AQ 2,3;'      Specify analog input 2 as 0-5V on the RIO-47120
:AQ 0,-3;'     Specify analog input 0 as 0-5V and the differential input to analog input 1 on the RIO-47120
:MG _AQ2
 3.0000
```

AQ applies to DMC40x0,DMC42x0,DMC41x3,DMC21x3,RIO,DMC30010,DMC50xx0

AT *At Time*



AT n

Usage	AT n ...	Arguments specified with an implicit, comma-separated order

Description

The AT command is a trippoint which is used to hold up execution of the next command until after the specified time has elapsed. The time is measured with respect to a defined reference time. AT 0 establishes the initial reference. AT n specifies n msec from the reference. AT -n specifies n msec from the reference and establishes a new reference after the elapsed time period.

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
n	-2,147,483,648	2,147,483,647	0	1	Specify a wait time for AT trippoint	See Remarks

Remarks

- n = 0 defines a reference time at current time
- n > 0 specifies a wait time of n msec from the reference time
- n < 0 specifies a wait time of n msec from the reference time and re-sets the reference time when the trippoint is satisfied.
  - AT -n is equivalent to AT n; AT (old reference +n)

Examples

```
'Galil DMC Code Example
#ex
AT 0;'   Establishes reference time 0 as current time
AT 50;'  Waits 50 msec from reference 0
AT 100;' Waits 100 msec from reference 0
AT -150;'Waits 150 msec from reference 0 and sets new reference at 150
AT 80;'  Waits 80 msec from new reference (total elapsed time is 230 msec)
EN

'I/O scan loop
'If inputs 1,4 and 5 are all high, set output 1 high
'Else, set ouput 1 low
#main
AT 0;'           set time reference for AT command
#loop
 ti= _TI0&$32;'  mask inputs 1,4 and 5 (00110010b = 32h)
 IF ti=$32
  out= 1;'       variable for output
 ELSE
  out= 0;'       variable for output
 ENDIF
 OB 1,out;'     set output at the end of the scan
AT -100;'        set loop scan time to 100 ms
JP #loop
```

AZ *Analog Output Select*

AZm= n

AZ n,n,n,n,n,n

Usage	AZm= n	Arguments specified with a single axis mask and an assignment (=)
	AZ n ...	Arguments specified with an implicit, comma-separated order
Operands	_AZm	Operand has special meaning, see Remarks

Description

The AZ command selects the Analog Outputs used for the control loops.

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
m	A	B	N/A	Channel	Channel to assign value	For RIO-47xx0
	A	F	N/A	Channel	Channel to assign value	For RIO-47xx2 and RIO-473xx
n	-1	7	-1	1	Analog output for process control	n = -1 disables control loop

Remarks

- The RIO-472xx requires additional daughter board hardware for analog outputs
  - See the part number generator for more information, [http://www.galilmc.com/products/rio-47xxx-part-number.php]
- _AZm contains the analog input channel selected for the specified control loop

Examples

```
'Galil DMC Code Example
CL 25; '25msec update rate
AF 0; 'analog input 0 as feedback
AZ 0; 'analog output 0 as control
KP 1; 'proportional gain to 1
KD 10; 'derivative gain to 10
KI 0.5; 'integral gain to 0.5
DB 0.1; 'deadband of 0.1V
PS 1.8; 'set-point at 1.8V
```

AZ applies to RIO

BK *Breakpoint*

BK n_0,n_1

Usage	BK n ...	Arguments specified with an implicit, comma-separated order
Operands	_BK	Operand has special meaning, see Remarks

Description

The BK command causes the controller to pause execution of the given thread at the given program line number. When that line is reached, program execution halts before the line is executed, while all other threads continue running. After a breakpoint is encountered, a new breakpoint can be armed (to continue execution to the new breakpoint) or BK will resume program execution. The SL command can be used to single step from the breakpoint.

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
n_0	0	199	N/A	1	Line number to set breakpoint	For RIO-47xx0. n = null resumes execution
	0	399	N/A	1	Line number to set breakpoint	For RIO-47xx2 and RIO-473xx. n = null resumes execution
n_1	0	7	0	1	Thread number to set breakpoint	If n omitted, default value used.

Remarks

- Only one breakpoint may be armed at any time.
- BK can be armed before or during thread execution.

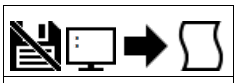
Operand Usage

- _BK will tell whether a breakpoint has been armed, whether it has been encountered, and the program line number of the breakpoint:
  - = -LineNumber: breakpoint armed
  - = LineNumber: breakpoint encountered
  - = -2147483648: breakpoint not armed

Examples

```
'Galil DMC Code Example
:BK 3;'     Pause at line 3 (the 4th line) in thread 0
:BK 5;'     Continue to line 5
:SL;'       Execute the next line
:SL 3;'     Execute the next 3 lines
:BK;'       Resume normal execution
```

BN *Burn*



BN

Usage	BN	Command takes no arguments
Operands	_BN	Operand has special meaning, see Remarks

Description

The BN command saves certain board parameters in non-volatile EEPROM memory. This command typically takes 1 second to execute and must not be interrupted. The controller returns a colon (:) when the Burn is complete.
This command reference will denote comands that can and cannot be burned with BN with the following usage icons.

Burnable with BN icon

Not burnable with BN icon

Arguments

The BN command has no arguments

Remarks

- The following table shows the commands that have their parameters saved with the BN command:

Parameters saved during burn

AF	IQ	MD	SB
AZ	KD	ME	SM
CB	KI	MI	RO
CW	KP	MS	VF
EO	LZ	MV	
IA	MA	PW	

- The RIO product line has a maximum of 10,000 write cycles for burning (BV,BP, BN combined).

Operand Usage

- _BN contains the serial number of the processor board.

Examples

```
'Galil DMC Code Example
SB 1;'   Set bit 1
CB 2;'   Clear bit 2
CW 1;'   Set data adjustment bit
BN;' Burn all parameter states
```

BP *Burn Program*

BP

Usage	BP	Command takes no arguments

Description

The BP command saves the application program in non-volatile EEPROM memory. This command may take several seconds to execute and must not be interrupted. The controller returns a : when the Burn is complete.

Arguments

The BP command has no arguments

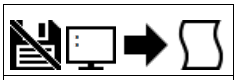
Remarks

- The RIO product line has a maximum of 10,000 write cycles for burning (BV,BP, BN combined).
- Legacy Software Note: This command may cause the Galil software to issue the following warning "A time-out occurred while waiting for a response from the controller". This warning is normal and is designed to warn the user when the controller does not respond to a command within the timeout period.
- The timeout can be changed in the Galil software but this warning does not affect the operation of the controller or software.

Examples

```
'Galil DMC Code Example
:BP;'    Burn in program to controller
:'       Get colon response when done
```

BV *Burn Variables and Array*



BV

Usage	BV	Command takes no arguments
Operands	_BV	Operand has special meaning, see Remarks

Description

The BV command saves the controller variables and arrays in non-volatile EEPROM memory. This command typically takes up to 2 seconds to execute and must not be interrupted. The controller returns a : when the Burn is complete.

Arguments

The BV command has no arguments

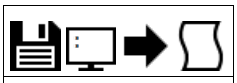
Remarks

- The RIO product line has a maximum of 10,000 write cycles for burning (BV,BP, BN combined).
- This command may cause the Galil software to timeout. This warning is normal and is designed to warn the user when the controller does not respond to a command within the timeout period. This occurs because this command takes more time than the default timeout period. The timeout can be changed in the Galil software. This warning does not affect the operation of the board or software.

Examples

```
'Galil DMC Code Example
:BV;'  burn in variables
:'     colon response returned
```

CB *Clear Bit*



CB n

Usage	CB n ...	Arguments specified with an implicit, comma-separated order

Description

The CB command clears a particular digital output. The SB and CB (Clear Bit) instructions can be used to control the state of output lines.

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
n	0	15	N/A	1	Output bit to be set	RIO-471xx and RIO-472xx
	0	23	N/A	1	Output bit to be set	RIO-473xx
	24	47	N/A	1	Digital output to be set	RIO-473xx with -24ExOut option
n	1,000	3,999	N/A	1	Set Modbus slave bit	For RIO-47xx0. See "CB via Modbus Slave" in Remarks
	1,000	5,999	N/A	1	Set Modbus slave bit	For RIO-47xx2 and RIO-473xx. See "CB via Modbus Slave" in Remarks

Remarks

- The state of the output can be read with the @OUT command

CB via Modbus Slave

- n = (SlaveAddress*10000) + (HandleNum*1000) + ((Module-1)*4) + (Bitnum-1)
  - Slave Address is used when the ModBus device has slave devices connected to it and specified as Addresses 0 to 255. Please note that the use of slave devices for modbus are very rare and this number will usually be 0.
  - HandleNum is the handle specifier where A is 1, B is 2 and so on.
  - Module is the position of the module in the rack from 1 to 16.
  - BitNum is the I/O point in the module from 1 to 4

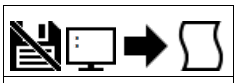
Examples

```
'Galil DMC Code Example
#main
SB 5;'     Set digital output 5
SB 1;'     Set digital output 1
CB 5;'     Clear digital output 5
CB 1;'     Clear digital output 1
EN
```

```
'Galil DMC Code Example
#modbus
REM connect to modubs slave at IP address 192.168.1.50
IHF= 192,168,1,50<502>2
WT 100
SB 5001;'set bit 1 on modbus slave
WT 10
CB 5003;'set bit 3 on modbus slave
EN
```

For detailed information on connecting to a Modbus slave, see:
http://www.galilmc.com/techtalk/io-control/setting-up-and-rio-as-extended-io-for-a-controller/

CF *Configure Unsolicited Messages Handle*



CF m

Usage	CF mm	Argument is an axis mask
Operands	_CF	Operand has special meaning, see Remarks

Description

The CF command sets the port for unsolicited messages. The CF command directs the controller to send unsolicited responses to the Main or Aux Serial Port (If equipped), or to an Ethernet handle. An unsolicited message is data generated by the controller which is not in response to a command sent by the host.

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
m	A	C	S	Handle	Ethernet Handle to assign as unsolicited message port	For RIO-47xx0
	A	E	S	Handle	Ethernet handle to assign as unsolicited message port	For RIO-47xx2 and RIO-473xx
	I	I	S	Handle	Set the port that sent the command as the unsolicited message port	Not valid in program
	S	S	S	Handle	Set Main serial port as unsolicited message port	

Remarks

- Examples of application code commands that will generate unsolicited messages follow.

```
'Galil DMC Code Example
MG "Hello";'       A message (MG)
TC 1;'             A command that returns a response
TP ;'              "
RP A;'             "
var= ?;'           A variable interogation
var= ;'            "
thisIsAnError;'  A dmc error will generate an error message
```

Ethernet Handle as Unsolicited Message Port

- When communicating over Ethernet, two Ethernet handles should be used:
  - 1.) The first handle should be used for command-and-response traffic. This is the primary handle that the host uses to communicate to the controller.
  - 2.) The second handle should be used for unsolicited traffic. This is the primary handle that the controller uses to asynchronously communicate to the host. Use CF to point unsolicited traffic to this handle.
- It is NOT recommended to use one Ethernet handle for both command-and-response, and unsolicited messages.
- GalilTools will by default establish a two handle connection when using Ethernet, and set CF to the second handle.

Operand Usage

- _CF contains the decimal value of the ASCII letter where unsolicited messages are currently routed.

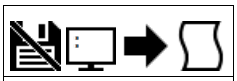
Examples

```
'Galil DMC Code Example
:CF I;' send unsolicited traffic to the terminal that sent the command
```

```
'Galil DMC Code Example
'Demonstrates from GalilTools terminal that the
'main handle is seperate from the unsolicited handle
'Note the connection indicators IHA and IHB in the following:
'192.168.1.3, RIO47102 Rev 1.0c, 1480, IHA IHB
:TH
CONTROLLER IP ADDRESS 192,168,1,3 ETHERNET ADDRESS 00-50-4C-28-05-C8
IHA TCP PORT 23 TO IP ADDRESS 192,168,1,100 PORT 2420
IHB UDP PORT 60007 TO IP ADDRESS 192,168,1,100 PORT 2421
IHC AVAILABLE
IHD AVAILABLE
IHE AVAILABLE
:WH
IHA
:'Main handle is A
:MG _CF
 66.0000
:'Unsolicited handle. 66 is ASCII for "B"
:
```

CF applies to DMC40x0,DMC42x0,DMC41x3,DMC21x3,RIO,DMC30010,DMC50xx0

CI *Configure Communication Interrupt*



CI n_0, n_1

Usage	CI n ...	Arguments specified with an implicit, comma-separated order

Description

The CI command configures program interrupts based on input of characters over the communication port.

The command configures a program interrupt based on characters received on communications port 1, the MAIN serial port. An interrupt causes program flow to jump to the #COMINT subroutine. If multiple program threads are used, the #COMINT subroutine runs in thread 0 and the remaining threads continue to run without interruption. The characters received can be accessed via the operands P1CH, P1ST, P1NM, P1CD.

Arguments

Argument	Value	Description	Notes
n_0	-1	Clear interrupt data buffer	
	0	Do not interrupt	Default
	1	Interrupt on carriage return	
	2	Interrupt on any character	
n_1	0	Main serial port configured as standard port for input of Galil commands.	Default. CI execution disabled.
	1	Main serial port configured for CI execution	Data received will not be interpreted as a command.

Remarks

- For more, see Operator Data Entry Mode in the user manual.

Examples

```
'Galil DMC Code Example
:CI 2, 1;'     Interrupt on a single character received from serial port
:CI ,0;'       Reenable port for standard Galil commands
```

CI applies to DMC40x0,DMC42x0,DMC41x3,DMC21x3,RIO,DMC30010,DMC50xx0

CL *Control Loop*

CLm= n
CL n,n,n,n,n,n

Usage	CLm= n	Arguments specified with a single axis mask and an assignment (=)
	CL n ...	Arguments specified with an implicit, comma-separated order
Operands	_CLm	Operand holds the value last set by the command

Description

The CL command sets the sampling period for the optional control loops. This parameter is control loop dependent.

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
m	A	B	N/A	Channel	Channel to assign value	RIO-47xx0
	A	F	N/A	Channel	Channel to assign value	RIO-47xx2 and RIO-47300
n	1	65,535	1	1	Update rate for process control loops in msecs	

Remarks

- For more information, see the RIO user manual.

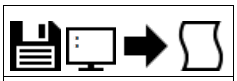
Examples

```
'Galil DMC Code Example
CL 25; '25msec update rate
AF 0; 'analog input 0 as feedback
AZ 0; 'analog output 0 as control
KP 1; 'proportional gain to 1
KD 10; 'derivative gain to 10
KI 0.5; 'integral gain to 0.5
DB 0.1; 'deadband of 0.1V
PS 1.8; 'set-point at 1.8V

EN
```

```
'Galil DMC Code Example
MG _CLA; 'message loop A default update rate 1ms
MG _CLB; 'message loop B default update rate 1ms
CL 25; 'Set loop A update rate to 25ms
CL ,10; 'Set loop B update rate to 10ms
MG _CLA; 'message new loop A update rate 25ms
MG _CLB; 'message new loop B update rate 10ms
CLA= 10; 'Set loop A update rate to 10ms
CLB= 25; 'Set loop B update rate to 25ms
MG _CLA; 'message new loop A update rate 10ms
MG _CLB; 'message new loop B update rate 25ms

EN
```

CL applies to RIO

CW *Copyright information and Data Adjustment bit on/off*



CW n_0,n_1

Usage	CW n ...	Arguments specified with an implicit, comma-separated order

Description

The CW command will return the copyright information when the argument, n, is 0 or is omitted. Otherwise, the CW command is used as a communications enhancement for use by the Galil terminal software programs. When turned on, the most significant bit of unsolicited ASCII characters is set to 1. Unsolicited ASCII characters are characters that are returned from a program running on the controller (usually from the MG command). This command does not affect solicited characters, which are characters that are returned as a response to a command sent from a host PC (e.g. TP).

Arguments

Argument	Value	Description	Notes
n_0	0	Causes controller to return a copyright information string	Equivalent to n_0 = ?
	1	Controller will set the MSB of unsolicited message characters	
	2	Controller will not set the MSB of unsolicited message characters	Default. Must be set when viewing unsolicited messages from non-Galil software
n_1	0	Controller will pause program execution when hardware handshaking disables character transmissions	
	1	Controller will continue program execution when hardware handshaking disables character transmissions	Default. Output characters will be lost if serial buffer is full.

Remarks

- Galiltools automatically sends CW 1 during connection to a controller.
  - If also reading unsolicited data through a non-Galil software (eg. Hyperterminal), issue CW 2

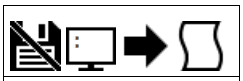
Operand Usage

- _CW contains the value set for n_0
- _CW4 contains the value set for n_1

Examples

```
'Galil DMC Code Example
CW 1;'     Set CW to Galil Driver mode (MSB set on unsolicited characters)

'         The CW command can cause garbled (non-ASCII) characters to be returned
'         by the controller when using third-party software. Use CW2.
CW 2;'     Set CW to third-party device mode (normal ASCII on unsoliticed characters)
```

DA *Deallocate Variables and Arrays*



```
DA str[],str
```

Usage	DA n ...	Arguments specified with an implicit, comma-separated order
Operands	_DAm	Operand has special meaning, see Remarks

Description

The DA command frees the array and/or variable memory space. In this command, more than one array or variable can be specified for memory de-allocation. Different arrays and variables are separated by comma when specified in one command.

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
str	1 char	8 chars	N/A	String	Array name to deallocate	If str = *, deallocate all arrays
	1 char	8 chars	N/A	String	Variable name to deallocate	If str = *, deallocate all variables

where
c[] - Defined array name
d - Defined variable name
d = * deallocates all the variables
c = *[] - Deallocates all the arrays
DA? Returns the number of arrays available.

Remarks

- _DA contains the total number of arrays available.
- Since this command deallocates the spaces and compacts the array spaces in the memory it is possible that execution of this command may take longer time than a standard command.
- Variables and arrays that are deallocated are not set to zero. A routine that writes zeros to the array and/or variables should be created if this is desired.

Examples

```
'Galil DMC Code Example
'Cars' and 'Salesmen' are arrays, and 'Total' is a variable.
DM cars[40],salesmen[50];'        Dimension 2 arrays
total= 70;'                        Assign 70 to the variable Total
DA cars[0],salesmen[0],total;'    Deallocate the 2 arrays & variable
DA *[0];'                          Deallocate all arrays
DA *,*[0];'                       Deallocate all variables and all arrays
```

DB *Deadband*

DBm= n
DB n,n,n,n,n,n

Usage	DBm= n	Arguments specified with a single axis mask and an assignment (=)
	DB n ...	Arguments specified with an implicit, comma-separated order
Operands	_DBm	Operand holds the value last set by the command

Description

The DB command selects the deadband where the error must exceed the deadband to execute the control loop.

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
m	A	B	N/A	Channel	Channel to assign value	For RIO-47xx0
	A	F	N/A	Channel	Channel to assign value	For RIO-47xx2 and RIO-473xx
n	-1	1	0	1/65,536	Deadband in volts	-n = flow control mode. +n = normal control mode. See Remarks.

Remarks

- AF and AZ commands must be set prior to the DB command.
- A negative value for n will place the RIO in a velocity or flow control mode. In this mode the output from the PID filter is held when the feedback is within the deadband range. This includes the contribution of OF.
- With a positive value for n, the output of the PID filter is cleared (set to 0) when the deadband is reached.

Examples

```
'Galil DMC Code Example
AF 0,1;AZ 0,1;'   Set analog input/output on A and B
DB .5,.6;'        Set deadband on A and B
MG _DBA;'         Query DB setting on A axis
```

DB applies to RIO

DF *Dual Feedback (DV feedback swap)*

DF n,n,n,n,n,n,n,n

Usage	DF n ...	Arguments specified with an implicit, comma-separated order
Operands	_DFm	Operand holds the value last set by the command

Description

The DF command allows configuration of BiSS or SSI feedback in Dual Loop mode as the load encoder. For users wishing to operate with SSI or BiSS in Dual Loop mode (DV), the DF command can be used to configure a load-side serial encoder and a motor-side incremental encoder with DV1.

Arguments

Argument	Value	Description	Notes
n	0	Disable feedback swap	Default
	1	Enable feedback swap	

Remarks

- Wire the motor's incremental encoder per normal to the DMC-4xxx main encoder inputs. The load SSI encoder should be wired to the axis aux encoder lines:

SSI Signals for DMC-4xxx

Nominal Signal Name	Signal Reassignment with SSI	Signal Reassignment with BiSS
AA+	Clock+	MA+
AA-	Clock-	MA-
AB+	Data+	SLO+
AB-	Data-	SLO-

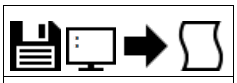
- Once wired, configure the serial encoder as an auxiliary encoder.
  - See SI or SS for configuration information.
- Once configured for Dual Loop (DV1), DF1 will swap the serial encoder to become the load (Main) encoder. The incremental encoder wired to the main encoder inputs becomes the motor (Auxiliary) encoder. TP will now report the serial encoder position, and TD will report the incremental encoder position.

Examples

```
'Galil DMC Code Example
MO A;'                    Disable motor on X
SIA= 2,25,15,0<13>2;' Setup SSI encoder to fill the Aux encoder register
DF 1;'                    Enable Dual Feedback Swap
DV 1;'                    Enable Dual Loop mode
SH A;'                    Enable servo with new configuration
```

DF applies to DMC50xx0,SER

DH *DHCP Client Enable*



DH n

Usage	DH n ...	Arguments specified with an implicit, comma-separated order

Description

The DH command configures the DHCP or BOOT-P functionality on the controller for Server IP addressing.

Arguments

Argument	Value	Description	Notes
n	0	Enable BOOT-P and disable DHCP	Allows IP assignment through IA command.
	1	Disable BOOT-P and enable DHCP	Default. Allows IP assignment through DHCP server.

Remarks

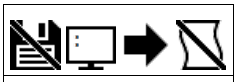
- DH 0 must be set to manually assign and burn in an IP address. With DH 1 set, the IA command will return an error if used to set the IP address.

Examples

```
'Galil DMC Code Example
DH 1;' Sets the DHCP function on.  IA assignment will no longer work.
DH 0;' Sets the DHCP function off, and the Boot-P function on.
```

DH applies to DMC40x0,DMC42x0,DMC41x3,RIO,DMC30010,DMC50xx0

DL *Download*



DL n
DL #str
DL s

Usage	DL n ...	Arguments specified with an implicit, comma-separated order

Description

The DL command transfers a data file from the host computer to the controller. Instructions in the file will be accepted as a data stream without line numbers. The file is terminated using <control> Z, <control> Q, <control> D, or \.

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
n	0	199	0	1	Line number to begin program download	For RIO-47xx0
	0	399	0	1	Line number to begin program download	For RIO-47xx2 and RIO-473xx
str	1 char	8 chars	""	String	Name of label in RAM to begin download from.	If str = "", download begins at the end of the current program in RAM
s	#	#	N/A	Symbol	Begins download at end of program in RAM	

Remarks

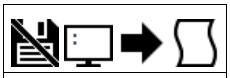
- Do not insert spaces before each command.

- _DL gives the number of available labels.
- The total number of labels is 62 on the RIO-47xx0.
- On the RIO-47xx2 this is increased to 126 labels.

Examples

```
'Galil DMC Code Example
:DL;'       Begin Download
SB0
CB2
EN
\
:'Ended download
```

DM *Dimension Array*



DM str[n]

Usage	DM n ...	Arguments specified with an implicit, comma-separated order

Description

The DM command defines a single-dimensional array with a name and n total elements. The first element of the defined array starts with element number 0 and the last element is at n-1.

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
str	1 char	8 chars	N/A	String	Name of array to dimension	
n	1	400	N/A	1	Number of array elements to assign to dimensioned array	For RIO-47xx0
	1	1,000	N/A	1	Number of array elements to assign to dimensioned array	For RIO-47xx2 and RIO-473xx

where
c is a array name of up to eight alphanumeric characters, starting with an alphabetic character.
i is the number of array elements.
n = ? returns the number of array elements available.

Remarks

- The first character of str must be alphabetic. The rest can be any alphanumeric characters.
- When assigning array elements, the number specified must be less than the current available array space
- _DM contains the available array space.

Examples

```
'Galil DMC Code Example
DM pets[5],dogs[2],cats[3];' Define dimension of arrays, Pets with 5 elements, Dogs with 2 elements, Cats with 3 elements
DM tests[1600];' Define dimension of array Tests with 1600 elements
```

DQ *Change Analog Output Range*

DQ n_0,n_1

Usage	DQ n ...	Arguments specified with an implicit, comma-separated order
Operands	_DQ0 _DQ1 _DQ2 _DQ3 _DQ4 _DQ5 _DQ6 _DQ7	Operand has special meaning, see Remarks

Description

The DQ command allows the ability to change the analog output range for individual channels. Check the ID command to see if your model supports DQ.

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
n_0	0	7	N/A	1	Analog output channel to assign value	
n_1	1	4	4	1	Designate the analog output range	

Argument	Value	Description	Notes
n	1	0 to +5 VDC	
	2	0 to +10 VDC	
	3	-5 to +5 VDC	
	4	-10 to +10 VDC	Default

Remarks

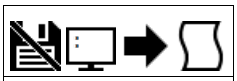
- _DQn_0 contains the present range setting.

Examples

```
'Galil DMC Code Example
'Set output 1 to 0-10v
DQ 1,2
```

DQ applies to RIO

DR *Configures I O Data Record Update Rate*



DR n_0, n_1

Usage	DR n ...	Arguments specified with an implicit, comma-separated order
Operands	_DR0 _DR1	Operand has special meaning, see Remarks

Description

DR specifies and enables the rate for the controller to output its data record.

For ethernet-based controllers, the controller creates a QR record and sends it to the unsolicited UDP Ethernet Handle at the specified rate. See the User Manual for the data record map

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
n_0	2	30,000	0	1	Data update rate specified in samples between packets.	
	0	0	0	0	Turn off data record output	
n_1	0	2	see Notes	1	Ethernet handle to output data record packet	For RIO-47xx0. 0=A,1=B,2=C.
	0	4	see Notes	1	Ethernet handle to output data record packet	For RIO-47xx2 and RIO-473xx. 0=A,1=B,2=C,3=D,4=E.

Remarks

- If a small sample period and a small update rate is used, the controller may become noticeably slower as a result of maintaining a high update rate.
- If n_1 is omitted, then the CF unsolicited message port is used by default.
- The DR port specified with n_1 must be a UDP handle.
- _DR0 contains the data record update rate (n)
- _DR1 contains the specified handle (n_1). Will return an integer 0-7 for handles A-H.

Examples

```
'Galil DMC Code Example
:WH
 IHA
:DR 8,0
GX~P
_`@~P
_H`~P
_0~P
:DR 0

'Note:  The data record is in a binary, non-printable format
'(the output above is normal when printing to the terminal)
```

DR applies to DMC40x0,DMC42x0,DMC41x3,DMC21x3,RIO,DMC18x6,DMC30010,DMC50xx0

DY *PWM output duty cycle*

DY n_0,n_1

Usage	DY n ...	Arguments specified with an implicit, comma-separated order
Operands	_DY0 _DY1	Operand holds the value last set by the command

Description

Sets the PWM duty cycle when using the PWM feature on outputs 14 and 15. PM enables the output of the PWM signal. FQ sets the PWM frequency.

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
n_0	0	100	0	1	Set PWM duty cycle percentage for output 14	See Remarks
n_1	0	100	0	1	Set PWM duty cycle percentage for output 15	See Remarks

Remarks

- Duty cycle is percentage ON with positive polarity, and percentage OFF with negative polarity (See PM for polarity)
- The -PWM option is necessary for precise resolution of the duty cycle. With the -PWM option the accuracy of the PWM output is +/- 0.5% of the DY setting.
- See the RIO user manual for more information.

Examples

```
'Galil DMC Code Example
FQ 100,200;'    Set output 14 to 100 Hz, and output 15 to 100 Hz
DY 50,25;'      Set output 14 to 50%, output 15 to 25%
PM 1,1;'        Turn PWM mode on for outputs 14 and 15
```

```
'Galil DMC Code Example
:MG _DY0;'      Show duty cycle for OUT14
 50.0000
```

DY applies to RIO

ED *Edit*

ED n

Usage	ED n ...	Arguments specified with an implicit, comma-separated order
Operands	_ED _ED1 _ED4	Operand has special meaning, see Remarks

Description

The ED command puts the controller into the Edit subsystem. The ED command is used when using Telnet style interface (not Galil Software). In the Edit subsystem, programs can be created, changed, or destroyed.

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
n	0	199	see Notes	1	Line number to begin editing	For RIO-47xx0. Default n is the last line of program space with commands.
	0	399	see Notes	1	Line number to begin editing	For RIO-47xx2 and RIO-473xx. Default n is the last line of program space with commands.

Remarks

- The commands in the Edit subsystem are the following.

ED Commands

Key Combination	Function
<ctrl>D	Deletes a Line
<ctrl>I	Inserts a line before the current
<ctrl>P	Displays the previous line
<ctrl>Q	Exits the ED subsystem
Enter	Saves a line and moves cursor to next

Operand Usage

- _ED0 contains the line number of the last line to have an error.
- _ED1 contains the number of the thread where the error occurred (for multitasking).
- _ED0 returns 0 if no error has occurred.
- _ED1 returns -1 if no error has occurred.

- _ED4 when evaluated in an embedded code thread, this operand will contain the thread id of the calling thread. This is useful for DMC code to determine which thread it is running in. See example below.

Examples

```
'Galil DMC Code Example
:ED
#START
PR 2000
BGA
xx;' bad command line
EN
#CMDERR Routine which occurs upon a command error
V=_ED0
MG "An error has occurred" {n}
MG "In line", V{F3.0}
ST
ZS0
EN
ctrl-Q
:'Hint:  Remember to quit the Edit Mode prior to executing or listing a program.
```

```
'Galil DMC Code Example
'Using _ED4
XQ #id,1
XQ #id,2
XQ #id,3
XQ #id,4
XQ #id,5
XQ #id,6
XQ #id,7
#id
MG {Z10.0}"This message is from thread",_ED4
EN

' Returns...
' :XQ
' This message is from thread 1
' This message is from thread 2
```

```
' This message is from thread 3
' This message is from thread 4
' This message is from thread 5
' This message is from thread 6
' This message is from thread 7
' This message is from thread 0
```

ELSE *Else function for use with IF conditional statement*

Usage	ELSE n ...	Arguments specified with an implicit, comma-separated order

Description

The ELSE command is an optional part of an IF conditional statement. The ELSE command must occur after an IF command and it has no arguments. It allows for the execution of a command only when the argument of the IF command evaluates False. If the argument of the IF command evaluates false, the controller will skip commands until the ELSE command. If the argument for the IF command evaluates true, the controller will execute the commands between the IF and ELSE command.

Arguments

ELSE is a command with no parameters

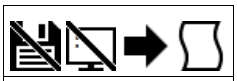
Remarks

- None

Examples

```
'Galil DMC Code Example
IF (@IN[1]=0);'                 IF conditional statement based on input 1
 IF (@IN[2]=0);'                2nd IF conditional statement executed if 1st IF conditional true
  MG "IN1 AND IN2 ARE ACTIVE";' Message to be executed if 2nd IF conditional is true
 ELSE;'                         ELSE command for 2nd IF conditional statement
  MG "ONLY IN1 IS ACTIVE";'     Message to be executed if 2nd IF conditional is false
 ENDIF ;'                        End of 2nd conditional statement
ELSE;'                          ELSE command for 1st IF conditional statement
 IF (@IN[2]=0);'               3rd IF conditional statement executed if 1st IF conditional false
  MG "ONLY IN2 IS ACTIVE";'   Message to be executed if 3rd IF conditional statement is true
 ELSE;'                        ELSE command for 3rd conditional statement
  MG "IN1 AND IN2 INACTIVE";'Message to be executed if 3rd IF conditional statement is false
 ENDIF ;'                       End of 3rd conditional statement
ENDIF ;'                        End of 1st conditional statement
```

EN *End*



EN n_0, n_1

Usage	EN n ...	Arguments specified with an implicit, comma-separated order

Description

The EN command is used to designate the end of a program or subroutine. If a subroutine was called by the JS command, the EN command ends the subroutine and returns program flow to the point just after the JS command.

Arguments

Argument	Value	Description	Notes
n_0	0	Return from subroutine without restoring trippoint	Default
	1	Return from subroutine and restore trippoint	
n_1	0	Return from #COMINT without restoring CI interrupt trigger	Default
	1	Return from #COMINT and restore CI interrupt trigger	

Remarks

- The EN command is used to end the automatic subroutines #MCTIME #COMINT and #CMDERR.
  - Use the RI command to end the #ININT0,#ININT1,#ININT2 and #ININT3 subroutines

Examples

```
'Galil DMC Code Example
#a;'        Program A
SB 1;'       Set output 1 high
WT 500;'    Wait for 500 msec
CB 1;'       Set output 1 low
MG "DONE";'Print message
EN;'        End of Program
```

ENDIF *End of IF conditional statement*

Usage	ENDIF n ...	Arguments specified with an implicit, comma-separated order

Description

The ENDIF command is used to designate the end of an IF conditional statement. An IF conditional statement is formed by the combination of an IF and ENDIF command. An ENDIF command must always be executed for every IF command that has been executed. It is recommended that the user not include jump commands inside IF conditional statements since this causes re-direction of command execution. In this case, the command interpreter may not execute an ENDIF command.

Arguments

ENDIF is a command with no parameters

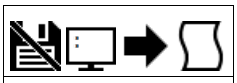
Remarks

- None

Examples

```
'Galil DMC Code Example
IF (@IN[1]=0);'                 IF conditional statement based on input 1
 IF (@IN[2]=0);'                2nd IF conditional statement executed if 1st IF conditional true
  MG "IN1 AND IN2 ARE ACTIVE";' Message to be executed if 2nd IF conditional is true
 ELSE;'                         ELSE command for 2nd IF conditional statement
  MG "ONLY IN1 IS ACTIVE";'     Message to be executed if 2nd IF conditional is false
 ENDIF ;'                        End of 2nd conditional statement
ELSE;'                          ELSE command for 1st IF conditional statement
 IF (@IN[2]=0);'               3rd IF conditional statement executed if 1st IF conditional false
  MG "ONLY IN2 IS ACTIVE";'   Message to be executed if 3rd IF conditional statement is true
 ELSE;'                        ELSE command for 3rd conditional statement
  MG "IN1 AND IN2 INACTIVE";'Message to be executed if 3rd IF conditional statement is false
 ENDIF ;'                       End of 3rd conditional statement
ENDIF ;'                        End of 1st conditional statement
```

EO *Echo*



EO n

Usage	EO n ...	Arguments specified with an implicit, comma-separated order
Operands	_EO	Operand holds the value last set by the command

Description

The EO command turns the echo on or off. If the echo is off, characters input over the bus will not be echoed back.

Arguments

Argument	Value	Description	Notes
n	0	Echo Off	
	1	Echo On	Default

Remarks

- This command is defaulted to EO1. Galil software upon connection will set EO0
- The EO command is accepted over the serial port only.
  - The ethernet port will not echo commands

Examples

```
'Galil DMC Code Example
EO 0;' Turns echo off
EO 1;' Turns echo on
```

FQ *PWM output frequency*

FQ n_0,n_1

Usage	FQ n ...	Arguments specified with an implicit, comma-separated order
Operands	_FQ0 _FQ1	Operand holds the value last set by the command

Description

Sets the PWM frequency when using the PWM feature on outputs 14 and 15. DY sets the duty cycle and PM enables the PWM output feature.

Arguments

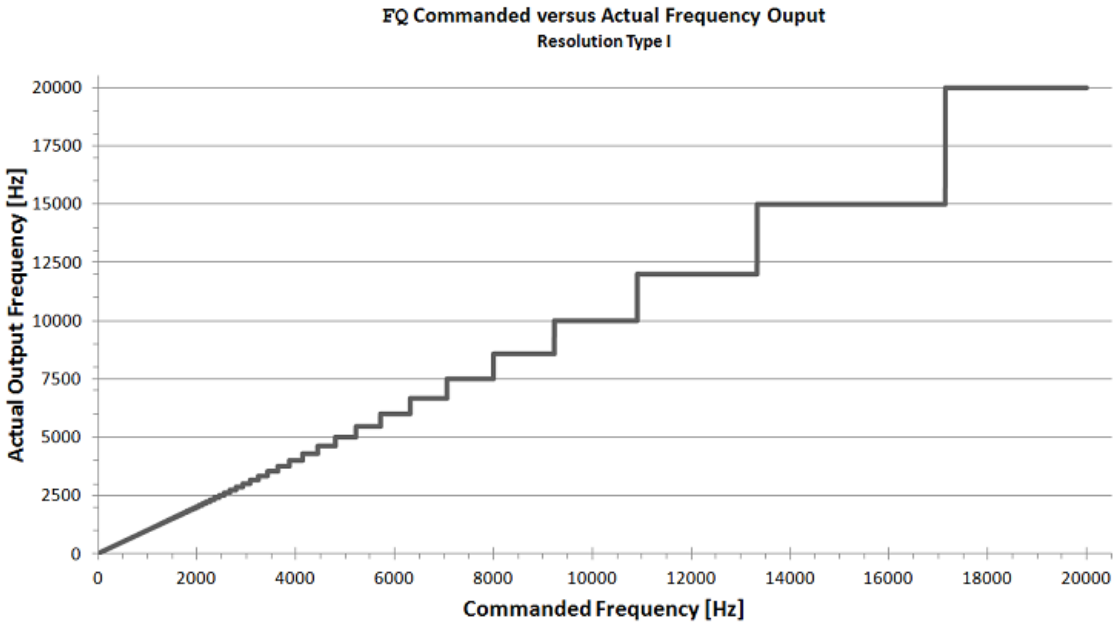
Argument	Min	Max	Default	Resolution	Description	Notes
n_0	10	20,000	0	1	Frequency of PWM signal for output 14 in Hz	PWM Resolution defined in Remarks
n_1	10	20,000	0	1	Frequency of PWM signal for output 15 in Hz	PWM Resolution defined in Remarks

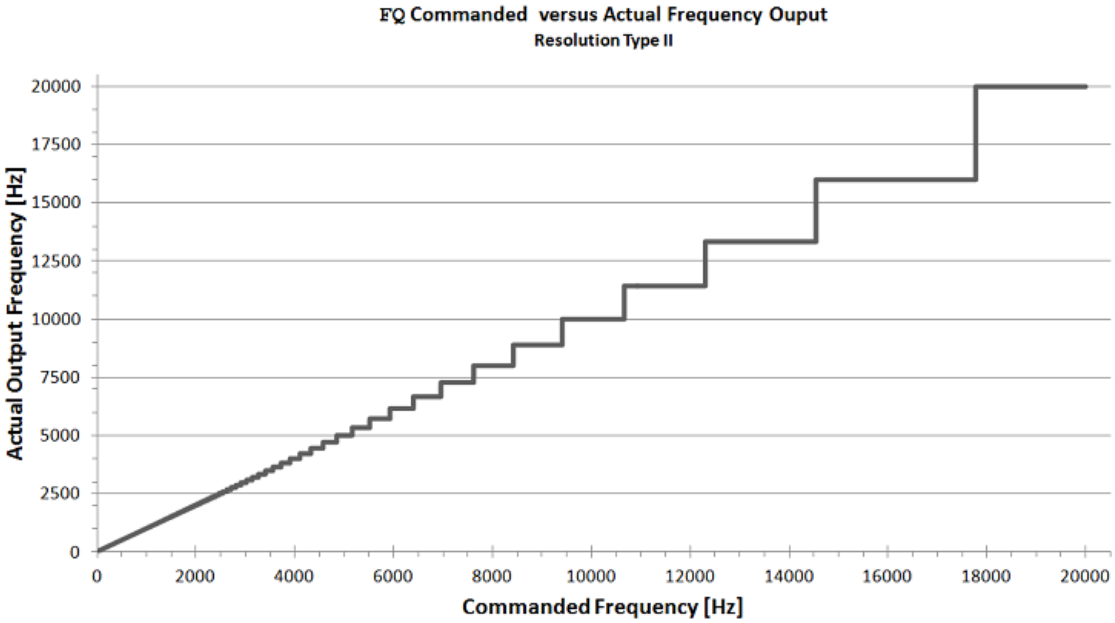
Remarks

- The -PWM option is necessary in order to obtain the full frequency range for the PWM output. See the RIO user manual for more information.
- **Usage note:**The FQ command should be set to a valid value before the PWM output is enabled.
- The actual resolution of the PWM frequency depends on the frequency set. See table and figures below and refer to the user manual for the equations necessary to determine the exact frequency the PWM feature will generate.

PWM Resolution

RIO model	Resolution Type Below
47100	I
47120	I
47200	I
47102	II
47122	II
47142	II
47202	II
47300	II



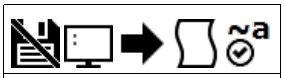


Examples

```
'Galil DMC Code Example
:FQ 100,200;'    Set output 14 to 100 Hz, and output 15 to 100 Hz
:DY 50,25;'      Set output 14 to 50%, output 15 to 25%
:PM 1,1;'        Turn PWM mode on for outputs 14 and 15
:
```

FQ applies to RIO

HS *Handle Assignment Switch*



HSm0= m

Usage	HSm0= m	Arguments are single axis masks and are specified with a single axis mask and an assignment (=)
	HS m ...	Arguments are single axis masks specified with an implicit, comma-separated order

Description

The HS command is used to switch the ethernet handle assignments between two handles. Handles are opened when a connection is established by an external client (TCP or UDP), or when a handle is assigned explicitly with the IH command. Should those assignments need modifications, the HS command allows the handles to be reassigned.

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
m0	A	C	N/A	Handle	First handle to switch	For RIO-47xx0
	A	E	N/A	Handle	First handle to switch	For RIO-47xx2 and RIO-473xx
	S	S	N/A	Handle	First handle to switch	S = current handle sending command. Not valid in program
m	A	C	N/A	Handle	Second handle to switch	For RIO-47xx0
	A	E	N/A	Handle	Second handle to switch	For RIO-47xx2 and RIO-473xx
	S	S	N/A	Handle	Second handle to switch	S = current handle sending command. Not valid in program

Remarks

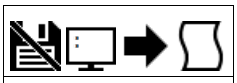
- A handle encapsulates the following 4 pieces of information:
  - 1. Local IP address (same for all handles)
  - 2. Remote IP address
  - 3. Local Port
  - 4. Remote Port
- Handles are used as a pointer to the network socket in commands such as SAh, MBh, {Eh}, and IHh where h is the handle letter

Examples

```
'Galil DMC Code Example
:HSC= D;' Connection for handle C is assigned to handle D.  Connection for handle D is assigned to handle C.
:HSS= E;' Executing handle connection is assigned to handle E.  Connection for handle E is assigned to executing handle.
```

HS applies to DMC40x0,DMC42x0,DMC41x3,DMC21x3,RIO,DMC30010,DMC50xx0

HX *Halt Execution*



HX n

Usage	HX n ...	Arguments specified with an implicit, comma-separated order
Operands	_HX0 _HX1 _HX2 _HX3	Operand has special meaning, see Remarks

Description

The HX command halts the execution of any program that is running.The parameter n specifies the thread to be halted.

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
n	0	3	N/A	1	Thread number to halt	If n omitted, all threads are halted.

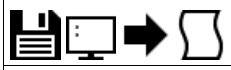
Remarks

- When used as an operand, _HXn contains the running status of thread n with:
  - 0 Thread not running
  - 1 Thread is running
  - 2 Thread has stopped at trippoint

Examples

```
'Galil DMC Code Example
XQ #a;'    Execute program #A, thread zero
XQ #b,3;' Execute program #B, thread three
HX 0;'     Halt thread zero
HX 3;'    Halt thread three
```

IA *IP Address*



IA n_0, n_1, n_2, n_3
IA n_4
IA < o

Usage	IA n ...	Arguments specified with an implicit, comma-separated order
Operands	_IA0 _IA1 _IA2 _IA3 _IA4 _IA5	Operand has special meaning, see Remarks

Description

The IA command assigns the controller IP address and the TCP time out. The IP address can also be assigned via Galil software or from an external server. The controller defaults to DHCP and will receive an IP address from a DHCP server if present. To manually set an IP address over the serial connection, send DH0 to disable DHCP prior to setting the new IP address with IA.

GalilTools and GalilSuite software packages feature a DHCP/BOOTP capability to assign the IP address to the controller. Please refer to the user manuals for those products for more information.

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
n_0	0	255	0	1	Byte 3 of the IP address	
n_1	0	255	0	1	Byte 2 of the IP address	
n_2	0	255	0	1	Byte 1 of the IP address	
n_3	0	255	0	1	Byte 0 of the IP address	
n_4	-2,147,483,648	2,147,483,647	0	1	The full IP address specified as a signed 32 bit two's complement integer	
o	1	2,147,483,647	250	1	The time in update samples between TCP retries	Up to 5 retries occur

Remarks

- When specifying the IP address with IA, remember to use commas as delimeters instead of periods
- n_4 = ? will return the IP address of the controller in comma seperated format
- Setting the IP address over Ethernet to a new value will cause an immediate disconnect/timeout. Reconnect to the controller on the new IP address and issue a BN to save the new value to flash
- To change the IP address manually over Ethernet on a controller which was initially assigned via DHCP, send "DH 0;IA n_0,n_1,n_2,n_3" as one command line. Reconect on the new IP and issue BN to save

Operands

- _IA0 contains the IP address representing a 32 bit signed number (Two's complement). See the example below.
- _IA1 contains the value for o (retry time)
- _IA2 contains the number of available handles
- _IA3 contains the number of the handle using this operand where the number is 0 to 7. 0 represents handle A, 1 handle B, etc. This is used by a remote device to detect its outgoing handle (see WH).
- _IA4 contains the number of the handle that lost communication last, contains a -1 on reset to indicate no handles lost
- _IA5 returns autonegotiation Ethernet speed. Returns 10 for 10-Base T and returns 100 for 100-Base T, it will return -1 if there is no physical link

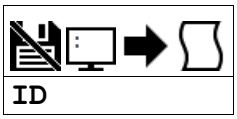
Examples

```
'Galil DMC Code Example
IA 151,12,53,89;' Assigns the controller with the address 151.12.53.89
IA 2534159705;'   Assigns the controller with the address 151.12.53.89
IA < 500;'        Sets the timeout value to 500 msec
```

```
'Galil DMC Code Example
REM The individual IP address bytes can be derived within embedded code using _IA0
a= @INT[(_IA0&($FF000000))/$1000000]&$FF
b= @INT[(_IA0&($00FF0000))/$10000]
c= @INT[(_IA0&($0000FF00))/$100]
d= @INT[(_IA0&($000000FF))]
REM IP address = a.b.c.d
```

IA applies to DMC40x0,DMC42x0,DMC41x3,DMC21x3,RIO,DMC30010,DMC50xx0

ID *Identify*



Usage	ID	Command takes no arguments

Description

The ID command is used to query the controller for the hardware configuration and facotry programming.

Arguments

ID is a command with no arguments

Remarks

- Refer to the Examples section for actual controller responses
- The following are descriptions of the ID response

outputs 0-3 = [power] [type] outputs
where
[power] - power indicates the outputs are high power outputs. No string here indicates low power outputs
[type]- specifies whether the outputs are sourcing or sinking

Output information is displayed in sets of 4 bits at a time, until all outputs have been described.

analog inputs 0-3 = [bit] [configuration]
where
[bit] - '12 bits' indicates 12 bit resolution of the analog inputs
'16 bits' indicates 16 bit resolution of the analog inputs
[configuration] - 'range of 0 to 5' indicates the unit has non-configurable analog ins (eg. RIO-47x0x)
- 'programmable range(AQ)' indicates the unit has configurable analog ins (eg. RIO-47x2x)
Analog input information is displayed in sets of 4 signals at a time, until all inputs have been described.

analog outputs 0-3 = [bit] [configuration]
where
[bit] - '12 bits' indicates 12 bit resolution of the analog inputs
'16 bits' indicates 16 bit resolution of the analog inputs
[configuration] - 'range of 0 to 5' indicates the unit has non-configurable analog outs (eg. RIO-47x0x)
- 'programmable range(AQ)' indicates the unit has configurable analog outs (eg. RIO-47x2x)
Analog output information is displayed in sets of 4 signals at a time, until all outputs have been described.

real time clock
Presence of the string 'real time clock' indicates power-loss persistant, real time clock circuitry

encoder options=[encoder_0] [encoder_1] [encoder_2] [encoder_3]
where
[encoder_n] = 'ssi' for SSI encoder input for the specified channel
'biss' for BiSS encoder input for the specified channel
'quad' for quadrature encoder input for the specified channel

Examples

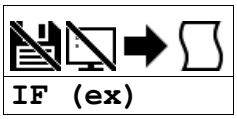
```
'Galil DMC Code Example
:^R^V
RIO47100 Rev 1.0f1
:ID
outputs 0-3 = power sourcing outputs
outputs 4-7 = power sourcing outputs
outputs 8-11 = sinking outputs
outputs 12-15 = sinking outputs
analog inputs 0-3 = 12 bits programmable range(AQ)
analog inputs 4-7 = 12 bits programmable range(AQ)
analog outputs 0-3 = 12 bits programmable range(DQ)
analog outputs 4-7 = 12 bits programmable range(DQ)
:
```

```
'Galil DMC Code Example
:^R^V
RIO47300 Rev 1.1b
:ID
outputs 0-3 = power sourcing outputs
outputs 4-7 = power sourcing outputs
outputs 8-11 = power sourcing outputs
outputs 12-15 = power sourcing outputs
outputs 16-19 = power sourcing outputs
outputs 20-23 = power sourcing outputs
analog inputs 0-3 = 12 bits programmable range(AQ)
analog inputs 4-7 = 12 bits programmable range(AQ)
analog outputs 0-3 = 12 bits programmable range(DQ)
```

```
analog outputs 4-7 = 12 bits programmable range(DQ)
:
```

ID applies to DMC40x0,DMC42x0,DMC41x3,RIO,DMC30010,DMC50xx0

IF *IF conditional statement*



Usage	IF n ...	Arguments specified with an implicit, comma-separated order

Description

The IF command is used in conjunction with an ENDIF command to form an IF conditional statement. The arguments consist of one or more conditional statements and each condition must be enclosed with parenthesis (). If the conditional statement(s) evaluates true, the command interpreter will continue executing commands which follow the IF command. If the conditional statement evaluates false, the controller will ignore commands until the associated ENDIF command or an ELSE command occurs in the program.

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
ex	N/A	N/A	N/A	Expression	Conditional statement for IF statement	See Remarks

Remarks

- Conditions are tested with the following logical operators:
  - < less than or equal to
  - > greater than
  - = equal to
  - <= less than or equal to
  - >= greater than or equal to
  - <> not equal
- Bit wise operators | and & can be used to evaluate multiple conditions.
- A true condition = 1 and an false condition = 0.
- Each condition must be placed in parenthesis for proper evaluation by the controller.

```
'Galil DMC Code Example
IF ((var0=1)&(var1=2));' valid IF statement

IF var0=1&var1=2;'      invalid IF statement

IF (var0=1&var1=2);'    invalid IF statement
```

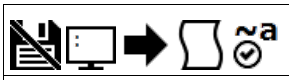
Examples

```
'Galil DMC Code Example
#input
IF (@IN[1]=0);'          IF conditional statement based on input 1
 MG "Input 1 is Low";'   Message to be executed if "IF" statement is true
ENDIF ;'                 End of IF conditional statement
EN
```

```
'Galil DMC Code Example
#var
v1= @AN[1]*5;'             some calculation for variable v1
IF ((v1>25)&(@IN[4]=1));' Conditions based on V1 variable and input 4 status
 MG "Conditions met";'   Message to be executed if "IF" statement is true
ENDIF ;'                 End of IF statement
EN
```

```
'Galil DMC Code Example
REM The conditions of an if statement can be simplied with the fact that
REM a true condition = 1 and a false condition = 0.
#true
v1= 1
IF (v1)
 MG "True v1=",v1
ENDIF
#false
v1= 0
IF (v1)
 'if statement evaluates false
ELSE
 MG "False v1=",0
ENDIF
EN
```

IH *Open IP Handle*



IHm= n_0,n_1,n_2,n_3 <o >p
IHm= n <o >p
IHm= >p

Usage	IHm= n	Arguments specified with a single axis mask and an assignment (=)
Operands	_IHm0 _IHm1 _IHm2 _IHm3 _IHm4	Operand has special meaning, see Remarks

Description

The IH command is used when the controller is operated as a master (client) to open a handle and connect to a slave (server).
The IH command is also used to set the realtime clock from a TIME protocol server.

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
m	A	C	N/A	Handle	Handle to assign connection	For RIO-47xx0
	A	E	N/A	Handle	Handle to assign connection	For RIO-47xx2 and RIO-473xx
	S	T	N/A	Handle	Special handle designator used when closing handles	See Remarks
n_0	0	255	0	1	Byte 3 of the slave IP address	
n_1	0	255	0	1	Byte 2 of the slave IP address	
n_2	0	255	0	1	Byte 1 of the slave IP address	
n_3	0	255	0	1	Byte 0 of the slave IP address	
n	-2,147,483,648	2,147,483,647	0	1	Slave IP address in its 32 bit value	
o	0	65,535	see Notes	1	Specify the slave port to connect over	If o is omitted, the controller selects the port starting at 1000
p	1	2	2	1	Specify the connection type to open	n = 2 is TCP. n = 1 is UDP.
	-3	-1	N/A	1	Specify the connection type to close when closing a handle	See Remarks

Remarks

- All 4 bytes must be assigned for an IP address to be valid.
- IHm=? returns the IP address as 4, 1-byte numbers.
- Use the following equation to change the 4 byte IP (n_0,n_1,n_2,n_3) to a single 32 bit number, n.
  - n = (n_0*2^24) + (n_1*2^16) + (n_2*2^8) + n_3.
- When using Modbus, port 502, note that Galil Modbus supports one master per slave.

Opening a Handle

- To open a handle, the user must specify:
  - The IP address of the slave.
  - (optional) The port number of the slave. If not specified, the firmware will choose a port.
    - Modbus connections must always be specified as port 502.
  - (optional)The connection type as TCP/IP or UDP/IP. If not specified, the controller will make a TCP connection.
- Issue the IH command on an available handle with the correct settings for IP (n_0-n_3), port (o) and connection type (p).
  - See TH to list handle status.

Closing a Handle

- Closing a handle is done with the S and T handle identifiers, along with connection type p selector.
  - IHS => p closes the handle that sent the command with connection type matching > p
  - IHT => p closes all handles except for the one sending the command with connection type matching > p
  - For closing handles, use > p where p = -1 closes UDP handles, p = -2 closes TCP handles, and p = -3 closes all handle types

Time server

- Connecting to the time server requires using port 37 with a TCP connection. Port 37 is used by the TIME protocol server. Only TCP is supported.
- The server transmits a 32 bit unsigned integer in network byte order representing the number of seconds since midnight, January 1, 1900 GMT.
- The Command RO is used to set the timezone offset from GMT and to see the raw value returned by the time server

Operand Usage

Operand	Reported Value	Description of Value	Notes
_IHm0	-2147483648 to 2147483648	IP address of handle m as a 32 bit number (n)	

_IHm1	0 to 65535	Slave port number for handle m	
_IHm2	0	Handle is free	Handle 'Available' in TH
	1	Handle connected as UDP slave	
	2	Handle connected as TCP slave	
	-1	Handle connected as UDP master	
	-2	Handle connected as TCP master	
	-5	Attempting to establish UDP handle	
	-6	Attempting to establish TCP handle	
_IHm3	0	ARP was successful	
	1	ARP failed or still in progress	
_IHm4	1	Waiting for ACK from slave controller after issuing a command	
	2	Received ":" as response to a command	
	3	Received "?" as response to a command	
	4	Connection timed-out waiting for a response to a command	

Examples

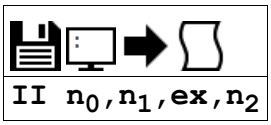
```
'Galil DMC Code Example
IHA= 251,29,51,1;'     Open handle A at IP address 251.29.51.1
'TCP is used as default
IHA= -2095238399;'     Open handle A at IP address 251.29.51.1
'When the IH command is given,
'the controller initializes an ARP
'on the slave device before opening a handle.
'This operation can cause a small time delay
'before the controller responds
```

```
'Galil DMC Code Example
'setting up a modbus handle
MW 1;'                          setup modbus wait
IHE= 192,168,100,200<502>2;' setup a modbus handle to slave
#wt;'                          wait for handle to be connected
WT 2;'                          before issuing a command
JP #wt,_IHE2<>-2;'
SB 5003;'                       Set output 3 on slave
WT 1000;'                       1 second wait
MBE= ,5,3,0;'                  Clear output 3 using MB command
EN
```

```
'Galil DMC Code Example
'Setting and printing the time with a TIME protocol server
#set
RO -7;'                    set the timezone offset for Pacific Daylight Time
IHE= >-3;'                 close handle E in case it's open
IHE= 10,0,62,23<37>2;'     querry the TIME server
WT 10;'                    Wait briefly for the transaction to occur
MG _RO1{$8.0};'            display the raw data returned from the server
JS #print;'                call the time print subroutine
EN

#print
MG _RT2{F2.0},":"{N};'     print the current hours
MG _RT1{F2.0},":"{N};'     print the current minutes
MG _RT0{F2.0};'            print the current seconds
EN

'Example output:
'$CF93127A
' 16: 17: 14
```

IH applies to DMC40x0,DMC42x0,DMC41x3,DMC21x3,RIO,DMC30010,DMC50xx0

II *Input Interrupt*



Usage	II n ...	Arguments specified with an implicit, comma-separated order

Description

The II command enables the input interrupt function for the specified inputs.

This function can trigger one of four input interrupt subroutines (#ININTn) when the controller sees that the conditional statement is satisfied. This subroutine will be executed in the specified thread, causing any trippoint set in that thread to be cleared. The cleared trippoint can be re-enabled by the proper termination of the interrupt subroutine using RI.

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
n_0	0	3	N/A	1	Specify the #ININTn routine to use for input interrupt	n_0=0 is #ININT0, n_0=1 is #ININT1, and so on
n_1	-1	3	-1	1	Thread number for #ININTn routine to run	n_1=-1 disables input interrupt
ex	N/A	N/A	N/A	Expression	Inputs to be used for interrupt routine	-IN= input must go low, +IN=input must go high, see Remarks
n_2	0	1	0	1	Sets the condition between multiple inputs	n_2=0 sets condition to AND. n_2=1 sets condition to OR

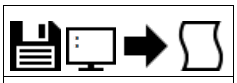
Remarks

- The specified thread, n_1, needs to be running when the interrupt occurs, otherwise the #ININTn subroutine will not be executed.
  - Upon interrupt, the existing thread n_1 will be interrupted to allow the execution of the interrupt subroutine. Upon completion of the interrupt, the main program in thread n_1 will once again be enabled from the point at which the interrupt occurred.
- ex is a statement of all inputs to be used, with polarity defining the input level to trigger the interrupt. All inputs specified must be separated by & characters
  - For example II0,0,1&2&-3 sets the interrupt to trigger when inputs 1 and 2 are logic '1' and input 3 is logic '0'
- If n_2 is omitted or is 0, the input statements must all be true to trigger #ININTn (&). If type is 1, then any true input statment will trigger #ININTn (|)
- The RI command is used to return from the #ININTn routines.
- Note: An application program must be running on the controller for the interrupt function to work.
- To avoid returning to the program on an interrupt, use the command ZS to zero the subroutine stack and use the II command to reset the interrupt.
- Any digital inputs can be used in an II expression with the exception of the RIO 47300 which is limited to inputs 0 to 15

Examples

```
'Galil DMC Code Example
#a;'                    Program A
II 2,0,3&5&-10,1;'      Specify interrupt #2 on main thread when
'                       inputs 3 OR 5 go high, OR 10 goes low
#loop;JP #loop;'        Loop
EN;'                    End Program
#ININT2;'                Interrupt subroutine number 2
MG "INTERRUPT";'        Print Message
AI -1;'                 Wait for input to switch states before continuing.
'                        Otherwise we'll jump back in to #ININT2
RI;'                    Return to main program
II 2,-1;'               Disable interrupt #2
```

IK *Block Ethernet ports*



IK n

Usage	IK n ...	Arguments specified with an implicit, comma-separated order

Description

The IK command blocks client connections to the controller on most ports below port number 1000. Specific port numbers and ports above 1000 are unaffected.

Arguments

Argument	Value	Description	Notes
n	0	Allow controller to receive Ethernet packets on any port	
	1	Blocks Ethernet packets on ports lower than 1000.	Default. Ports 0, 23, 25, 37, 68, 80 and 502 are unaffected.

Remarks

- A Galil Ethernet controller simultaneously operates as a server (listening for Ethernet connections from a client) and a client (able to create connections to a server).
- Ports 0, 23, 68 and 502 are used for standard client connections to the controller.
- Port 37 is used for TIME protocol synchronization. This mechanism has the controller connect as a client to the TIME server.
- Port 25 and 80 are allowed connections for SMTP Mail support and the Web Server Feature.

Examples

```
'Galil DMC Code Example
:IK 1;' Blocks undesirable port communication
:IK 0;' Allows all Ethernet ports to be used
:
```

IK applies to DMC40x0,DMC42x0,DMC41x3,DMC21x3,RIO,DMC30010,DMC50xx0

IL *Integrator Limit*

ILm= n
IL n,n,n,n,n,n,n,n

Usage	ILm= n	Arguments specified with a single axis mask and an assignment (=)
	IL n ...	Arguments specified with an implicit, comma-separated order
Operands	_ILm	Operand holds the value last set by the command

Description

The IL command limits the effect of the integrator gain in the filter to a certain voltage.

For example: IL 2 limits the output of the integrator of the A-channel to the +/-2 Volt range.

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
m	A	B	N/A	Axis	Axis to assign value	RIO-47xx0
	A	F	N/A	Axis	Axis to assign value	RIO-47xx2 and RIO-473xx
n	0	9.998	9.998	20/65,536	Value of Integrator limit in volts	RIO-4712x
	0	5	5	5/4,096	Value of Integrator limit in volts	RIO-4710x

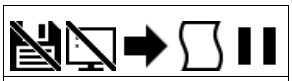
Remarks

- IL is the absolute value of the integrator limit. For example:
  - ILA= 2 limits the output of the integrator of the A-axis to the +/-2 Volt range.
  - KD and KP terms remain active in any case. The output from the KD and KP terms is not affected.
- AF/AZ must be set prior to adjusting IL.
- For further details see the Process Control section in the User's Manual.

Examples

```
'Galil DMC Code Example
AF 0,1;'         Set analog feedback
AZ 0,1;'         Set analog output
IL 3,2;'        Integrator limits
IL ?;'          Returns the first limit
```

IN *Input Variable*



```
IN str,arg
```

Usage	IN n ...	Arguments specified with an implicit, comma-separated order

Description

The IN command allows a variable to be input from a keyboard. When the IN command is executed in a program, the prompt message is displayed. The operator then enters the variable value followed by a carriage return. The entered value is assigned to the specified variable name. The IN command holds up execution of following commands in a program until a carriage return or semicolon is detected. If no value is given prior to a semicolon or carriage return, the previous variable value is kept.

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
str	0 chars	34 chars	N/A	String	The prompt message	See Remarks
arg	N/A	N/A	N/A	N/A	The variable where the response will be placed	

Remarks

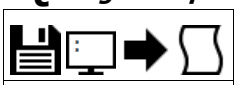
- The IN command may only be used in thread 0
- Do not include a space between the comma at the end of the input message and the variable name
- Entire command must be less than the total maximum line length. This determines the maximum length of str.
- Backlash'\' character will clear the IN command trippoint. The variable will not be overwritten in (will be last set value).
- The IN command can only be used with a serial connection to the controller
- Input Interrupts will still be active during the prompt

Examples

```
'Galil DMC Code Example
'Operator specifies a bit that is to be turned on.
#a
'Prompt operator for bit to set high
IN "Enter bit number to turn on",n1
'
SB n1;'       Set the specified bit high
MG "DONE";'   Print Message
EN;'          End Program
```

IN applies to DMC40x0,DMC42x0,DMC21x3,RIO,DMC18x6,DMC18x2,DMC50xx0

IQ *Digital Input Configuration*



IQ n_0,n_1

Usage	IQ n ...	Arguments specified with an implicit, comma-separated order
Operands	_IQ0 _IQ1	Operand has special meaning, see Remarks

Description

The IQ command sets the bitwise active level for each of the digital inputs. The input for IQ is a bitmask representing the inputs of the controller. When bit n of IQ is 0, then current flowing through the opto of input n returns a 0. When bit n is 1, current flow returns a 1.

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
n_0	0	65,535	0	1	Active level setting for inputs 0-15	RIO-471xx and RIO-472xx
	0	16,777,215	0	1	Active level setting for inputs 0-24	RIO-473xx
n_1	0	16,777,215	0	1	Active level setting for inputs 25-47	RIO-473xx with -24ExIn option

Remarks

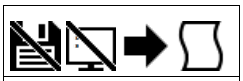
- Setting IQ to the Min value means current flowing through the opto results in logic 0 for all inputs (@IN[n]=0). Current not flowing through the opto results in logic 1 (@IN[n]=1).
- Setting IQ to the Max value means means current not flowing through the opto is logic 0 for all inputs (@IN[n]=0). Current flowing through the opto results in logic 1 (@IN[n]=1).
- Current flowing through the opto can be seen on the RIO when the green LED turns ON.
- IQ is not queriable with a ?
- _IQn contains the current setting for IQ

Examples

```
'Galil DMC Code Example
:IQ 255;'This sets inputs 0-7 such that current flowing results in logic 1
:
:
:
:IQ 192;'Current flowing on inputs 6 and 7 results in logic 1
'current flowing on 0-5 and 8-15 are logic 0
```

IQ applies to RIO

JP *Jump to Program Location*



```
JP #str,(ex)
JP n,(ex)
```

Usage	JP n ...	Arguments specified with an implicit, comma-separated order

Description

The JP command causes a jump to a program location on a specified condition. The program location may be any program line number or label. A jump is taken if the specified condition is true. Multiple conditions can be used in a single jump statement.

JP can be used for relative jumps and for jump tables, see Examples.

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
str	1 char	7 chars	N/A	String	Label name for jump destination	Must be a valid label in application code
n	0	see Notes	N/A	1	Line number for jump destination	Maximum is number of lines of controller program memory - 1
ex	N/A	N/A	N/A	Expression	Conditional statement/s that must evaluate true for jump to occur	If omitted, JP automatically evaluates as true

Remarks

- The logical operators that can be used in the conditional statement are:
  - < less than
  - > greater than
  - = equal to
  - <= less than or equal to
  - >= greater than or equal to
  - <> not equal to
- The conditional statements are combined in pairs using the operands "&" and "|".
  - The "&" operand between any two conditions requires that both statements must be true for the combined statement to be true.
  - The "|" operand between any two conditions requires that only one statement be true for the combined statement to be true.
- Each condition must be placed in parentheses for proper evaluation by the controller.

```
'Galil DMC Code Example
REM Use of parentheses
JP #a,((var0=1)&(var1=2));' valid conditional jump
JP #a,var0=1&var1=2;'       invalid conditional jump
```

Examples

```
'Galil DMC Code Example
JP #pos1,(v1<5);'   Jump to label #POS1 if variable V1 is less than 5
JP #a,((v7*v8)=0);' Jump to #A if V7 times V8 equals 0
JP #b,(@IN[1]=1);'  Jump to #B if input 1 = 1
JP #c;'             Jump to #C unconditionally
```

Jump Table

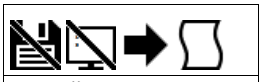
```
'Galil DMC Code Example
REM Example of jumping to a label plus an offset
REM #error is a subroutine that prints an error
REM  message based on the value of an error
REM  variable, ecode
#a
REM Set error code and then JS to sub
ecode = 1
JS #error
ecode = 3
JS #error
ecode = 56;' bad error code
JS #error
EN
'
'****************
'Example of a Jump table
#error
REM First check that ecode is valid
IF (ecode < 0)
 ecode = 4
ENDIF
IF (ecode > 4)
 ecode = 4
ENDIF
REM Call the helper label with an offset
JP #error_h + ecode
```

```
'CRITICAL! Do not change line
' spacing in following text
#error_h;MG "No error, zero";EN
MG "Error code 1, foo";EN
MG "Error code 2, bar";EN
MG "Error code 3, baz";EN
MG "Invalid error code";EN
REM ecode indexes the line to execute
REM  above, relative to #error_h
REM
REM Returned messages:
REM Error code 1, foo
REM Error code 3, baz
REM Invalid error code
```

Relative Jump

```
'Galil DMC Code Example
REM A loop for delaying 1000 samples (~ 1 sec)
REM sample time
MG "Relative jump"
t= TIME
REM print sampled time
MG t
REM loop until TIME increments 1000 samples
REM _XQ0-1 points back to the beginning of the line
JP _XQ0-1,(TIME < (t+1000))
REM print current time
MG TIME
REM This is NOT thread safe as
REM _XQ0 refers to thread 0 only
REM For easier readability and stability, use labels
REM wherever possible
MG "Label-based jump"
t= TIME
MG t
#wait
JP #wait, (TIME < (t+1000))
MG TIME
REM Also, where possible use trippoints
MG "Trippoint"
t= TIME
MG t
WT 1000;' see WT for units
MG TIME
EN

REM Relative jump
REM  3459.0000
REM  4459.0000
REM Label-based jump
REM  4461.0000
REM  5461.0000
REM Trippoint
REM  5463.0000
REM  6464.0000
```

JS *Jump to Subroutine*



```
JS #str, (ex)
JS n, (ex)
```

Usage	JSm= n	Arguments specified with a single axis mask and an assignment (=)
Operands	_JS	Operand has special meaning, see Remarks

Description

Allows the program to jump to a subroutine and return back after completion. This command is often used to call reusable code.

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
str	1 char	7 chars	N/A	String	Label Name for jump destination	Must be a valid label in application code
n	0	see Notes	N/A	1	Line number for jump destination	Maximum is maximum number of lines of program memory
ex	N/A	N/A	N/A	N/A	Conditional statement/s that must evaluate true for jump to occur	If omitted, the jump is taken

Remarks

- JS can be nested, called up to 16 deep

- The JS command will change the sequential order of execution of commands in a program
- If the jump is taken, program execution will continue at the line specified by the destination parameter, which can be either a line number or label. A variable holding a line number or an expression resulting in the calculation of a line number can also be used
- The line number of the calling JS command is saved and after an EN command is encountered (End of subroutine), program execution will continue with the instruction following the calling JS command.
- A jump is taken if the specified condition is true. Each condition must be placed in parenthesis for proper evaluation by the controller.
- Code flexibility/reuse. A single subroutine can be written and called many times and from various locations in code. The stack "remembers" where to return when completed. This is opposite from a "blind jump" (JP).

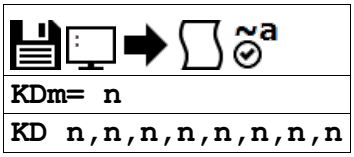
Conditional Syntax

Condition	Validity
JS#A,(var1=0)&(var2=1)	This conditional statement is valid
JS#A,var1=0&var2=1	This conditional statement is not valid

Examples

```
'Galil DMC Code Example
REM Example of pulsing an output
pulse= 0
JS #pulse,(pulse > 0);'JS not taken
WT 2000
pulse= 3
JS #pulse,(pulse > 0);'JS taken
WT 2000
pulse= 5
JS #pulse;'unconditionally take jump
EN
'
'
REM Subroutine called after
REM  setting pulse variable
#pulse
SB 1;' set bit 1
WT 500;' delay 500 ms
CB 1;' clear bit 1
WT 500;' delay 500 ms
pulse= pulse-1;' decrement pulse
JP #pulse,pulse>0;' continue till zero
EN;' return to calling JS
```

KD *Derivative Constant*



KDm= n
KD n,n,n,n,n,n,n,n

Usage	KDm= n	Arguments specified with a single axis mask and an assignment (=)
	KD n ...	Arguments specified with an implicit, comma-separated order
Operands	_KDm	Operand holds the value last set by the command

Description

KD designates the derivative constant in the control filter. The derivative gain outputs a voltage based on the rate of change of the error. The filter transfer function follows:

$$D(z) = KP + KD\frac{z-1}{z} + KI\frac{z}{2(z-1)}$$

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
m	A	F	N/A	Axis	Axis to assign value	RIO-47xx2 and RIO-473xx
	A	B	N/A	Axis	Axis to assign value	RIO-47xx0
n	0	4,095.875	64	1/8	Value of derivative term	

Remarks

- n=? will return the currently set value of KD
- m=* will set the KD value for all axes/channels

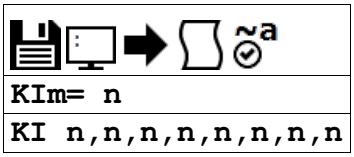
- RIO-47xx2 and RIO-473xx have 6 control loops (KP n,n,n,n,n,n). RIO-47xx0 has 2 control loops (KP n,n)
- For further details see the "Process Control" section in the RIO user manual.

Examples

```
'Galil DMC Code Example
:KD 12,14;' Implicit notation to set channel A and B term
:KDB= 14;'  Explicit notation to set channel B only
:KD ,8;'    Implicit notation to set B
:KD ?,?;'   Return A,B values
 12, 14
:KDB= ?;'   Return B value
 14
:MG _KDA;'  Message the operand for the A channel
 12
:
```

```
'Galil DMC Code Example
REM Zeroing the PID filter allows the
REM motor command signal to be
REM used as a programmable DAC
KI*= 0;'                Zero KI
KP*= 0;'                Zero KP
KD*= 0;'                Zero KD
ER -1,-1;'              Rurn off position error limit
OF 1,2;'                Set one volt on A and two volts on B
EN
```

KI *Integrator*



KIm= n
KI n,n,n,n,n,n,n,n

Usage	KIm= n	Arguments specified with a single axis mask and an assignment (=)
	KI n ...	Arguments specified with an implicit, comma-separated order
Operands	_KIm	Operand holds the value last set by the command

Description

The KI command sets the integral gain of the control loop. The integrator term will reduce the position error at rest to zero. It fits in the control equation as follows:

$$D(z) = KP + KD\frac{z-1}{z} + KI\frac{z}{2(z-1)}$$

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
m	A	F	N/A	Axis	Axis to assign value	RIO-47xx2 and RIO-473xx
	A	B	N/A	Axis	Axis to assign value	RIO-47xx0
n	0	255.999	0	1/1,024	Value of integral term	

Remarks

- n=? will return the currently set value of KD
- m=* will set the KD value for all axes/channels

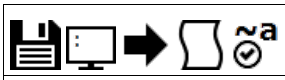
- RIO-47xx2 and RIO-473xx have 6 control loops (KP n,n,n,n,n,n). RIO-47xx0 has 2 control loops (KP n,n)
- For further details see the "Process Control" section in the RIO user manual.

Examples

```
'Galil DMC Code Example
:KIB= 14;'  Explicit notation to set channel B only
:KI ,8;'    Implicit notation to set B
:KI ?,?;'   Return A,B values
 7, 14
:KIB= ?;'   Return B value
 14
:MG _KIA;'  Message the operand for the A channel
 7
:
```

```
'Galil DMC Code Example
REM Zeroing the PID filter allows the
REM motor command signal to be
REM used as a programmable DAC
KI*= 0;'                Zero KI
KP*= 0;'                Zero KP
KD*= 0;'                Zero KD
OF 1,2;'                Set one volt on A and two volts on B
EN
```

KP *Proportional Constant*



```
KPm= n
KP n,n,n,n,n,n,n,n
```

Usage	KPm= n	Arguments specified with a single axis mask and an assignment (=)
	KP n ...	Arguments specified with an implicit, comma-separated order
Operands	_KPm	Operand holds the value last set by the command

Description

KP designates the proportional constant in the controller filter. The proportianal gain outputs a control signal proportional to the amount of error. The filter transfer function follows.

$$D(z) = KP + KD\frac{z-1}{z} + KI\frac{z}{2(z-1)}$$

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
m	A	H	N/A	Axis	Axis to assign value	
n	0	1,023.875	6	1/8	Value of proportional term	

Remarks

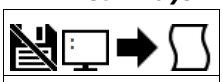
- n=? will return the currently set value of KP
- KP now has four times more resolution as prior controllers, and thus the same value as that of an Optima controller is four times less effective
- RIO-47xx2 and RIO-473xx have 6 control loops (KP n,n,n,n,n,n). RIO-47xx0 has 2 control loops (KP n,n)
- For further details see the "Process Control" section in the RIO user manual.

Examples

```
'Galil DMC Code Example
:KP 12,14;' Implicit notation to set channel A and B term
:KPB= 14;'  Explicit notation to set channel A only
:KP ,8;'    Implicit notation to set B
:KP ?,?;'   Return A,B values
 7, 14
:KPB= ?;'   Return B value
 14
:MG _KPA;'  Message the operand for the A channel
 12
:
```

```
'Galil DMC Code Example
REM Zeroing the PID filter allows the
REM motor command signal to be
REM used as a programmable DAC
KI*= 0;' Zero KI
KP*= 0;' Zero KP
KD*= 0;' Zero KD
OF 1,2;' Set one volt on A and two volts on B
EN
```

LA *List Arrays*



LA

Usage	LA	Command takes no arguments

Description

The LA command returns a list of all arrays in memory. The size of each array will be included next to each array name in square brackets.

Arguments

LA is an interrogation command with no parameters

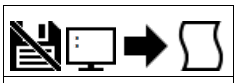
Remarks

- The listing will be in alphabetical order.

Examples

```
'Galil DMC Code Example
:DM gold[100],silver[50],plat[200];'     Dimensions arrays with given name and the number of array elements in square brakets
:LA;'                                    Commands the controller to list arrays in alphabetical order
gold[100]
plat[200]
silver[50]
:DA *[];'                                Dialocates all arrays
:LA;'                                    List arrays now returns with no arrays
:
```

LL *List Labels*



LL

Usage	LL	Command takes no arguments

Description

The LL command returns a listing of all of the program labels in memory.

Arguments

LL is an interrogation command with no arguments

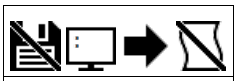
Remarks

- The LL command label listing will be in alphabetical order.
- The LL command returns all of the program labels in memory and their associated line numbers

Examples

```
'Galil DMC Code Example
:LL
#FIVE=5
#FOUR=4
#ONE=1
#THREE=3
#TWO=2
```

LS *List*



LS n_0,n_1

Usage	LS n ...	Arguments specified with an implicit, comma-separated order

Description

The LS command returns a listing of the programs in memory.

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
n_0	0	198	0	1	Specifies the line in the program for which the listing will start	For RIO-47xx0
	0	398	0	1	Specifies the line in the program for which the listing will start	For RIO-47xx2 and RIO-473xx
n_1	1	199	199	1	Specifies the line at which the listing will end	For RIO-47xx0
	1	399	399	1	Specifies the line at which the listing will end	For RIO-47xx2 and RIO-473xx

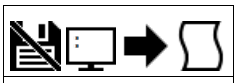
Remarks

- $n_0 < n_1$ must always be true
- If n_0 or n_1 is omitted, default values are used
- n_0 and n_1 can also specify a label, for example:
  - "LS #label,20" would print out program lines from #label to line 20.

Examples

```
'Galil DMC Code Example
:LS #a,6;        'List program starting at #A through line 6
002 #a
003 MG "Program A"
004 COUNT=1
005 SB 2
006 WT 2000
```

LV *List Variables*



LV

Usage	LV	Command takes no arguments

Description

The LV command returns a listing of all of the program variables in memory. The listing will be in alphabetical order.

Arguments

LV is an interrogation command with no parameters

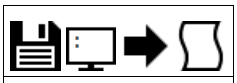
Remarks

- Use the _UL operand for total number of variables available for your controller.
  - See the UL command for more details.

Examples

```
'Galil DMC Code Example
:LV
APPLE = 60.0000
BOY = 25.0000
ZEBRA = 37.0000
:
```

LZ *Omit leading zeros*



LZ n

Usage	LZ n ...	Arguments specified with an implicit, comma-separated order
Operands	_LZ	Operand has special meaning, see Remarks

Description

The LZ command is used for formatting the values returned from interrogation commands, variables, and arrays. By enabling the LZ function, all leading zeros of returned values will be removed.

Arguments

Argument	Value	Description	Notes
n	0	Does not remove leading zeros from interrogated values	
	1	Removes leading zeros from interrogated values	Default

Remarks

- _LZ contains the state of the LZ function. '0' is disabled and '1' is enabled.

Examples

```
'Galil DMC Code Example
:LZ 0;      'Disable the LZ function
:TB;        'Tell status bits
001
:LZ 1;      'Inhibit leading zeros
:TB;        'Tell status
1
```

MA *Email Server IP Address*

MA n_0,n_1,n_2,n_3

Usage	MA n ...	Arguments specified with an implicit, comma-separated order
Operands	_MA	Operand holds the value last set by the command

Description

The MA command sets the SMTP e-mail server IP address.

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
n_0	0	255	0	1	First field of the IP address	
n_1	0	255	0	1	Second field of the IP address	
n_2	0	255	0	1	Third field of the IP address	
n_3	0	255	0	1	Last field of the IP address	

Remarks

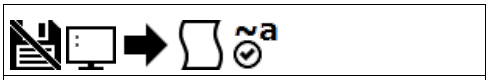
- _MA reports the IP address assigned to MA
- MA ? returns the setting for the MA command in 4 byte notation.

Examples

```
'Galil DMC Code Example
:MA 10,0,62,10;              'Set the SMTP e-mail server IP address to 10.0.62.10
:MA ?;                      'Interrogates the current MA address
 10, 0, 62, 10
:MD "someone@domain.com";  'MD sets the e-mail recipient
:MS "RIO@domain.com";      'Specifies it's from the RIO, or another e-mail address
:MG {M}"Volts",@AN[1];     'E-mails user the message "Volts" following the analog input 1 value
```

MA applies to RIO

MB *Modbus*



MBm= n_0, n_1, n_2, n_3, str[]

Usage	MBm= n	Arguments specified with a single axis mask and an assignment (=)

Description

The MB command is used to communicate with I/O devices using the Modbus TCP/IP protocol. The MB command supports the first two levels of Modbus commands. The function code -1 designates that the first level of Modbus is used (creates raw packets and receives raw data). The other codes are the 10 major function codes of the second level. The format of the command varies depending on each function code.

Galil Modbus supports one master per slave.

Arguments

Level 2 Modbus Function Codes

Function Code, n_1	Modbus Definition	Slaved Galil Description (RIO only)
01	Read Coil Status (Read Bits)	Read Digital Outputs (RIO only)
02	Read Input Status (Read Bits)	Read Digital Inputs (RIO only)
03	Read Holding Registers (Read Words)	Read Analog Inputs (RIO only)
04	Read Input Registers (Read Words)	Read Analog Outputs (RIO only)
05	Force Single Coil (Write One Bit)	Write Digital Output (RIO only)
06	Preset Single Register (Write One Word)	Write Digital Outputs (RIO only)
07	Read Exception Status (Read Error Code)	Read Digital Outputs (RIO only)
15	Force Multiple Coils (Write Multiple Bits)	Write Digital Outputs (RIO only)
16	Preset Multiple Registers (Write Words)	Write Analog Outputs (RIO only)
17	Report Slave ID	

01: MBm= n_0, 1, n_2, n_3, str[]

Read Coil Status (Read Bits)

Argument	Min	Max	Default	Resolution	Description	Notes
m	A	C	N/A	Handle	Handle to send Modbus command	For RIO-47xx0.
	A	E	N/A	Handle	Handle to send Modbus command	For RIO-47xx2 and RIO-473xx
n_0	0	255	see Notes	1	Unit ID	Default to Handle number (A=1, B=2, etc.)
n_2	0	9,999	N/A	1	Address of first coil	
n_3	0	99	N/A	1	Quantity of coils	Or, number of IO points to read
str	1 char	8 chars	N/A	String	Name of array to store values	str[0] holds the first value.

```
'Galil DMC Code Example
MBC= ,1,2,8,example[];'  Read inputs 2-9 from handle C, save to example[]
'equivalent to reading Digital Outputs or registers mapped to 100xxx
```

02: MBm= n_0, 2, n_2, n_3, str[]

Read Input Status (Read Bits)

Argument	Min	Max	Default	Resolution	Description	Notes
m	A	C	N/A	Handle	Handle to send Modbus command	For RIO-47xx0.
	A	E	N/A	Handle	Handle to send Modbus command	For RIO-47xx2 and RIO-473xx
n_0	0	255	1	see Notes	Unit ID	Default to Handle number (A=1, B=2, etc.)
n_2	0	9,999	N/A	1	Address of first input	
n_3	0	99	N/A	1	Quantity of inputs	Or, number of IO points to read
str	1 char	8 chars	N/A	String	Name of array to store values	str[0] holds the first value.

```
'Galil DMC Code Example
MBC= ,2,4,3,example[];'  Read inputs 4,5 and 6 from handle C, save to example[]
'equivalent to reading Digital Inputs or registers mapped to 000xxx
```

03: MBm= n_0, 3, n_2, n_3, str[]

Read Holding Registers (Read Words)

Argument	Min	Max	Default	Resolution	Description	Notes
m	A	C	N/A	Handle	Handle to send Modbus command	For RIO-47xx0
	A	E	N/A	Handle	Handle to send Modbus command	For RIO-47xx2 and RIO-473xx
n_0	0	255	see Notes	1	Unit ID	Default to Handle number (A=1, B=2, etc.)
n_2	0	9,999	N/A	1	Address of first register	

n_3	0	99	N/A	1	Quantity of registers to read	
str	1 char	8 chars	N/A	String	Name of array to store values	str[0] holds the first value. 2 bytes per element. Array must be as large as the value for n_3

```
'Galil DMC Code Example
MBB= ,3,1,4,example[];'  Read registers 1 through 4 from handle B, save to example[]
'equivalent to reading Analog Outputs, or registers mapped to 400xxx
```

04: MBm= n_0, 4, n_2, n_3, str[]

Read Input Registers (Read Words)

Argument	Min	Max	Default	Resolution	Description	Notes
m	A	C	N/A	Handle	Handle to send Modbus command	For RIO-47xx0
	A	E	N/A	Handle	Handle to send Modbus command	For RIO-47xx2 and RIO-473xx
n_0	0	255	see Notes	1	Unit ID	Default to Handle number (A=1, B=2, etc.)
n_2	0	9,999	N/A	1	Address of first register	
n_3	1	99	N/A	1	Quantity of registers to read	
str	1 char	8 chars	N/A	String	Name of array to store values	str[0] holds the first value. 2 bytes per element. Array must be as large as the value for n_3

```
'Galil DMC Code Example
MBB= ,4,1,2,example[];'  Read registers 1 through 2 from handle B, save to example[]
'equivalent to reading Analog Inputs, or registers mapped to 300xxx
```

05: MBm= n_0, 5, n_2, n_3

Force Single Coil (Write One Bit)

Argument	Min	Max	Default	Resolution	Description	Notes
m	A	C	N/A	Handle	Handle to send Modbus command	For RIO-47xx0
	A	E	N/A	Handle	Handle to send Modbus command	For RIO-47xx2 and RIO-473xx
n_0	0	255	see Notes	1	Unit ID	Default to Handle number (A=1, B=2, etc.)
n_2	0	9,999	N/A	1	Address of coil	
n_3	0	1	0	1	Set coil status	0 = turn off coil. 1 = turn on coil

```
'Galil DMC Code Example
MBB= ,5,11,1;'  Set coil 11 high
'equivalent to setting a Digital Output (SB/CB)
```

06: MBm= n_0, 6, n_2, n_3

Preset Single Register (Write One Word)

Argument	Min	Max	Default	Resolution	Description	Notes
m	A	C	N/A	Handle	Handle to send Modbus command	For RIO-47xx0
	A	E	N/A	Handle	Handle to send Modbus command	For RIO-47xx2 and RIO-473xx
n_0	0	255	see Notes	1	Unit ID	Default to Handle number (A=1, B=2, etc.)
n_2	0	9,999	N/A	1	Address of holding register	
n_3	0	65,535	0	1	Set register value	RIO-471xx and RIO-472xx
	0	16,777,215	0	1	Set register value	RIO-473xx

```
'Galil DMC Code Example
MBC= ,6,10,128;'        Write 128 to holding register 10 on handle C
'equivalent to setting digital outputs on the RIO, or setting registers addressed 400xxx
```

07: MBm= n_0, 7, str[]

Read Exception Status (Read Error Code)

Argument	Min	Max	Default	Resolution	Description	Notes
m	A	C	N/A	Handle	Handle to send Modbus command	For RIO-47xx0
	A	E	N/A	Handle	Handle to send Modbus command	For RIO-47xx2 and RIO-473xx
n_0	0	255	see Notes	1	Unit ID	Default to Handle number (A=1, B=2, etc.)
str	1 char	8 chars	N/A	String	Name of array to store value	str[0] holds the received value, one byte only.

- When using function code 7 with a Galil slave, array element zero will be set to the byte value of the combined first 8 digital outputs.
- Only one byte in the array will be populated, element zero of array str[].

```
'Galil DMC Code Example
MBE= ,7,example[];'   Read register and store in example[0]
```

15: MBm= n_0, 15, n_2, n_3, str[]

Force Multiple Coils (Write Multiple Bits)

Argument	Min	Max	Default	Resolution	Description	Notes
m	A	C	N/A	Handle	Handle to send Modbus command	For RIO-47xx0
	A	E	N/A	Handle	Handle to send Modbus command	For RIO-47xx2 and RIO-473xx
n_0	0	255	see Notes	1	Unit ID	Default to Handle number (A=1, B=2, etc.)
n_2	0	9,999	N/A	1	Address of first coil	
n_3	1	16	N/A	1	Quantity of coils	RIO-471xx and RIO-472xx
	1	24	N/A	1	Quantity of coils	RIO-473xx
str	1 char	8 chars	N/A	String	Array to set values for coils	str[0] holds the first value. 16 bits per element

```
'Galil DMC Code Example
example[0]= 255;'
MBC= ,15,0,16,example[];'   Set 1st byte of coils high and 2nd byte of coils low
'equivalent to setting digital outputs on RIO, or setting coils addressed 000xxx
```

16: MBm= n_0, 16, n_2, n_3, str[]

Preset Multiple Registers (Write Words)

Argument	Min	Max	Default	Resolution	Description	Notes
m	A	C	N/A	Handle	Handle to send Modbus command	For RIO-47xx0
	A	E	N/A	Handle	Handle to send Modbus command	For RIO-47xx2 and RIO-473xx
n_0	0	255	see Notes	1	Unit ID	Default to Handle number (A=1, B=2, etc.)
n_2	0	9,999	N/A	1	Address of first register	
n_3	0	99	N/A	1	Quantity of registers	
str	1 char	8 chars	N/A	String	Array containing modbus data	str[0] holds the first value. 2 bytes per element. Array size must be > n_3

```
'Galil DMC Code Example
example[0]= $AEAE
MBD= ,16,2,1,example[];'     Set $AEAE to holding register 2 on handle D
'equivalent to setting analog outputs, or writing to holding registers addressed 400xxx
```

Raw Modbus Packet Send

MBm= n_0,-1,n_2,str[]

Raw Modbus Send

Argument	Min	Max	Default	Resolution	Description	Notes
m	A	C	N/A	Handle	Handle to send Modbus command	For RIO-47xx0
	A	E	N/A	Handle	Handle to send Modbus command	For RIO-47xx2 and RIO-473xx
n_0	0	255	1	see Notes	Unit ID	Default to Handle number (A=1, B=2, etc.)
n_2	0	999	N/A	1	Number of array bytes to send	
str	1 char	8 chars	N/A	String	Name of array containing outgoing data	Array size >= n_2. See Remarks

Raw Modbus Packet Send/Receive

MBm= n_0,-1,n_2,str0[],n_3,n_4,str1[]

MB applies to DMC40x0,DMC42x0,DMC41x3,DMC21x3,RIO,DMC30010,DMC50xx0

MD *Email Destination Address*

MD str

Usage	MD n ...	Arguments specified with an implicit, comma-separated order

Description

The MD command sets the e-mail destination address.

Arguments

Argument	Value	Description	Notes
str	String	E-mail address destination	Maximum 30 characters

Remarks

- None

Examples

```
'Galil DMC Code Example
MA 10,10,10,1;                'SMTP server address
MD "example@domain.com";      'Destination address of email is 'example@test.com'
MS "RIO@domain.com";          'Sender e-mail address
MG {M}"Variable status",var;  'Sends the status of variable var to example@domain.com
```

MD applies to RIO

ME *Modbus array write enable*

ME n

Usage	ME n ...	Arguments specified with an implicit, comma-separated order

Description

The ME command enables the ability for Modbus masters to write to array locations in the hardware's array table. When enabled, array locations can be written to as 16 bit integers or as 32 bit floating point by a modbus master by specifying different address ranges. ME is not required to read array locations, reads are always supported.

Arguments

Argument	Value	Description	Notes
n	0	Disables the ability for Modbus masters to write to the array table	Default
	1	Enables ability for Modbus masters to write to the array table	

Remarks

- The function code used to read arrays can be modified by MV. Galil recommends MV-1 when using array read/write functionality. This makes function code 3 the default read command.
- Array writes when enabled by ME are done using function code 16
- Galil Modbus supports one master per slave.
- A useful utility for determining the 32 bit floating point value for a given fractional number can be found here: http://babbage.cs.qc.cuny.edu/IEEE-754/index.xhtml

Modbus Register Map

- Each element is accessible as a 16 bit unsigned integer (Modbus registers 1xxx) -OR- as a 32 bit floating point number (Modbus registers 2xxx).
- The table below shows the mapping for a Modbus master writing to the controller with ME 1 set.
- 1000 elements are available in the RIO-471x2/47300 array table and 400 in the RIO-471x0/47200.

Modbus Register Map to Galil Array A[]

Modbus Registers:	1000-1xxx	2000-2xxx
Register range for RIO-47xx2 and RIO-47300	1000-1999 (xxx=999)	2000-2999 (xxx=999)
Register range for RIO-471x0 and 47200	1000-1399 (xxx=399)	2000-2399 (xxx=399)
Available Modbus function codes	3 (read) and 16 (write)	3 (read) and 16 (write)
Number Type	16 bit unsigned integer	32 bit floating point
References in A[] array (RIO-47xx2 and RIO-47300)	A[0]-A[999]	A[0]-A[999]
References in A[] array (RIO-471x0 RIO-47200)	A[0]-A[399]	A[0]-A[399]
Number written to A[]	Integer only, fraction not changed	Galil 4.2 format (internal from float conversion)
Number read from A[]	Integer only, fraction not read	32 bit float (internal to float conversion)
Example Modbus Master Write	MBH=0,16,1000,1,write[]	MBH=0,16,2001,2,write[]
Example Modbus Master Read	MBH=0,3,1000,1,read[]	MBH=0,3,2001,2,read[]

Embedded Array Mapping

- Once enabled, the entire array table can be written remotely. These writes can span across dimensioned user arrays. It is the user's responsibility to partition the array table and to read/write remotely to the correct location.
- When using multiple array names, the array table is partitioned alphabetically.
  - For example, a partioned array of Grape[600] and Orange[200] would place the first 600 registers in Grape[], and the next 200 registers in Orange[]. The last 200 elements would be inaccesible from embedded code. If the user then dimensioned the array Apple[200], the register mapping would change. The first 200 registers would read/write from Apple[], the next 600 from Grape[], and finally the last 200 from Orange[].
- For simplicity, Galil recommends that a single, contiguous array be dimensioned with the array name "A".

Examples

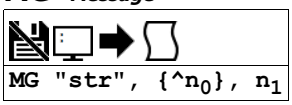
```
'Galil DMC Code Example
:DA *[];'       Deallocates all arrays
:DM a[400];'    Allocates array for Modbus Read/Write
:ME 0;'          Disables write access
:ME 1;'          Enables write access
:ME ?;'          Interrogate current value
 1
:
```

```
'Galil DMC Code Example
'This example is written for a Galil modbus master to an RIO-471x2 or DMC-30010
'Master is E.G. DMC-21x3, RIO, DMC-40x0
'This code runs on the master.
'Assumes a Modbus handle is available at H,
' and that ME1 has been set on the remote device

MW 1;'                              Turn on modbus wait
```

```
DM write[2];'                          Dimension an array for holding data to transmit

write[0]= 1234;'                        Assign an integer to element 0
MBH= 0,16,1000,1,write[];'              Send the integer to register 1000 on the remote

write[0]= $42F6;'                       Set the 32 bit float in two steps, the value is 123.456
write[1]= $E978
MBH= 0,16,2001,2,write[];'              Send the float to register 2001 on the remote
'note that register 2000 would have stepped on the integer memory written at 1000

DM read[2];'                           Dimension an array for holding read data

MBH= 0,3,1000,1,read[];'                Read the integer at register 1000
MG "Integer=",read[0];'                Print the read integer

MBH= 0,3,2001,2,read[];'                Read the float at register 1000
float= (read[0]*$10000) + read[1];'     Construct the float. Shifting necesary for high bytes
MG "Float=", float{$8.0};'             Print the float in hex
```

ME applies to DMC30010,RIO

MG *Message*



Usage	MG n ...	Arguments specified with an implicit, comma-separated order

Description

The MG command is used to send strings, operands, variables, and array values to a specified destination.

Arguments

Argument	Value	Description	Notes
str	String	A string including alphanumeric characters to be displayed	Limited to 76 characters
n_0	ASCII character in decimal	Allows users to print ASCII characters	Range of 0-255
n_1	Numeric value	Prints the numeric value specified	See Examples for valid uses of n_1.
	Variable name	Prints the numeric value stored by the variable	
	Operand	Prints the numeric value stored by the operand	
	Array element	Prints the numeric value stored by the array element	
	Mathematical expression	Prints the numeric value of the solved equation	

Remarks

- Multiple strings, variables, and ASCII characters may be used; each must be separated by a comma.
- Solicited Messages
  - From a host terminal, application code, or device, sending the MG command will return with the requested information. This is known as a solicited command, because the host sends the command and expects a response.
- Unsolicited Messages
  - From embedded DMC code, the MG command will send an unsolicited, asynchronous message from the controller to the host. This can be used to alert an operator, send instructions, or return a variable value. This is known as an unsolicited command because the host is not explicitly requesting it.
  - The CW command controls the ASCII format of all unsolicited messages.
  - Unsolicited messages can go to any of the Ethernet handles or serial ports.
  - The CF command sets the default communication port for routing unsolicited messages.

Formatting

- Formatters can be placed after each argument in to modify how it is printed.
  - {Fm.n} Display variable in decimal format with m digits to left of decimal and n to the right.
  - {Zm.n} Same as {Fm.n} but suppresses leading zeros.
  - {$m.n} Display variable in hexadecimal format with m digits to left of decimal and n to the right.
  - {Sn} Display variable as a string of length n, where n is 1 through 6. If n is greater than the length of the string stored in the variable, null chars (0x00) will be inserted at the end of the string.
  - {N} Suppress carriage return at the end of the message.

Message Routing

MG can override the default CF setting by using the following modifiers at the beginning of the message, right after MG.

- {Pn} Sends the message out the Serial port n, where n is 1 or 2 denoting Main or Auxilary (where equipped).
- {Ex} Sends the message out the Ethernet handle x, where x is A,B,C,D,E or F (RIO-47xx2 and RIO-473xx)
- {Ex} Sends the message out the Ethernet handle x, where x is A,B, or C (RIO-47xx1)
- {M} Sends message to the e-mail specified by the MD command.
- See the MD, MS, and MA command for more information.

Examples

Valid uses of n_1 argument

```
'Galil DMC Code Example
:'Values
:MG 1234.5678
 1234.5678
:'
:'Variables
:var= 12345678.9101
:MG var
 12345678.9101
:'
:'Operands
:MG @AN[1]
 0.0121
:'
:'Array Elements
:DM arr[3]
:arr[0]= 0
:arr[1]= 1
:arr[2]= 2
:MG arr[0],arr[1],arr[2]
 0.0000 1.0000 2.0000
:'
:'Mathematical Expressions
:MG 1+2
 3.0000
:MG arr[2]+var
 12345680.9101
:
```

General Use

```
'Galil DMC Code Example
:MG "Good Morning";                  'Message command displays ASCII string
Good Morning
:total= 1234.5322;                   'Assigns variable total with the value 1234.5322
:MG "The answer is...",total{F4.2};  'Will print the message and the value of variable total formatted with 4 integer digits and 2 fractional digits
The answer is... 1234.53
:MG {^13}, {^10}, {^48}, {^055};     'Specifies carriage return, line feed, and the characters 0 and 7 in ASCII decimal values

07
:MG TIME;                            'Messages the operand TIME
 261928200.0000
:variable= 10;                       'Sets the variable equal to 10
```

```
:MG variable+5;                    'Messages out variable + 5
 15.0000
:MG _TI0;                          'Messages the value stored in the operand _TI0
 255.0000
```

```
'Galil DMC Code Example
CF A;          'Messages configured to go out Ethernet handle A
MG {EB}var;    'Override CF and send the value of variable var to B handle
```

MH *Modbus Heartbeat*

MH n

Usage	MH n ...	Arguments specified with an implicit, comma-separated order
Operands	_MH	Operand holds the value last set by the command

Description

The MH command is used to setup the modbus timeout feature of the RIO when configured as a Modbus TCP slave.

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
n	0	32,767	0	1	The time in milliseconds for a modbus command to be received before #MODERR is called.	0 disables the timeout feature

Remarks

- _MH contains the current value of MH
- Any commands received over the modbus port (port 502) will reset the time for a timeout to occur.
- Changing the value of the MH command resets the timer to 0 to generate a modbus timeout.

Examples

```
'Galil DMC Code Example
#AUTO;          'Auto Start
MH 100;         'Set timeout at 100msec
#loop;'         'Main loop
JP #loop;'      'Repeat loop
EN
'
#MODERR;        'Modbus Timeout Automatic subroutine occurred
IHA = >-2;      'Close ethernet handle A
RE;            'Return from subroutine
```

MH applies to RIO

MI *Modbus Integer*

MI n

Usage	MI n ...	Arguments specified with an implicit, comma-separated order

Description

The MI command configures how a RIO slave will respond to Analog I/O requests. MI specifies whether the RIO will respond to analog Modbus requests in 32-Bit Floating Point notation or as a 16-Bit Integer.

Arguments

Argument	Value	Description	Notes
n	0	Analog I/O responses will be in 32-bit floating point notation	Default. Units in Volts [V]
	1	Analog I/O responses will return as 16-bit bit integer	Units in counts.

Remarks

- n= ? returns the state of the MI command, either a 0 or 1
- This command is of paricular use for software packages that require data to be in integer format.
- The MI command affects the way the RIO responds to function codes 3, 4 and 16.
- When MI is set to 1 the range of the 16-bit integer depends on the AQ and DQ setting.

Examples

```
'Galil DMC Code Example
MI 1;' Set slave to respond to Analog I/O related Modbus requests in counts
```

```
'Galil DMC Code Example
'From RIO (modbus slave)
:MI 0;'     Output analog IO data as 32bit float
:DQ 1,2;'   Set AO1 to 0-10V
:AO 1,9.9;' Set AO1 to 9.9V
:MG @AO[1];'Output analog output 1
 9.9001

'From controller (modbus master)
:IHF= 192,168,1,2<502;'  RIO IP, modbus port 502
:DM read[10];'          Setup array to read modbus data
:MBF= ,4,2,2,read[];'    Read analog out 1 (2 regs x 16 bits= 32 bit float)
:float= read[0]*$8000;'  Construct float, shift high byte
:float= float+float+read[1]
:MG @REAL[float];'       Convert float and read
 9.9001      Correct analog out for 32 bit float

'From RIO
:MI 1;'      Output analog IO data as 16 bit integer

'From controller
:MBF= ,4,1,1,read[];'    Read analog out 1 (1 reg x 16bits = 16 bit int)
:MG read[0]
 64880       Correct for 9.9V read as 16 bit int (0-10V range)
```

MI applies to RIO

MS *Email Source Address*

MS str

Usage	MS n ...	Arguments specified with an implicit, comma-separated order

Description

The MS command sets the e-mail source address.

Arguments

Argument	Value	Description	Notes
str	String	Source e-mail address	Does not need to be a valid e-mail address. Maximum 30 characters.

Remarks

- None

Examples

```
'Galil DMC Code Example
MA 10,0,0,1;                    'Example STMP e-mail server IP
MD "someone@example.com";         'Destination e-mail address
MS "rio@example.com";             'RIO e-mail address
MG {M}"Testing Email";          'Message to send via Email
EN
```

MS applies to RIO

MV *Modbus Reversal*

MV n

Usage	MV n ...	Arguments specified with an implicit, comma-separated order

Description

Enabling the MV command causes the firmware to change the way it responds to function codes 3 and 4. Some modbus software packages may require function codes 3 and 4 to be switched.

Arguments

n	Analog Inputs	Analog Outputs	Array Read Access (See ME)	Notes
0	Function Code 3	Function Code 4	Function Code 3	Default
1	Function Code 4	Function Code 3	Function Code 4	
-1	Function Code 4	Function Code 3	Function Code 3	

Remarks

- Use of the Galil commands @AN[], @AO[] require MV to be set to 0.

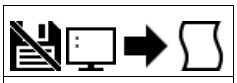
Examples

```
'Galil DMC Code Example
MV 1;      'Swap function code 3 and 4 from defaults, e.g. for Array Reads
```

```
'Galil DMC Code Example
'From RIO  (modbus slave)
:MV 0;'  Set analog outs read by FC4,analog ins read by FC3
:AO 0,1.2;'  Set AO[0] to 1.2V
:MG @AN[0];' Read AN[0] as 2.5V
 2.5891

'From controller (modbus master)
:DM read[10];'          Setup read array for MB command
:IHF= 192,168,1,2<502;'  RIO IP
:MBF= ,3,0,2,read[];'    Get analog ins
:float= read[0]*$8000
:float= float+float+read[1];'    Reconstruct 32bit float from 2 words in read array
:MG @REAL[float];'       Convert float to 4.2 and report value
 2.5891    Confirm analog input is read

'From RIO
:MV 1;'  Set analog outs read by FC3, analog ins read by FC4

'From controller
:MBF= ,3,0,2,read[];'        Same FC gets analog outs now due to MV1
:float= read[0]*$8000
:float= float+float+read[1];' Reconstruct 32bit float
:MG @REAL[float];'       Convert float to 4.2 and report value
 1.2001    Confirm analog out is read
```

MV applies to DMC30010,RIO

MW *Modbus Wait*



MW n

Usage	MW n ...	Arguments specified with an implicit, comma-separated order
Operands	_MW0 _MW1	Operand has special meaning, see Remarks

Description

Enabling the MW command causes the controller to hold up execution of the program after sending a Modbus command until a response from the Modbus device has been received. The MW command ensures that the command that was sent to the Modbus device was successfully received before continuing program execution.

Arguments

Argument	Value	Description	Notes
n	0	Disables Modbus wait	
	1	Enables Modbus wait	Default

Remarks

- n = ? returns the state of the Modbus wait, either 1 or 0
- If a Modbus response is never received, then thread 0 would jump to the #TCPERR subroutine if it exists and an error code of 123 will occur on _TC.
- MW prevents the controller from sending multiple commands to the same Modbus device before it has a chance to execute them.
- Operands
  - _MW0 returns last function code received
  - _MW1 returns Modbus error code

_MWn operands

```
'Galil DMC Code Example
:MG _MW0{$8.0};' $ is the hex formatter
$00000001
:'above is an expected response to function code 1
:MG _MW1{$8.0}
$00000000
:'no error
```

_MW0 Responses

Function Code Sent	Normal _MW0 Response	_MW0 Exception Response
1	$01	$81
2	$02	$82
3	$03	$83
4	$04	$84
5	$05	$85
6	$06	$86
7	$07	$87
15	$0F	$8F
16	$10	$90

_MW1 Responses

_MW1 returns	Exception description
$00	Normal response
$01	The request referenced an illegal function code
$02	The request referenced an illegal data address

Examples

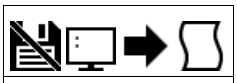
```
'Galil DMC Code Example
MW 1;       'Enables Modbus Wait
SB 1001;    'Set Bit 1 on Modbus Handle A
CB 1001;    'Clear Bit 1 on Modbus Handle A
```

```
'Galil DMC Code Example
REM Example on Modbus master, DMC-40x0
REM Using _MW operands
:IHH= 192,168,42,43<502>2;' connect to RIO
:MW 1
:SB 8001;' set bit one on RIO
::MBH= ,5,1,0;' clear it with MB
::'CB 8001 would also work
:MG _MW0
 5.0000
:'funct code 5 confirmed
:MG _MW1
```

```
 0.0000
:'no errors
:MBH=  ,5,100,1;' invalid output point
::TC 1
 0
:MG _MW0{$8.0}
$00000085
:'Exception on funct code 5
:MG _MW1{$8.0}
$00000002
:'illegal data address
```

MW applies to DMC40x0,DMC42x0,DMC41x3,DMC21x3,RIO,DMC30010,DMC50xx0

NO *No Operation*



```
NO str
```

Operands	_NO	Operand has special meaning, see Remarks

Description

The NO command performs no action in a sequence and can be used as a comment in a program.

Arguments

Argument	Value	Description	Notes
str	String	A no action sequence used to document a program	Comments are limited to the maximum row size in a program. This will vary by controller.

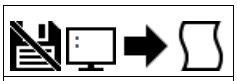
Remarks

- _NO returns a bit mask indicating which threads are running.
  - For example:
    - 0 means no threads are running
    - 1 means only thread 0 is running
    - 3 means threads 0 and 1 are running

Examples

```
'Galil DMC Code Example
#a;                    'Program A
NO;                    'No Operation
NO This Program;       'No Operation
NO This Program ;      'No Operation
NO Does Absolutely;    'No Operation
NO Nothing;            'No Operation
EN;                    'End of Program
```

OB *Output Bit*



OB n,ex

Usage	OB n ...	Arguments specified with an implicit, comma-separated order

Description

The OB command allows variable control of an output bit based on logical expressions. The OB n, logical expression command defines output bit i as either 0 or 1 depending on the result from the logical expression.

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
n	0	15	0	1	Output bit specified	RIO-41xxx and RIO-42xxx
	0	23	0	1	Output bit specified	RIO-473xx
	24	47	0	1	Output bit specified	RIO-473xx with -24ExOut option
n	1,000	3,999	N/A	1	Modbus output bit specified	For RIO-47xx0. See Remarks
	1,000	5,999	N/A	1	Modbus output bit specified	For RIO-47xx2 and RIO-473xx. See Remarks
ex	N/A	N/A	N/A	Expression	Expression that defines status of output	If ex is true/non-zero, set output to 1. If ex is false/zero, set output to 0

Remarks

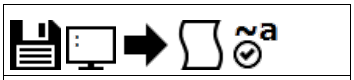
- An expression is any valid logical expression, variable or array element.
- Any non-zero value of the expression results in a one set to the output bit.

- n_0 = (SlaveAddress*10000) + (HandleNum*1000) + ((Module-1)*4) + (Bitnum-1)
  - Slave Address is used when the ModBus device has slave devices connected to it and specified as Addresses 0 to 255. Please note that the use of slave devices for modbus are very rare and this number will usually be 0.
  - HandleNum is the handle specifier where A is 1, B is 2 and so on.
  - Module is the position of the module in the rack from 1 to 16.
  - BitNum is the I/O point in the module from 1 to 4

Examples

```
'Galil DMC Code Example
OB 1, pos;'           If pos<>0, Bit 1 is high.
'                     If pos=0, Bit 1 is low
OB 2, @IN[1]&@IN[2];' If Input 1 and Input 2 are both high, then
'                     Output 2 is set high
OB 3, count[1];' If the element 1 in the array is zero, clear bit 3
OB n, count[1];' If element 1 in the array is zero, clear bit n
```

OF *Offset*



OFm= n
OF n,n,n,n,n,n,n,n

Usage	OFm= n	Arguments specified with a single axis mask and an assignment (=)
	OF n ...	Arguments specified with an implicit, comma-separated order
Operands	_OFm	Operand holds the value last set by the command

Description

The OF command sets a bias voltage in the command output or returns a previously set value.

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
m	A	F	N/A	Axis	Channel to assign value	Valid for RIO-47xx2 and RIO-473xx
	A	B	N/A	Axis	Channel to assign value	Valid for RIO-47xx0
n	-2.5	2.5	0	5/65,536	Offset voltage applied to control output	Valid for RIO-4710x
	-9.9982	9.9982	0	20/65,536	Offset voltage applied to control output	Valid for RIO-4712x. Range determined by DQ command.

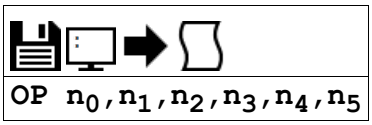
Remarks

- AF/AZ must be set prior to changing OF.
- For more information see the "Process Loop" section of the User Manual.

Examples

```
'Galil DMC Code Example
:AF 0,1
:AZ 0,1
:OF -2;'   Set control channel A to -2  Leave other channel unchanged
:OF ,0;'   Set control channel B to 0  Leave other channel unchanged
:OF ?,?;'  Return offsets
-2.0000,0.0000
:OF ?;'    Return A offset
-2.0000
:OF ,?;'   Return B offset
0.0000
```

OP *Output Port*



OP n_0,n_1,n_2,n_3,n_4,n_5

Usage	OP n ...	Arguments specified with an implicit, comma-separated order
Operands	_OP0 _OP1 _OP2 _OP3 _OP4 _OP5	Operand holds the value last set by the command

Description

The OP command sets the output ports of the controller in a bank using bitmasks. Arguments to the OP command are bit patterns (decimal or hex) to set entire banks (bytes) of digital outputs. Use SB, CB or OB to set bits individually.

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
n_0	0	255	0	1	Decimal representation: Outputs 0-7	
n_1	0	255	0	1	Decimal representation: Outputs 8-15	
n_2	0	255	0	1	Decimal representation: Outputs 16-23	RIO-473xx
n_3	0	255	0	1	Decimal representation: Outputs 24-31	RIO-473xx with -24ExOut option
n_4	0	255	0	1	Decimal representation: Outputs 32-39	RIO-473xx with -24ExOut option
n_5	0	255	0	1	Decimal representation: Outputs 40-47	RIO-473xx with -24ExOut option

Remarks

- Bit patterns for extended I/O banks (where available) configured as inputs have no affect on the IO status.

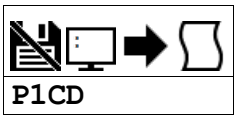
Output Mapping Examples

Examples	Command issued (Hex version)	Bits Set	Bits Cleared
Set bank high	OP255 (OP$FF)	0-7	-
Set bank low	OP0 (OP$00)	-	0-7

Examples

```
'Galil DMC Code Example
OP 0;'   Clear Output Port -- all bits
OP $85;' Set outputs 1,3,8 and clear the others
MG _OP0;' Returns the parameter "n0"
```

P1CD *Serial port 1 code*



Usage	variable= P1CD	Holds a value
Operands	P1CD	Operand has special meaning, see Remarks

Description

P1CD returns the status of the serial port when in the operator data entry mode (CI,1). The value of P1CD returns zero after the corresponding string or number is read.

Arguments

P1CD is an operand that holds a value cooresponding to status. See Examples for use in code.

Remarks

- PICD contains the following status codes

P1CD Status Codes

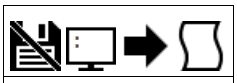
Status Code	Meaning
-1	Mode disabled
0	Nothing received
1	Received character, but not carriage return
2	received a string, not a number
3	received a number

Examples

```
'Galil DMC Code Example
CI 1,1;'            Interrupt on main serial port
#wait
WT 100000
JP #wait;'          dummy loop
'
'
#COMINT;'           Interrupt runs on carriage return
IF (P1CD = 2);'    If string received
 MG P1ST{S6}{EA};'  Message the string out the Ethernet port
ENDIF
IF (P1CD = 3);'    If number received
 OP P1NM;'         Set outputs based on received number
ENDIF
EN
```

P1CD applies to DMC21x3,RIO,DMC30010

P1CH *Serial port 1 character*



P1CH

Usage	variable= P1CH	Holds a value
Operands	P1CH	Operand has special meaning, see Remarks

Description

P1CH returns the last character sent to the serial port when in the operator data entry mode (CI,1).

Arguments

P1CD is an operand that holds a value cooresponding to ASCII characters sent over the serial port. See Examples for use in code.

Remarks

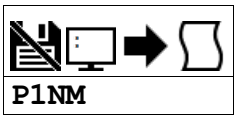
- None

Examples

```
'Galil DMC Code Example
:^R^S
:CI ,1
:MG "TEST" {P1} ;'send a message to the hand terminal
:MG P1CH {S1} ;'the 6 button was pushed on the hand terminal
6
:
```

P1CH applies to DMC21x3,RIO,DMC30010

P1NM *Serial port 1 number*



Usage	variable= P1NM	Holds a value
Operands	P1NM	Operand has special meaning, see Remarks

Description

P1NM returns the last number (followed by carriage return) sent to the serial port when in the operator data entry mode (CI,1).

Arguments

P1NM is an operand that holds a numerical value sent over the serial port. See Examples for use in code.

Remarks

- Converts from ASCII (e.g. "1234") to binary so that a number can be stored into a variable and math can be performed on it.
  - Numbers from -2147483648 to 2147483647 can be processed.

Examples

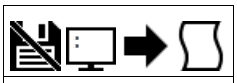
Simple example with Ethernet and Serial port on PC

1. Connect to the controller via Ethernet in Galil software
2. Download and run the following code
3. Now connect via Hyperterm or other terminal software to the RS232 port. "X" will print every second. This string can be changed to whatever command string is required for the third party device. Now type a number and enter.
4. The "Number Received" message will print on the Ethernet connection

```
'Galil DMC Code Example
CI 1,1;' Interrupt on CR
CW 2;' don't set MSB
#loop
'Send a character to the port
MG {P1} "X"
WT 1000
JP #loop
#COMINT
MG "Number Received:",P1NM
EN ,1
```

P1NM applies to DMC21x3,RIO,DMC30010

P1ST *Serial port 1 string*



P1ST

Usage	variable= P1ST	Holds a value
Operands	P1ST	Operand has special meaning, see Remarks

Description

P1ST returns the last string (followed by carriage return) sent to the serial port when in the operator data entry mode (CI,1).

Arguments

P1ST is an operand that contains a string. See Examples for usage.

Remarks

- No more than 6 characters can be accessed.
- Strings must be messages out using the {Sx} operator in the MG command. Otherwise the string will be reported as its ASCII numerical value.

Examples

```
'Galil DMC Code Example
:CI ,1
:MG "TEST" {P1} ;'send a message to the hand terminal
:MG P1ST {S3} ;'the characters ABC were entered
ABC
```

P1ST applies to DMC21x3,RIO,DMC30010

PC *Pulse Counter Enable*

PC n

Usage	PC n ...	Arguments specified with an implicit, comma-separated order
Operands	_PC	Operand has special meaning, see Remarks

Description

The PC command enables the use of a pulse counter input on the RIO controller. When turned on, input DI3 will not be available as a general purpose input accessible with IF or @IN[ ] and will be reconfigured as a pulse counter.

Arguments

Argument	Value	Description	Notes
n	0	IN3 set as a general purpose input	Default
	1	IN3 set as a rising edge pulse counter	PC 1 also clears current pulse count
	-1	IN3 set as a falling edge pulse counter	PC -1 also clears current pulse count

Remarks

- Digital Input 2 with HS Option: When the -HS (high speed counter) option is ordered with the RIO, IN2 will be the differential input for the counter input. IN2 will not be available as a general purpose input.
- Expanded Memory RIO: When using the expanded memory RIO (RIO-47102, RIO-47122, RIO-47202) IN3 cannot be used as the Pulse Counter Input unless the -HS option is ordered.
- Maximum frequencies:
  - Without -HS option - 300Hz (50% duty cycle)
  - With -HS option - 3MHz (50% duty cycle)
- See the -HS section in the RIO-47xxx User Manual for more information.

Operand Usage

- _PC contains the number of pulses counted. _PC will return an integer in the range of 2147483647 to -2147483648

Examples

```
'Galil DMC Code Example
:PC 1
:MG _PC
 214
:MG _PC
 515
:t= _PC
:MG t
 718
```

PC applies to RIO

PM *PWM output enable*

PM n,n

Usage	PM n ...	Arguments specified with an implicit, comma-separated order
Operands	_PM0 _PM1	Operand holds the value last set by the command

Description

PM enables the PWM output feature for the RIO. The PWM frequency is configurable up to 20Khz and the duty cycle from 0 to 100%. The PWM output can also be used as the control signal for process cotrol loops.

Arguments

Argument	Value	Description	Notes
n	3	Inverter Mode	PWM used as control signal in process control loop 0 or 1
	2	Chopper Mode	PWM used as control signal in process control loop 0 or 1
	1	Generic PWM	High polarity with DY 100 (100% duty cycle) is the same as the "CB" state with PM0
	0	Default Value, PWM Off	PWM output disabled for corresponding output
	-1	Generic PWM, inverted duty cycle	Low polarity with DY 100 (100% duty cycle) is the same as the "SB" state with PM0
	-2	Chopper Mode, inverted sign bit	PWM used as control signal in process control loop 0 or 1
	-3	Inverter Mode, inverted duty cycle	PWM used as control signal in process control loop 0 or 1

Remarks

- First and second arguments apply to PWM signal on output 14 and 15, respectively
- When used in the process control loop, the first argument applies to process loop A, and the second to B
- The -PWM option is necessary for full resolution of the frequency. See the RIO user manual for more information.
- Inverter vs. Chopper
  - Inverter: 50% duty cycle for zero command signal. 0% for full negative signal, 100% for full possitive signal.
  - Chopper: 0% duty cycle for zero command signal. 100% for full signal. Negative/positive bit on outputs 12 and 13 for control signals 14 and 15, respectively.

Steps to use the PWM as a control signal for the PID process loop

1. Set PWM Frequency (FQ)
2. Turn on the PWM mode (PM)
3. Define analog feedback channels
4. Set up analog input configuration as necesary (AQ)
5. Set PIDs (KP,KD,KI)
6. Turn on control loop (CL)
7. Set the procees loop setpoint (PS)

Examples

```
'Galil DMC Code Example
:FQ 100,200;'   Set output 14 to 100 Hz, and output 15 to 200 Hz
:DY 50,25;'     Set output 14 to 50%, output 15 to 25%
:PM 1,1;'       Turn PWM mode on for outputs 14 and 15
:
```

```
'Galil DMC Code Example
REM Using the PWM as a control signal for the PID process loop
FQ 100,100;'  Set PWM Freq
PM 3,3;'      Turn on Inverter
AF 0,1;'      Analog 0 map to process loop B
AQ 0,2;'      Set +/- 10v on analog input 1
AQ 1,2;'         (RIO-47x2x only)
KD 10,10;'    Set PID
KP 4,4
KI 0.5,0.5
CL 1,1;'      1000 Hz sample loop
PS 0,0;'      Zero Setpoint
EN
```

PM applies to RIO

PS *Control Setpoint*

PSm= n
PS n,n,n,n,n,n

Usage	PSm= n	Arguments specified with a single axis mask and an assignment (=)
	PS n ...	Arguments specified with an implicit, comma-separated order
Operands	_PSm	Operand holds the value last set by the command

Description

The PS command set the voltage setpoint for the process loop. The command is used in a process control loop to specify the analog value that will be used as the target voltage for the analog input.

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
m	A	F	N/A	Axis	Channel to assign value	Valid for RIO-47xx2 and RIO-473xx
	A	B	N/A	Axis	Channel to assign value	Valid for RIO-47xx0
n	-10	10	-5	0.0001	Voltage setpoint for process loop	Valid for RIO-47x2x. Range determined by AQ command.
	0	5	0	0.0001	Voltage setpoint for process loop	Valid for RIO-47x0x

Remarks

- The AF and AZ commands must be set before the use of PS.
- The range and resolution for the setpoint is dependant on the RIO hardware configuration. See the AQ command for the Analog Input range.

Examples

```
'Galil DMC Code Example
PSA= 2.2;' set A process loop setpoint to 2.2V
PS ,1.2;' set B process loop setpoint to 1.2V
```

```
'Galil DMC Code Example
'enable process loop example
CL 25; '25msec update rate
AF 0; 'analog input 0 as feedback
AZ 0; 'analog output 0 as control
KP 1; 'proportional gain to 1
KD 10; 'derivative gain to 10
KI 0.5; 'integral gain to 0.5
DB 0.1; 'deadband of 0.1V
PS 1.8; 'set-point at 1.8V
```

PS applies to RIO

PW *Password*

PW str,str
PW n,n

Usage	PW n ...	Arguments specified with an implicit, comma-separated order

Description

The PW command sets the password used to lock the controller. Locking the controller prevents interrogation of the controller program space.

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
str	0 chars	8 chars	""	String	String to be used for password	Both parameters must match for the PW command to succeed

Remarks

- The password can only be changed when the controller is in the unlocked state. See the ^L^K for more details.
- The password is burnable but cannot be interrogated. If you forget the password and the controller is locked you must master reset the controller to gain access.

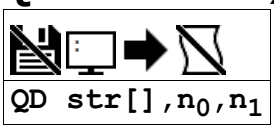
Examples

```
'Galil DMC Code Example
:PW apple,orange
?
:TC 1
138 Passwords not identical
:PW apple,apple
:^L^K apple,1
```

```
'Galil DMC Code Example
:PW test,test;'            Set password to "test"
:^L^K test,1;'             Lock the program
:ED;'                      Attempt to edit program
?
:TC 1
106 Privilege violation
```

PW applies to DMC40x0,DMC42x0,DMC41x3,RIO,DMC18x6,DMC30010,DMC50xx0

QD *Download Array*



Usage	QD n ...	Arguments specified with an implicit, comma-separated order

Description

The QD command transfers array data from the host computer to the controller. QD array[], start, end requires that the array name be specified along with the index of the first element of the array and the index of the last element of the array.

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
str	1 char	7 chars	N/A	String	Name of array to receive data via download.	
n0	0	see Notes	0	1	Index of the first array element.	Value cannot exceed size of array - 2
n1	1	see Notes	see Notes	1	Index of the last array element.	Value cannot exceed size of array - 1. Defaults to size of array - 1.

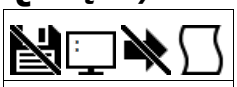
Remarks

- Array name must be a valid, dimensioned array name followed by empty [] brackets.
- The array elements can be separated by a comma (,) or by CR/LF.
- The downloaded array is terminated by a \ character.
- QD is not supported in the Galiltools terminal
  - It is recommended to use the array download functions available through the GalilTools software and drivers rather than directly using the QD command.

Examples

```
'Galil DMC Code Example
:'From a character-buffered terminal such as Telnet or Hyperterm
:DM array[3]
:QD array[]
1,2,3\:LA
array[3]
:array[0]= ?
 1.0000
:array[1]= ?
 2.0000
:array[2]= ?
 3.0000
:
```

QE *Query Encoder*



QE n

Usage	QE n ...	Arguments specified with an implicit, comma-separated order
Operands	_QE0 _QE1	Operand has special meaning, see Remarks

Description

The QE command returns the current position of the encoders inputs. The encoder option is available for the RIO-47122 and RIO-473xx models. All RIO-47122 encoder options will utilize Digital Inputs 12,13,14 and 15 and Digital Outputs 12,13,14 and 15. These digital inputs and outputs will not be available as standard digital I/O when one of the encoder options is ordered with the RIO-47122. See the User manual for detailed pin out information. All RIO-473xx encoder options come in the form of add-on boards. More information about the RIO-473xx add-on boards can be found in the appendix of the RIO user manual .

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
n	0	1	N/A	1	Channel selected to report position	If no number selected, both channel 0 and channel 1 report position

Remarks

- The register that is read using the QE command is updated by the RIO every 25ms.
- Encoder support is only valid for RIO models that are ordered with the -QUAD, -SSI or -BISS options.

Operand Usage

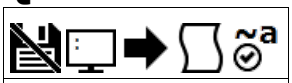
- _QEn contains the current encoder position value for the specified channel (n = 0 or 1)

Examples

```
'Galil DMC Code Example
:QE 0
 10254
:
```

QE applies to RIO

QR *I O Data Record*



QR mm
QR

Usage	QR mm	Argument is an axis mask

Description

The QR command causes the controller to return a record of information regarding controller status.
This status information includes 4 bytes of header information and specific blocks of I/O information. The details of the status information are described in the RIO user manual.

Arguments

QR is an interrogation command with no arguments.

Remarks

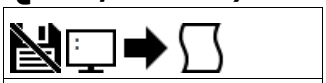
- The data returned by the QR command is in binary format and is unreadable in programs such as Galiltools.
  - The Galiltools API has specialized commands to parse the data record packet. See the Galiltools User Manual for more details.

Examples

```
'Galil DMC Code Example
:QR ;'   Return the data record, binary format
?8K)^A^A          ! !0!0!0! ! ! !
```

QR applies to DMC40x0,DMC42x0,DMC41x3,DMC21x3,RIO,DMC18x6,DMC18x2,DMC30010,DMC50xx0

QU *Upload Array*



QU str[],n_0,n_1,n_2

Usage	QU n ...	Arguments specified with an implicit, comma-separated order

Description

The QU command transfers array data from the controller to a host computer. The QU requires that the array name be specified along with the first element of the array and last element of the array.

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
str	1 char	7 chars	N/A	String	Name of array to be uploaded	
n_0	0	see Notes	0	1	Index of first array element	Value cannot exceed size of array - 2
n_1	1	see Notes	see Notes	1	Index of last array element	Defaults to last element of array. Value cannot exceed size of array - 1
n_2	0	1	0	1	Selects character delimiter between array elements	n_2 = 0 selects CR delimiting. n_2 = 1 select comma delimiting.

Remarks

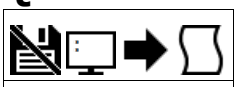
- Array name must be a valid, dimensioned array name followed by empty [] brackets.
- The uploaded array will be followed by a <control>Z as an end of text marker.
- The GalilTools array upload functions can be used to upload array data in .csv format.

Examples

```
'Galil DMC Code Example
DM test[10];'     Dimension a 10 element sized array
QU test[],0,1,1;' Upload first 2 elements
QU test[],8,9,1;' Upload last 2 elements (size-2 and size-1 used for n1,n2)
EN
```

```
'Galil DMC Code Example
:DM array[5];'                          Dimension Array
:QU array[],0,4,1;'                     Upload Array
0.0000, 0.0000, 0.0000, 0.0000, 0.0000
:array[0]= 9;'                           Set value
:array[1]= 1
:QU array[],0,4,1
9.0000, 1.0000, 0.0000, 0.0000, 0.0000
:array[0]= ?;'                           Alternative method to return just one array value
 9.0000
```

QZ *Return Data Record information*



Usage	QZ	Command takes no arguments
Operands	_QZ0 _QZ1 _QZ2 _QZ3	Operand has special meaning, see Remarks

Description

The QZ command is an interrogation command that returns information regarding the data record. The controller's response to this command will be the return of 4 integers separated by commas.

Arguments

QZ is an interrogation command with no parameters.

Remarks

- The four fields returned by QZ represent the following:
  1. First field returns the number of control loops
  2. Second field returns the number of bytes in the general data block of the QR record. This is always 4 for the RIO.
  3. Third field returns the number of bytes in the I/O block of the QR record.
     - This value is different on the -SER version of firmware used when ordering an encoder option as compared to the standard firmware. This is to designate the extra bytes used to store encoder data.
  4. Fourth field returns 0, indicating there is no axis-specific data in the data record. This field is reserved because it has context on Galil motion controllers.

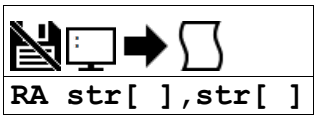
_QZ operands

Operand	Description
_QZ0	Holds the number of control loops
_QZ1	Holds the number of bytes in the general data block of the QR record. This is always 4 for the RIO
_QZ2	Holds the number of bytes in the I/O block of the QR record
_QZ3	Holds 0, indicating there is no axis-specific data in the data record. This field is reserved because it has context on Galil motion controllers

Examples

```
'Galil DMC Code Example
:QZ;'          standard RIO firmware response
 2, 4, 48, 0
```

RA *Record Array*



Usage	RA n ...	Arguments specified with an implicit, comma-separated order

Description

The RA command selects the user arrays to be populated by the Record Array function. The data to be captured is specified by the RD command and time interval by the RC command.

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
str	1 char	7 chars	N/A	String	Valid array name to use in record array function	The arrays listed correspond to the source list defined by the RD command. See Remarks

Remarks

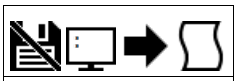
- The array name str must be followed by the [] brackets. Those brackets must be empty.
- The array name str must be a valid array defined by the DM command and reported by LA.

Examples

```
'Galil DMC Code Example
'  try to start record array without defining array[]
:RA array[]
?
:TC 1
82 Undefined array
:DM array[100]
:RA array[]
```

```
'Galil DMC Code Example
#record;'       Label
DM input[100];' Define array for input status
RA input[];'    Specify Record Mode
RD _TI;'        Specify data type for record
RC 1;'          Begin recording at 2 msec intervals
EN;'            End

'GalilTools: The GalilTools Realtime scope can
'often be used as an alternative to record array.
```

RC *Record*



RC n_0,n_1

Usage	RC n ...	Arguments specified with an implicit, comma-separated order
Operands	_RC	Operand has special meaning, see Remarks

Description

The RC command begins recording for the Automatic Record Array Mode. RC 0 stops recording. The record array mode loads source data specified by the RD command into the arrays defined by the RA command. The address for the array element for the next recording can be interrogated with _RD.

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
n_0	0	9	0	1	Specify the record array time interval as 2^(n-1) samples.	n_0 = 0 and 1 have special behavior. See Remarks
n_1	see Notes	see Notes	0	1	Specify the number of records to perform	n_1 has special rules for the maximum setting. See Remarks

Remarks

- Firmware Note: Do not allocate or deallocate arrays (DM,DA) while the Automatic Record Array Mode is running.
- GalilTools Note: Do not download arrays from GalilTools, or call the arrayDownload() or arrayDownloadFile() functions while automatic record array mode is running.

First Parameter Rules

- n_0 = non zero number automatically starts record mode.
- n_0 = ? returns status of recording. '1' if recording, '0' if not recording.

- n_0 = 0 disables the record array mode
- n_0 = 1 sets the time interval to 1 millisecond for the record array mode.
- n_0 = 2-9 sets time interval to 2^(n-1) milliseconds for a range of 2msecs - 256 msecs

Second Parameter Rules

- n_1 specifies the last array element to use for record mode.
- If arrays specified by RA have different sizes, the smallest array size is the maximum value for n_1
- If n_1 = 0 or not specified, the maximum value is used.
- A negative value for n_1 specifies circular (continuous) record over array addresses 0 to (n_1-1).
  - The absolute value of the minimum n_1 allowed = maximum n_1 allowed

Operand Usage

- _RC contains status of recording. '1' if recording, '0' if not recording.

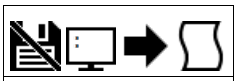
Setting up the record array mode

1. Dimension an array/arrays for storing data. Make sure you dimension the array with the number of elements required to capture data for your application.
2. Set the RA command with the arrays to be used for recording
3. Set the RD command with the data sources to be applied to the arrays. The order of your arrays entered into RA will match the order of data sources set by RD
4. Set the RC command to get the desired time between records and enable the recording.
5. Monitor the _RC operand for a 0 to indicate recording is done.
6. View the data in your embedded code, or extract the data using Galiltools software and the Upload array function.

Examples

```
'Galil DMC Code Example
#record;'               Record label
DM anaout[1000];'       Define Array
RA anaout[];'           Specify Array to record data
RD _AO1;'               Specify Data Type
RC 2;'                  Begin recording and set 2 msec between records
JG 1000;BG ;'           Begin motion
#a;JP #a,_RC=1;'        Loop until done
MG "DONE RECORDING";'   Print message
EN;'                    End program
```

RD *Record Data*



Usage	RD n ...	Arguments specified with an implicit, comma-separated order
Operands	_RD	Operand has special meaning, see Remarks

Description

The RD command specifies the data type to be captured for the Record Array (RA) mode. The data defined in this command is stored in arrays defined by the RA command at the time interval specified with the RC command.

Arguments

Argument	Value	Description	Notes
arg	_TI	Input status	Returned bit mask represents all bits
	_OP	Output status	Returned bit mask represents all bits
	_AFm	Analog feedback status	m corresponds to the analog feedback axis. See AF command. **Syntax Note:** Unlike the operand _AFm, the symbol _AFm in the context of RD records the ADC value, not the AF setting.
	_AOm	Analog output status	m corresponds to the analog output value. See AO command.

Remarks

- Arguments listed as _XXm are valid when m is a valid axis mask
- The order of args specified in RD corresponds with the array order specified in the RA command.
- the operand _RD contains the address for the next array element for recording.
- When recording _AFm, the returned value is signed. This means that when AQ is used to set unipolar inputs, values on the upper half of the voltage range are sign extended. Anding the value with $0000FFFF will return the expected unsigned value.

Examples

```
'Galil DMC Code Example
#record;'       Label
DM input[100];' Define array for input status
RA input[];'    Specify Record Mode
RD _TI;'        Specify data source for record
RC 1;'          Begin recording at 2 msec intervals
EN;'            End the program, RC continues to run until complete

'The GalilTools Realtime scope can often be used as an alternative to record array.
```

```
'Galil DMC Code Example
AFA= 0;' analog feedback ADC
' for control loop A is input 0
DA *[]
DM analog[200], time[200]
RA analog[], time[]
RD _AFA, TIME
RC 2
#loop;
WT 2
JP #loop,_RC=1
MG "Done"
EN
```

RE *Return from Error Routine*

RE n

Usage	RE n ...	Arguments specified with an implicit, comma-separated order

Description

The RE command is used to end subroutines in application code. An RE at the end of these routines causes a return to the main program. Specific automatic error subroutines require the use of the RE command to end the code correctly.

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
n	0	1	0	1	Determines state of interrupted trippoint when returning from an automatic subroutine.	n = 1 restores the interrupted trippoint. n = 0 clears the trippoint

Remarks

- The RE command is used to end the following error automatic subroutines.

Automatic Subroutines Used	Notes
#SERERR	Only when equipped with serial encoder firmware support
#TCPERR	

- Care should be taken to ensure the error conditions are cleared when finishing the subroutine to avoid immediate re-entering of the error routine.
- To avoid returning to the main program on an interrupt, use the ZS command to zero the subroutine stack, then use JP to return to the desired location in code.
- RE 1 restores the trippoint that was interrupted by an automatic subroutine (like WT)

Examples

```
'Galil DMC Code Example
#l
MG {EA} "L"
WT 1000
JP #l

#TCPERR
MG {P1} "TCPERR.  Dropped handle", _IA4
RE
```

REM *Remark*

```
REM str
```

Description

REM is used for comment lines. The REM statement is NOT a controller command. Rather, it is recognized by Galil PC software, which strips away the REM lines before downloading the DMC file to the controller.

NO (or ') should be used instead of REM for commenting in application code unless speed or program space is an issue.

Arguments

Argument	Value	Description	Notes
str	String	Comment to be removed from code prior to download	This comment is not limited by the character limit of the controller, as it is never downloaded

Remarks

- REM differs from NO (or ') in the following ways:
  - 1. NO (or ') comments are downloaded to the controller and REM comments aren't
  - 2. NO (or ') comments take up execution time and REM comments don't; therefore, REM should be used for code that needs to run fast.
  - 3. REM comments cannot be recovered when uploading a program but NO (or ') comments are recovered. Thus the uploaded program is less readable with REM.
  - 4. NO (or ') comments take up program line space and REM lines don't.
  - 5. REM comments must be the first and only thing on a line, whereas NO (or ') can be used to place comments to the right of code (after a semicolon) on the same line

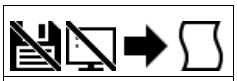
Special Strings

- REM DISABLE COMPRESSION
  - Inserting this line into the beginning of your application code disables Galiltools download compression utility. This is not a controller function.

Examples

```
'Galil DMC Code Example
REM This comment will be stripped when downloaded to the controller
'This comment will be downloaded and takes some execution time
PRA= 1000 ;'this comment is to the right of the code
```

RI *Return from Interrupt Routine*



RI n_0,n_1

Usage	RI n ...	Arguments specified with an implicit, comma-separated order

Description

The RI command is used to end the input interrupt subroutine.

The input interrupt subroutine begins with the label #ININT0, #ININT1, #ININT2 and #ININT3. The second field of the RI command either restores or disables the input interrupt feature.

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
n_0	0	1	0	1	Determines state of interrupted trippoint when returning from an automatic subroutine.	n = 0 clears the trippoint. n = 1 restores the interrupted trippoint.
n_1	0	1	0	1	Sets whether the current input interrupt subroutine is re-enabled.	n = 0 re-enables the interrupt routine. n = 1 disables the interrupt routine

Remarks

- To avoid returning to the main program on an interrupt, use the command ZS to zero the subroutine stack. This turns the jump subroutine into a jump only.
  - http://www.galilmc.com/support/appnotes/optima/note2418.pdf
- If the program sequencer was interrupted while waiting for a trippoint, such as WT, RI 1 restores the trippoint on the return to the program. RI 0 clears the trippoint.
- An application program must be executing in thread 0 for the input interrupt subroutine to function.

Examples

```
'Galil DMC Code Example
#a;'              Program label
II 1,0,3;'         enable interrupt on input 3
AI 5;'             AI trippoint on input 5
MG "DONE"
EN;'              end of program
#ININT1;'          Begin interrupt subroutine
MG "IN[3] INTERRUPTED"
CB 3;'            Set output line 1
RI 1,1;'          Return to the main program,
'restore AI trippoint and disable interrupt on input 3
```

RO *Realtime Offset*

RO n

Usage	RO n ...	Arguments specified with an implicit, comma-separated order
Operands	_RO0 _RO1	Operand has special meaning, see Remarks

Description

The RO command sets the hour offset from GMT time for the realtime clock feature. RO is used when synching the realtime clock with a TIME server. The TIME protocol provides GMT time, and RO allows for localization of time.

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
n	-12	12	0	1	Hourly time zone offset	Offsets based on GMT time.

Remarks

- RTC functionality is only available on the RIO-471x2 models

Operand Usage

- _RO0 contains the current GMT offset
- _RO1 contains the value last received from a network TIME protocol server (See IH and RT)

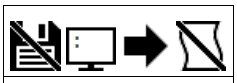
Examples

```
'Galil DMC Code Example
'Some Time Zone Examples:
RO -10;'  Hawaii, USA
RO -9;'   Alaska, USA
RO -8;'   Pacific Time, US and Canada
RO -7;'   Mountain Time, US and Canada
RO -6;'   Central Time, US and Canada
RO -5;'   Eastern Time, US and Canada
RO -3;'   Buenos Aires, Argentina
RO 0;'    London, England
RO 1;'    Paris, France
RO 2;'    Cairo, Egypt
RO 3;'    Plovdiv, Bulgaria
RO 8;'    Beijing, China
RO 9;'    Tokyo, Japan
RO 10;'   Melbourne, Australia
```

```
'Galil DMC Code Example
REM Changing RO for Daylight Savings
RO -7;'Pacific Daylight Time
REM Hit TIME server
IHE= 10,0,62,23<37>2
WT 10
JS #print
RO -8;'Pacific Standard Time
IHE= 10,0,62,23<37>2
WT 10
JS #print
EN
#print;'Print Time
MG _RT2{F2.0},":"{N};'Hour
MG _RT1{F2.0},":"{N};'Minute
MG _RT0{F2.0};'Second
EN
'SAMPLE OUTPUT:
' 11: 23: 16
' 10: 23: 16
```

RO applies to RIO,DMC30010

RS *Reset*



RS n

Usage	RS n ...	Arguments specified with an implicit, comma-separated order
Operands	_RS	Operand has special meaning, see Remarks

Description

The RS command resets the state of the processor to its power-on condition. The previously saved state of the hardware, along with parameter values and saved program, are restored.

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
n	-1	0	0	1	Set behavior of RS command	n = 0 peforms normal reset. n = -1 performs soft master reset. See Remarks.

Remarks

- A soft master reset performed by issuing RS -1 restores factory default settings without erasing the EEPROM. To restore saved EEPROM settings use RS with no arguments, or RS 0.

Operand Usage

- _RS returns the state of the processor on its last power-up condition. The value returned is the decimal equivalent of the 4 bit binary value shown below.
  - Bit 3 For master reset error
  - Bit 2 For program checksum error
  - Bit 1 For parameter checksum error
  - Bit 0 For variable checksum error
- At startup the controller operating system verifies the firmware sector. If there is a checksum error shown by _RS in firmware, it is not loaded and the controller will boot to monitor mode.
  - The #AUTOERR automatic subroutine will run if this error occurs and the subroutine is located in the program space.

Examples

```
'Galil DMC Code Example
:RS;'     Reset the hardware

:RS -1;'   Perform a soft master reset

:
```

RT *Real Time*

RT n_0,n_1,n_2

Usage	RT n ...	Arguments specified with an implicit, comma-separated order
Operands	_RT0 _RT1 _RT2 _RT3	Operand has special meaning, see Remarks

Description

The RT command provides the ability to set and query the current time on the realtime clock. RT can be set manually, or automatically with the TIME protocol (See IH).

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
n_0	0	59	0	1	Current seconds value	
n_1	0	59	0	1	Current minutes value	
n_2	0	23	0	1	Current hour value	24 hour clock used (no AM/PM)

Remarks

- Available on the RIO-471x2 only.
- The RIO-471x2 has two clock options:
  - 1. Processor RTC. Clock does not persist through power cycles and must be set at startup either by RT command or by TIME protocol over Ethernet (See IH).
  - 2. Precision RTC chip. Upgrade option for the RIO-41x2. More precise than processor RTC feature. Persists time through power cycle and Master Reset. Provides calendar function (See RY).

Operand Usage

- _RT0 contains the seconds field of the current time.
- _RT1 contains the minutes field of the current time.
- _RT2 contains the hours field of the current time.
- _RT3 (without precision RTC circuitry) contains the days since the time was last set with the RT command or with the TIME protocol.
  - If neither event occured, _RT3 contains the number of days since last power cycle.
  - With the precision RTC upgrade, use _RY0 for the day of week counter.

Examples

```
'Galil DMC Code Example
:RT 30,25,22;'     Set time to 10:25:30 PM
:
```

```
'Galil DMC Code Example
RO -7;'                set timezone
IHE= 10,0,62,23<37>2;' hit TIME server
WT 10
MG _RO1{$8.0};'        print data from server
MG _RT2{F2.0},":"{N};' print hour
MG _RT1{F2.0},":"{N};' print minutes
MG _RT0{F2.0};'        print seconds
EN
'Sample Output:
'$CF943C7B
' 13: 28: 43
```

RT applies to RIO,DMC30010

RY *Real Year Calendar Function*

RY n_0,n_1,n_2,n_3

Usage	RY n ...	Arguments specified with an implicit, comma-separated order
Operands	_RY0 _RY1 _RY2 _RY3	Operand has special meaning, see Remarks

Description

RY provides a calender feature for the realtime chip. Available information is day of week, day of month, month of year, and year. RY can be set manually, or automatically with the TIME protocol (See IH). The state of the calender will persist through power cycle and Master Reset.

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
n_0	0	7	0	1	Day of the week to assign to calender	n_0 = 0 disables calender feature. 1=Sunday, 2=Monday, 3=Tuesday, 4=Wednesday, 5=Thursday, 6=Friday, 7=Saturday
n_1	0	31	0	1	Sets the current day of the month	
n_2	0	12	0	1	Sets the current month of the year	n_2 = 0 disables calender feature. 1=January, 2=February, 3=March, ... , 10=October, 11=November, 12=December
n_3	0	99	0	1	Sets the current year	0 - 99 corresponds to year 2000 through 2099

Remarks

- Available only on RIO-471x2 with -RTC order option for precision realtime clock chip
- The calender function is leap-year compliant.

Operand Usage

- _RY0 contains the current day of the week field
- _RY1 contains the current day of the month field
- _RY2 contains the current month of the year field
- _RY3 contains the current year field

Examples

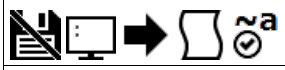
```
'Galil DMC Code Example
:RY 6,19,2,10;'     Set to Fri, February 19th, 2010
:
```

```
'Galil DMC Code Example
REM DISABLE COMPRESSION <- This String Disables GalilTools Compression
#print;'call sub when time is needed
JS #printd+_RY0;'helper subs w/ offsets
JS #printm+_RY2
MG _RY1{Z2.0},",{N};'print info
MG 2000+_RY3{Z4.0}
MG _RT2{F2.0},":{N}
MG _RT1{F2.0},":{N}
MG _RT0{F2.0}
EN
'
REM The following Subs depend upon line spacing
REM Do not add or remove lines
#printd
MG "SUN "{N};EN
MG "MON "{N};EN
MG "TUE "{N};EN
MG "WED "{N};EN
MG "THR "{N};EN
MG "FRI "{N};EN
MG "SAT "{N};EN
'
#printm
MG "JAN "{N};EN
MG "FEB "{N};EN
MG "MAR "{N};EN
MG "APR "{N};EN
MG "MAY "{N};EN
MG "JUN "{N};EN
MG "JUL "{N};EN
MG "AUG "{N};EN
MG "SEP "{N};EN
```

```
MG "OCT "{N};EN
MG "NOV "{N};EN
MG "DEC "{N};EN
'
'Example Output
'TUE MAY  11, 2010
' 14: 07: 48
```

RY applies to RIO,DMC30010

SA *Send Command*



SAm= str

SAm= str,n,n,n,n,n,n,n

Usage	SAm= n	Arguments specified with a single axis mask and an assignment (=)
Operands	_SAm0 _SAm1 _SAm2 _SAm3 _SAm4 _SAm5 _SAm6 _SAm7	Operand has special meaning, see Remarks

Description

SA sends a command, and optionally receives a response, from one controller to another via Ethernet.

Arguments

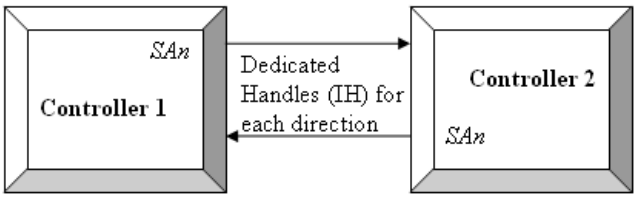
Argument	Min	Max	Default	Resolution	Description	Notes
m	A	C	N/A	Handle	Handle to specify for message output	For RIO-47xx0
	A	E	N/A	Handle	Handle to specify for message output	For RIO-47xx2 and RIO-473xx
str	1 char	6 chars	""	String	String to send over handle	
n	-2,147,483,648	2,147,483,647	0	1	Value to send for the specified parameter	

Remarks

- Strings are encapsulated by quotations. This will typically begin an SA command.
- n is a number, controller operand, variable, mathematical function, or string. The range for numeric values is 4 bytes of integer followed by two bytes of fraction.
- Typical usage would have the first argument as a string such as "KI" and the subsequent arguments as the arguments to the command:
  - Example SAF="KI", 1, 2 would send the command: KI1,2
  - SA automatically adds commas between two number values being sent.
- There is a 38 character maximum payload length for the SA command.

Operational Notes

1. SA is non-blocking. A wait (e.g. WT10) must occur between successive calls to SA.
2. SA is not valid over a handle configured for Modbus (port 502).
3. When writing multi-threaded DMC code, send all traffic from only one thread.
4. The Galil that establishes the connection and issues the SA command is called the master. The Galil that receives the connection and answers the SA is the slave.
   1. For both controllers in a connection to be both masters and slaves, open two Ethernet handles. Each of the controllers is a master over one of the handles, and a slave on the other.



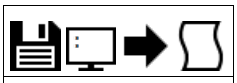
Operand Usage

- _SAmn gives the value of the response to the command sent with an SA command.
  - The m value represents the handle A thru H and the n value represents the specific field returned from the controller (0-7).
  - If the specific field is not used, the operand will be -2^31.

Examples

```
'Galil DMC Code Example
#a
IHA= 10,0,0,12;'     Configures handle A to be connected to a controller with IP 10.0.0.12
#b;JP #b,_IHA2<>-2;' Wait for connection
SAA= "KI", 1, 2;'    Sends the command to handle A (slave controller):  KI 1,2
WT 10
SAA= "TE";'          Sends the command to handle A (slave controller):  TE
WT 10
MG _SAA0;'           Display the content of the operand_SAA (first response to ;'TE command)
MG _SAA1;'           Display the content of the operand_SAA (2nd response to TE ;'command)
SAA= "TEMP=",16;'    Sets variable temp equal to 16 on handle A controller
EN;'                End Program
```

SB *Set Bit*



SB n

Usage	SB n ...	Arguments specified with an implicit, comma-separated order

Description

The SB command sets a particular digital output. The SB and CB (Clear Bit) instructions can be used to control the state of output lines.

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
n	0	15	N/A	1	General output bit to be set	RIO-471xx and RIO-472xx
	0	23	N/A	1	General output bit to be set	RIO-473xx
	24	47	N/A	1	General output bit to be set	RIO-473xx with -24ExOut option
n	1,000	3,999	N/A	1	Set Modbus slave bit	For RIO-47xx0. See "SB via Modbus Slave" in Remarks
	1,000	5,999	N/A	1	Set Modbus slave bit	For RIO-47xx2 and RIO-473xx. See "SB via Modbus Slave" in Remarks

Remarks

- The state of the output can be read with the @OUT command

SB via Modbus Slave

- n_0 = (SlaveAddress*10000) + (HandleNum*1000) + ((Module-1)*4) + (Bitnum-1)
  - Slave Address is used when the ModBus device has slave devices connected to it and specified as Addresses 0 to 255. Please note that the use of slave devices for modbus are very rare and this number will usually be 0.
  - HandleNum is the handle specifier where A is 1, B is 2 and so on.
  - Module is the position of the module in the rack from 1 to 16.
  - BitNum is the I/O point in the module from 1 to 4

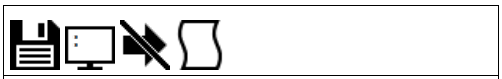
Examples

```
'Galil DMC Code Example
#main
SB 5;'     Set digital output 5
SB 1;'     Set digital output 1
CB 5;'     Clear digital output 5
CB 1;'     Clear digital output 1
EN
```

```
'Galil DMC Code Example
#modbus
REM connect to modubs slave at IP address 192.168.1.50
IHF= 192,168,1,50<502>2
WT 100
SB 5001;'set bit 1 on modbus slave
WT 10
CB 5003;'set bit 3 on modbus slave
EN
```

For detailed information on connecting to a Modbus slave, see:
http://www.galilmc.com/techtalk/io-control/setting-up-and-rio-as-extended-io-for-a-controller/

SE *Serial Encoder*



SE n_0, n_1, n_2, n_3, n_4 <o >p

Usage	SE n ...	Arguments specified with an implicit, comma-separated order
Operands	_SE0 _SE1	Operand has special meaning, see Remarks

Description

This command is used to configure an RIO with the -SSI or -BISS option to read either SSI or BiSS serial encoders. Both serial encoder types receive a master clock which is used to report position data serially to the RIO.

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
n_0	0	1	0	1	Channel to set	n = 0 sets channel 0. n = 1 sets channel 1
n_1	0	2	0	1	Select encoder type	0 = No encoder, 1 = SSI encoder, 2 = BiSS encoder

*For **SSI** encoders*

Argument	Min	Max	Default	Resolution	Description	Notes
n_2	-31	31	N/A	1	Total number of bits	$n_2 < 0$ enables rollover. See Remarks.
n_3	0	31	N/A	1	Number of single-turn bits	
n_4	-8	8	N/A	1	Number of status (error) bits	$n_4 < 0$ specifies bits leading SSI data. $n_4 > 0$ specifies bits trailing SSI data
o	4	26	N/A	1	Clock divider	Read data on rising clock edge
	-26	-4	N/A	1	Clock divider	Read data on falling clock edge. See Table
p	1	2	N/A	1	Select data encoding style	1 = Binary, 2 = Gray Code

*For **BiSS** encoders*

Argument	Min	Max	Default	Resolution	Description	Notes
n_2	-31	31	N/A	1	Number of single-turn bits	$n_2 < 0$ enables rollover. See Remarks.
n_3	0	31	N/A	1	Number of total bits before error bits	See Example for BiSS example
n_4	0	8	N/A	1	Number of zero padding bits	
o	4	26	N/A	1	Clock divider	Read data on rising clock edge. See Table
	-26	-4	N/A	1	Clock divider	Read data on falling clock edge. See Table

Remarks

- RIO-47122-SSI or RIO-47122-BISS is required to use this feature. This feature is only available on the RIO-47122
- For n_2, A positive number designates No Rollover. A negative number will cause the RIO to act as an incremental encoder, allowing the encoder to count past the max value of the encoder.
  - Note: when the controller is powered down, the rollover values are lost
- The clock frequencies specified below by 'o' are approximate values and may vary from RIO to RIO.

'o' Value	Clock Frequency (MHz)
4	2
5	1.7
6	1.4
7	1.3
8	1.1
9	1.0
10	0..91
11	0..83
12	0.77
13	0.71
14	0.67
15	0.63
16	0.59
17	0.56
18	0.53
19	0.50
20	0.48
21	0.45
22	0.43

23	0.42
24	0.40
25	0.38
26	0.37

SSI

- Synchronous Serial Interface (SSI) allows for serial transmission of absolute position data (either binary or Gray code) from the encoder based on a timed clock pulse train from the controller.
- Connection between the controller and encoder is based on two signal lines, clock and data, which are usually differential for increased noise immunity.
- For each sequential clock pulse of the controller, the encoder transmits one data bit from shift registers on the encoder.
- The number of Multi-turn bits of the encoder is internally calculated by the following equation: Multi-turn Bits = (Total Bits) - (Single-Turn) - (Status Bits)

BiSS

- BiSS is an open source digital interface for sensors and actuators. BiSS is hardware compatible to the industrial standard SSI (Serial Synchronous Interface). It allows serial transmission of absolute position data from BiSS encoders based on a master clock signal from the controller.
- Galil implementation of BiSS is unidirectional. Contact Galil for a different implementation

Operand Usage

- _SEi contains the status bit values where i = the channel number (0 or 1). The bitmap is found below
- Note: The encoder manufacturer may name the Error and Warning bits differently. Consult the encoder documentation for the naming convention.
- Galil defines the Warning bit as the bit directly preceeding the CRC. The Error bit is defined as the bit directly preceeding the Warning bit. See table 1.

_SEi Bit Map

Bit Position	Bit Meaning	Description
0	No timeout = 0, timeout occurred = 1	The BiSS decoding hardware will timeout if the encoder doesn't set the start bit within 30uS
1	CRC valid = 0, invalid = 1	BiSS employs a Cyclic Redundancy Check to verify data after transmission
2	Error bit* (active state set with SY)	When SY is set correctly, this bit should be low when there is no active warning. Consult the encoder documentation for the Warning bit definition
3	Warning bit* (active state set with SY)	When SY is set correctly, this bit should be low when there is no active alarm/error. Consult the encoder documentation for the Alarm bit definition

Examples

```
'Galil DMC Code Example
SE 0,1,25,25,0<10>1;'     SSI on channel 0, 25 bits total, all single turn, no status
SE 0,0;'                  Disable serial encoder on channel 0
```

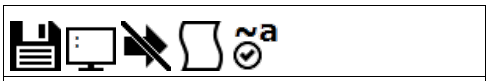
Table 1: SE Example for BiSS encoder: Hengstler 12 bit MT 10 bit ST

Bit Sequence:	T-2	T-1 (Delay)	T0	T1... T12	T12... T22	T23... T26	T27	T28	T29... T34	T35
Data (Data/SLO line):	1	0	1	M11... M0	S9... S0	0	E	W	C5... C0	MCD
Data Description:	Idle	Encoder acquiring	Start Bit	Multi-Turn data	Single-turn data	Zero Padding	Error Bit	Warning Bit	CRC	Multi-Cycle Data
SE command details:	-	-	-	n_3 = (10+12+4) = 26	n_2 = 10	n_4 = 4	E bit read in _SEn	W read in _SEn	CRC valid bit read in _SEn	Ignored by default

```
'Galil DMC Code Example
'Final command for table above
'on channel 0, with 2MHz clock
'
SE 0,2,10,26,4<4
EN
```

SE applies to RIO

SI *Configure the special Galil SSI feature*



SIm = n_0, n_1, n_2, n_3 <o >p

Usage	SIm= n	Arguments specified with a single axis mask and an assignment (=)

Description

The SI command enables and configures the controller to read SSI encoder data. Synchronous Serial Interface (SSI) allows for serial transmission of absolute position data (either binary or Gray code) from the encoder based on a timed clock pulse train from the controller. Connection between the controller and encoder is based on two signal lines, clock and data, which are usually differential for increased noise immunity. For each sequential clock pulse of the controller, the encoder transmits one data bit from shift registers on the encoder.

Arguments

Remarks

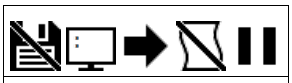
- SIm = ? Returns the configuration parameters
- n_1: A positive number designates No Rollover. A negative number will cause the controller to act as an incremental encoder, allowing the encoder to count past the max value of the encoder. This prevents a discontinuity in servo error at the ends of the absolute data. When the controller is powered down, the rollover values are lost.
- n_3: A negative number designates status bits as leading the SSI data. A positive number designates status bits as trailing the SSI data,
- The number of Multi-turn bits of the encoder is internally calculated by the following equation:
  - Multi-turn Bits = (Total Bits) - (Single-Turn) - (StatusBits)
- See Application Note 2438 for more information

Examples

```
'Galil DMC Code Example
SIA= 0;'           Disable SSI on axis A
```

SI applies to SER

SL *Single Step*



SL n

Usage	SL n ...	Arguments specified with an implicit, comma-separated order

Description

The SL command is used to single-step through a program for debugging purposes. SL can be used after execution has paused at a breakpoint (BK). The argument n allows user to specify the number of lines to execute before pausing again.

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
n	1	255	1	1	Number of lines to execute before pausing	If n is omitted, default value used.

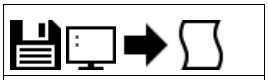
Remarks

- The BK command resumes normal program execution.

Examples

```
'Galil DMC Code Example
:BK 3;' Pause at line 3 (the 4th line) in thread 0
:BK 5;' Continue to line 5
:SL;' Execute the next line
:SL 3;' Execute the next 3 lines
:BK;' Resume normal execution
```

SM *Subnet Mask*



SM n_0,n_1,n_2,n_3
SM n

Usage	SM n ...	Arguments specified with an implicit, comma-separated order
Operands	_SM0	Operand has special meaning, see Remarks

Description

The SM command assigns a subnet mask to the controller. All packets sent to the controller whose source IP address is not on the subnet will be ignored by the controller. For example, for SM 255,255,0,0 and IA 10,0,51,1, only packets from IP addresses of the form 10.0.xxx.xxx will be accepted.

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
n_0	0	255	0	1	Byte 3 of the Subnet mask	
n_1	0	255	0	1	Byte 2 of the Subnet mask	
n_2	0	255	0	1	Byte 1 of the Subnet mask	
n_3	0	255	0	1	Byte 0 of the Subnet mask	
n	-2,147,483,648	2,147,483,647	0	1	The full subnet mask specified as a signed 32 bit two's complement integer	

Remarks

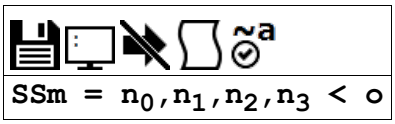
- n = ? will return the subnet mask of the controller as n_0,n_1,n_2,n_3
- _SM0 contains the subnet mask representing a 32 bit signed number (Two's complement)
- Use the following equation to change the 4 byte subnet (n_0,n_1,n_2,n_3) to a single 32 bit number, n
  - n = (n_0*2^24) + (n_1*2^16) + (n_2*2^8) + n_3
- For more information, see http://www.galilmc.com/techtalk/software/blocking-unwanted-ethernet-devices-from-connecting/

Examples

```
'Galil DMC Code Example
SM 255,255,255,255;' Ignore all incoming Ethernet packets
SM 0,0,0,0;' Process all incoming Ethernet packets
```

SM applies to DMC40x0,DMC42x0,DMC41x3,RIO,DMC30010,DMC50xx0

SS *Configure the special Galil BiSS feature*



SSm = n_0,n_1,n_2,n_3 < o

Usage	SSm= n	Arguments specified with a single axis mask and an assignment (=)
Operands	_SSm	Operand has special meaning, see Remarks

Description

The SS command enables and configures the controller to read BiSS encoder data. BiSS is an open-standard, digital interface for sensors and actuators. BiSS is hardware compatible to the industrial standard SSI (Serial Synchronous Interface). It allows serial transmission of absolute position data from BiSS encoders based on a master clock signal from the controller.

Arguments

Remarks

- SIm = ? Returns the configuration parameters
- n_1: A positive number designates No Rollover. A negative number will cause the RIO to act as an incremental encoder, allowing the encoder to count past the max value of the encoder. Note, when the controller is powered down, the rollover values are lost
- BiSS clock (MA) frequency is set with the o argument and has the following form:
  - MA freq= 20 MHz / (2 * (o+1))
- Clocking in BiSS data has a timing overhead which may be non-negligible. In the event that clocking in data may have a negative effect on servo performance (e.g. using multiple encoders with a lowered TM sample rate) the controller will respond with an error mode. See #AUTOERR for more information.
  - This error mode is very rare, and is expected to occur only in development.

Operand Usage

- _SSm Returns 4 bits of axis status data where n is the axis designator used.
  - #SERERR is an automatic sub which will run in the event of an encoder problem. See SY for setting up the active high/low status of bits 2 and 3.
  - Note: The encoder manufacturer may name the Error and Warning bits differently. Consult the encoder documentation for the naming convention.
  - Galil defines the Warning bit as the bit directly preceeding the CRC. The Error bit is defined as the bit directly preceeding the Warning bit. See "_SSm Bit Map" table below.

_SSm Bit Map

Bit Position	Bit Meaning	Description
0	No timeout = 0, timeout occurred = 1	The BiSS decoding hardware will timeout if the encoder doesn't set the start bit within 30uS
1	CRC valid = 0, invalid = 1	BiSS employs a Cyclic Redundancy Check to verify data after transmission
2	Error bit* (active state set with SY)	When SY is set correctly, this bit should be low when there is no active warning. Consult the encoder documentation for the Warning bit definition
3	Warning bit* (active state set with SY)	When SY is set correctly, this bit should be low when there is no active alarm/error. Consult the encoder documentation for the Alarm bit definition

Examples

SS Example for Hengstler 12 bit MT 10 bit ST

Bit sequence:	T-2	T-1 (Delay)	T0	T1... T12	T13... T22	T23... T26	T27	T28	T29... T34	T35
Data (Data/SLO line):	1	0	1	M11... M0	S9... S0	0	E	W	C5... C0	MCD
Data Description:	Idle	Encoder acquiring	Start Bit	Multi-turn data	Single-turn data	Zero padding	Error Bit	Warning Bit	CRC	Multi-Cycle Data
SS command details:	-	-	-	-	ss1=10	ss3=4	ss2=26, E bit read in _SSn	W read in _SSn	CRC valid bit read in _SSn	Ignored by default

```
'Galil DMC Code Example
'BiSS setup command for the Hengstler 12 bit MT 10 bit ST
'Data will be available in TP and for servo feedback
SSA= 1,10,26,4<13
```

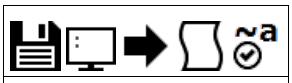
```
'Galil DMC Code Example
'Configuration for 26 bit Renishaw Resolute single-turn encoder
SYA= 0;'              Warning and Alarm bits are active low
SSA= 1,26,27,0<14
'The 27 includes the Resolute single leading zero bit
```

```
'Galil DMC Code Example
'Configuration for 36 bit Hengstler multi-turn encoder
```

```
SYA= 3;'              Warning and Alarm bits are active high
SSA= 1,19,36,5<14
'19 bits single turn, 12 bits multi turn, 5 zero padding bits
```

SS applies to SER

SY *Serial encoder BiSS active level*



```
SY n,n
```

Usage	SYm= n	Arguments specified with a single axis mask and an assignment (=)
	SY n ...	Arguments specified with an implicit, comma-separated order
Operands	_SYm	Operand holds the value last set by the command

Description

This command is used to designate the active level of the Error and Warning bits when using the Galil BiSS upgrade. The BiSS protocol defines two bits which can be used by the encoder to signal various events.

Arguments

Argument	Value	Description	Notes
n	0	Warning bit = Active Low; Error bit = Active Low	
	1	Warning bit = Active Low; Error bit = Active High	
	2	Warning bit = Active High; Error bit = Active Low	
	3	Warning bit = Active High; Error bit = Active High	Default

Remarks

- RIO-47122-SSI or RIO-47122-BISS is required for use of this command
- The encoder manufacturer dictates the high/low active state of both of these bits. Consult your encoder documentation for details.
- The SY mask should be set appropriately to ensure that the #SERERR automatic subroutine will run when the bits are active, and that the _SEn operand reports the fault state of the encoder correctly.

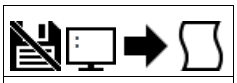
- Example of Warning and Alarm/Error bit use, Quoted from Renishaw Data Sheet L-9709-9005-03-A
  - Error (1 bit) "The error bit is active low: "1" indicates that the transmitted position information has been verified by the readhead's internal safety checking algorithm and is correct; "0" indicates that the internal check has failed and the position information should not be trusted. The error bit is also set to "0" if the temperature exceeds the maximum specification for the product."
  - Warning (1 bit) "The warning bit is active low: "0" indicates that the encoder scale (and/or reading window) should be cleaned. Note that the warning bit is not an indication of the trustworthiness of the position data. Only the error bit should be used for this purpose."

Examples

```
'Galil DMC Code Example
'configure SY for Renishaw Resolute encoder
SYA= 0
```

SY applies to SER

TB *Tell Status Byte*



TB

Usage	TB	Command takes no arguments
Operands	_TB	Operand has special meaning, see Remarks

Description

The TB command returns status information from the controller as a decimal number. Each bit of the status byte denotes an active condition when the bit is set (high):

Arguments

TB is an interrogation command with no parameters

The following table describes the specific conditions reported with each bit of the TB report.

Tell Status Byte Response Bit Description

Bit #	Status
Bit 7	Executing application program
Bit 6	N/A
Bit 5	N/A
Bit 4	N/A
Bit 3	Input Interrupt enabled
Bit 2	Executing input interrupt routine
Bit 1	0 (Reserved)
Bit 0	Echo on

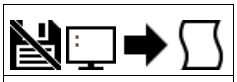
Remarks

- _TB Contains the status byte reported by the TB command

Examples

```
'Galil DMC Code Example
:TB;'       Tell status information
129'     Executing program and echo on (2^7 + 2^0 = 128 + 1 = 129)
```

TC *Tell Error Code*



TC n

Usage	TC n ...	Arguments specified with an implicit, comma-separated order
Operands	_TC	Operand has special meaning, see Remarks

Description

The TC command reports programming or command errors detected by the controller. The TC command returns a number between 1 and 255. This number is a code that reflects why a command was not accepted by the controller. This command is useful when the controller halts execution of a program or when the response to a command is a question mark.

Arguments

Argument	Value	Description	Notes
n	0	Return the numerical code only	Default
	1	Return the numerical code and human-readable message	

TC Error Code List

Tell Code Number	Description	Notes
1	Unrecognized command	
2	Command only valid from program	
3	Command not valid in program	
4	Operand error	
5	Input buffer full	
6	Number out of range	
9	Variable error	
10	Empty program line or undefined label	
11	Invalid label or line number	
12	Subroutine more than 16 deep	
14	EEPROM check sum error	
15	EEPROM write error	
17	ED, BN and DL not valid while program running	
19	Application strand already executing	
25	Variable not given in IN command	
50	Not enough fields	
51	Question mark not valid	
52	Missing " or string too long	
53	Error in {}	
54	Question mark part of string	
55	Missing [or []	
56	Array index invalid or out of range	
57	Bad function or array	
58	Bad command response	i.e._GNX
59	Mismatched parentheses	
60	Download error - line too long or too many lines	
61	Duplicate or bad label	
62	Too many labels	
63	IF statement without ENDIF	
65	IN command must have a comma	
66	Array space full	
67	Too many arrays or variables	
71	IN only valid in thread #0	
80	Record mode already running	
81	No array or source specified	
82	Undefined Array	
83	Not a valid number	
84	Too many elements	
97	Bad Binary Command Format	
98	Binary Commands not valid in application program	
99	Bad binary command number	
106	Privilege Violation	
120	Bad Ethernet transmit	
121	Bad Ethernet packet received	

123	TCP lost sync	
124	Ethernet handle already in use	
125	No ARP response from IP address	
126	Closed Ethernet handle	
127	Illegal Modbus function code	
128	IP address not valid	
130	Remote IO command error	
131	Serial Port Timeout	See Remarks
132	Analog inputs not present	
133	Command not valid when locked / Handle must be UDP	
136	Invalid Password	
137	Invalid lock setting	
138	Passwords not identical	
140	Serial encoder missing	Valid for BiSS support
141	Incorrect ICM Configuration	

Remarks

- TC command accepts ? as a query. This is equivalent to TC or TC 0
- After TC has been read, the error code is set to zero.
- _TC contains the value of the error code. Use of the operand does not clear the error code.

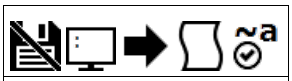
- Note: Error code 131 means that an RS232/USB timeout is being generated while trying to transmit data to the serial port.
  - This is usually caused by MG. Numerous timeouts on serial communication can cause a slowdown in DMC code execution and should be avoided.

Examples

```
'Galil DMC Code Example
:GF32;'   Bad command
?
:TC 1;'    Tell error code
1       Unrecognized command
:
```

TC applies to DMC50xx0,DMC40x0,DMC42x0,DMC41x3,DMC30010,DMC21x3,RIO,DMC18x6,DMC18x2

TE *Tell Error*



TE mm

Usage	TE mm	Argument is an axis mask
Operands	_TEm	Operand has special meaning, see Remarks

Description

The TE command returns the current error in the control loop.

The error is the difference of the analog signal in the control loop from the setpoint. For further details see the Process Control section in the User's Manual.

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
mm	A	ABCDEF	ABCDEF	Multi-Axis Mask	Process loops to report error	Valid for RIO-47xx2 and RIO-473xx
	A	AB	AB	Multi-Axis Mask	Process loops to report error	Valid for RIO-47xx0

Remarks

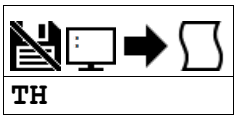
Operand Usage

- _TEm contains the current position error value for the specified process loop.

Examples

```
'Galil DMC Code Example
:TE ;'          Return all position errors
1,-2
:error = _TEA;'  Sets the variable, Error
'with the channel A position error
```

TH *Tell Ethernet Handle*



Usage	TH	Command takes no arguments

Description

The TH command returns a list of data pertaining to the Galil's Ethernet connection. This list begins with the IP address and Ethernet address (physical address), followed by the status of each handle indicating connection type and IP address.

Arguments

TH is an interrogation command with no parameters

Remarks

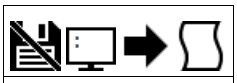
- If no handles are shown as *AVAILABLE*, the controller will be unable to create or accept more Ethernet connections with TCP or UDP. Ping will still function when all handles are taken.

Examples

```
'Galil DMC Code Example
:TH;' show the status of RIO-47xx0 handles
CONTROLLER IP ADDRESS 10,0,51,82 ETHERNET ADDRESS 10-80-3C-10-01-2F
IHA TCP PORT 1010 TO IP ADDRESS 10,0,51,87 PORT 1030
IHB TCP PORT 1020 TO IP ADDRESS 10,0,51,87 PORT 1070
IHC AVAILABLE
:'note that the RIO-47xx2 and RIO-473xx have 5 available ethernet handles
```

TH applies to DMC40x0,DMC42x0,DMC41x3,DMC21x3,RIO,DMC30010,DMC50xx0

TI *Tell Inputs*



TI n

Usage	TI n ...	Arguments specified with an implicit, comma-separated order
Operands	_TI0 _TI1 _TI2 _TI3 _TI4 _TI5	Operand has special meaning, see Remarks

Description

The TI command returns the state of the inputs in banks of 8 bits, or 1 byte. The value returned by this command is decimal and represents an 8 bit value (decimal value ranges from 0 to 255). Each bit represents one input where the LSB is the lowest input number and the MSB is the highest input bit.

Arguments

Argument	Value	Description	Notes
n	0	Report status of Inputs 0-7	Default
	1	Report status of Inputs 8-15	
	2	Report status of Inputs 16-23	RIO-473xx
	3	Report status of Inputs 16-23	RIO-473xx with -24ExIn option
	4	Report status of Inputs 16-23	RIO-473xx with -24ExIn option
	5	Report status of Inputs 16-23	RIO-473xx with -24ExIn option

Remarks

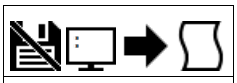
Operand Usage

- _TIn contains the status byte of the input block specified by 'n'.
  - Note that the operand can be masked to return only specified bit information - see section on Bit-wise operations.

Examples

```
'Galil DMC Code Example
:TI 1;'              Tell input state on bank 1
8                   Bit 3 is high, others low
:TI 0
0                   All inputs on bank 0 low
:input= _TI1;'      Sets the variable, Input, with the TI1 value
:input= ?
8.0000
```

TIME *Time Operand*



TIME

Usage	variable= TIME	Holds a value
Operands	TIME	Operand has special meaning, see Remarks

Description

The TIME operand returns the value of the internal free running, real time clock.

The operand TIME will increase by 1 count every millisecond. The clock is reset to 0 with a standard reset or a master reset.

Arguments

TIME is an operand and has no parameters

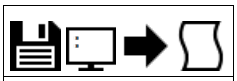
Remarks

- The keyword, TIME, does not require an underscore (_) as with the other operands.
- TIME will increment up to +2,147,483,647 before rolling over to -2,147,483,648 and continuing to count up.
    - TIME rollover occurs after ~24-25 days of on-time with no reset.

Examples

```
'Galil DMC Code Example
MG TIME;'  Display the value of the internal clock
t1= TIME;'  Sets the variable t1 to the TIME value
```

TR *Trace*



TR n_0, n_1

Usage	TR n ...	Arguments specified with an implicit, comma-separated order

Description

The TR command causes each instruction in a program to be sent out the communications port prior to execution. The trace command is useful in debugging programs.

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
n_0	0	1	0	1	Set status of trace function	n_0 = 0 or null disables Trace. n_0 = 1 enables trace.
n_1	0	15	15	1	Set threads to trace by bitmask	See Remarks

Remarks

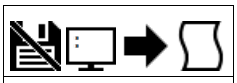
- Note: The lines following the Line Continuation Character (`) will not be displayed in the trace output.

```
'Galil DMC Code Example
#a
a= 123`
456;'not displayed with TR1 output
EN
```

Examples

```
'Galil DMC Code Example
:'Turn on trace during a program execution
:LS
0 MGTIME
1 WT1000
2 JP0
3
:XQ
:
18003461.0000
18004461.0000
18005461.0000

:TR 1
:
2 JP0
0 MGTIME
18006461.0000
1 WT1000
2 JP0
0 MGTIME
18007461.0000
1 WT1000

:TR 0
:
18008461.0000
18009461.0000

:ST
:
```

TZ *Tell I O Configuration*



Usage	TZ	Command takes no arguments

Description

The TZ command is used to request the I/O status of the controller. This is returned to the user as a human-readable text string.

On each line, the information starts with the I/O block, the corresponding I/O number range, the configuration (as inputs or outputs), and the values (255 for all 8 output bits high etc.)

Arguments

TZ is an interrogation command with no parameters

Remarks

- The data reported by TZ is also accessible through the TI (inputs) and OP (outputs) command
- For the RIO, the analog input and output data is all queriable through the @AN[] and @AO[] command, respectively

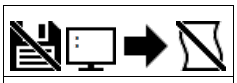
Examples

```
'Galil DMC Code Example
:TZ; 'issued for RIO-471xx and RIO-472xx
Block 0 (7-0) Inputs - value 255 (1111_1111)
Block 1 (15-8) Inputs - value 255 (1111_1111)
Block 0 (7-0) Outputs - value 0 (0000_0000)
Block 1 (15-8) Outputs - value 0 (0000_0000)
Analog Inputs(7-0)  0.0000,0.0000,0.0000,0.0000,0.0000,0.0000,0.0000,0.0000
Analog Outputs(7-0) 0.0000,0.0000,0.0000,0.0000,0.0000,0.0000,0.0000,0.0000
```

```
'Galil DMC Code Example
:TZ; 'issued for RIO-473xx
Block 0 (7-0) Inputs - value 255 (1111_1111)
Block 1 (15-8) Inputs - value 255 (1111_1111)
Block 2 (23-16) Inputs - value 255 (1111_1111)
Block 0 (7-0) Outputs - value 0 (0000_0000)
Block 1 (15-8) Outputs - value 0 (0000_0000)
Block 2 (23-16) Outputs - value 0 (0000_0000)
Analog Inputs(7-0)  0.0000,0.0000,0.0000,0.0000,0.0000,0.0000,0.0000,0.0000
Analog Outputs(7-0) 0.0000,0.0000,0.0000,0.0000,0.0000,0.0000,0.0000,0.0000
```

TZ applies to DMC40x0,DMC42x0,DMC41x3,DMC21x3,RIO,DMC50xx0

UL *Upload*



UL

Usage	UL	Command takes no arguments
Operands	_UL	Operand has special meaning, see Remarks

Description

The UL command transfers data from the controller to a host computer. Programs are sent without line numbers. The Uploaded program will be followed by a <control>Z or a '\' as an end of text marker.

Arguments

UL is a command with no parameters

Remarks

- In the Galil software, the UL command is not necessary because the UL command is handled by the graphical interface (Upload Program).
- In a terminal utility such as HyperTerminal or Telnet, the UL command will bring the uploaded program to screen.
- From there, the user can copy it and save it to a file.

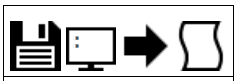
Operand Usage

- When used as an operand, _UL gives the number of available variables.

Examples

```
'Galil DMC Code Example
:UL;'     Begin upload
#A;'    Line 0
SB1;'   This is an Example Line 1
CB1;'   Program Line 2
EN;'    Line 3
{cntrl}Z        Terminator
:
```

VF *Variable Format*



VF $n_0.n_1$

Usage	VF n ...	Arguments specified with an implicit, comma-separated order
Operands	_VF	Operand has special meaning, see Remarks

Description

The VF command formats the number of digits to be displayed when interrogating the controller. If a number exceeds the format, the number will be displayed as the maximum possible positive or negative number (i.e. 999.99, -999, $8000 or $7FF).

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
n_0	-8	10	10	1	Specify the number of digits displayed before the decimal point.	A negative value specifies hexadecimal format. See Remarks
n_1	0	4	4	1	Specify the number of digits displayed after the decimal point.	

Remarks

- A negative n_0 specifies hexadecimal format. When in hexadecimal, the string will be preceded by a $ and Hex numbers are displayed as 2's complement with the first bit used to signify the sign.
- A positive n_0 specifies standard decimal format.
- A ? is only valid for querying n_0. When queried, the value reported will be the value of the format for variables and arrrays specified by n_0 and n_1
  - eg. VF 10,4 would respond to VF ? with 10.4
- _VF contains the value of the format for variables and arrays
- If the number of digits set by n_0 is insufficient for representing the integer portion of a variable, the returned value will be the greatest number representable by $n_0.n_1$. For example, if *var=123*, and `VF` is 2.4, `var=?` will return `99.9999`.

Examples

```
'Galil DMC Code Example
VF 5.3;' Sets 5 digits of integers and 3 digits after the decimal point
VF 8.0;' Sets 8 digits of integers and no fractions
VF -4.0;' Specify hexadecimal format with 4 bytes to the left of the decimal
```

```
'Galil DMC Code Example
:VF 8,4;'  set vf to 8 digits of integers and 4 digits of fraction
:VF ?;'    query the value of VF
8.4
:MG _VF;'  query again
8.4
```

WE *Write Encoder*

WE n_0,n_1

Usage	WE n ...	Arguments specified with an implicit, comma-separated order

Description

The WE command sets the current encoder position to a specified value. The units are in quadrature counts. This command will set the QE values.

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
n_0	-2,147,483,648	2,147,483,647	N/A	1	Encoder value set for channel 0	
n_1	-2,147,483,648	2,147,483,647	N/A	1	Encoder value set for channel 1	

Remarks

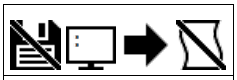
- This command is not valid with SSI or BISS encoder channels.
- -QUAD is required to use the Quadrature encoder option.
- This option is available on the RIO-47122 only.

Examples

```
'Galil DMC Code Example
:WE 1000,10000;'     Set encoder channel 0 to 1000, channel 1 to 10000
:
```

WE applies to RIO

WH *Which Handle*



WH

Usage	WH	Command takes no arguments
Operands	_WH	Operand has special meaning, see Remarks

Description

The WH command is used to identify the handle from which the command was received. This is useful for determining what interface or handle you are connected to.

Arguments

WH is an interrogation command with no parameters

Remarks

- _WH contains the numeric representation of the handle from which the command was received.
- The following table lists the possible string returned by WH, and the numerical value returned by _WH

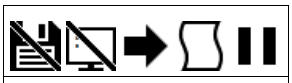
Communication Channel	WH	_WH	Notes
Main Serial Port	RS232	-1	
Ethernet Handle A	IHA	0	
Ethernet Handle B	IHB	1	
Ethernet Handle C	IHC	2	
Ethernet Handle D	IHD	3	Valid for RIO-47xx2 and RIO-473xx
Ethernet Handle E	IHE	4	Valid for RIO-47xx2 and RIO-473xx

Examples

```
'Galil DMC Code Example
:WH;' Request incoming handle identification
IHC
:MG _WH
2
```

WH applies to DMC40x0,DMC42x0,DMC41x3,DMC21x3,RIO,DMC30010,DMC50xx0

WT *Wait*



WT n

Usage	WT n ...	Arguments specified with an implicit, comma-separated order

Description

The WT command is a trippoint used to time events.When this command is executed, the controller will wait for the amout of time specified before executing the next command.

The amount of time in the WT command is specified in milliseconds

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
n	1	2,147,483,646	N/A	1	Number of milliseconds to hold execution of code.	

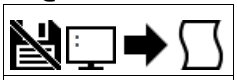
Remarks

- None

Examples

```
'Galil DMC Code Example
REM 2 seconds after input 1 goes low, turn on output 1 for 3 seconds
#main
AI -1;   'wait for input 1 to go low
WT 2000; 'wait 2 sec
SB 1;    'set output 1
WT 3000; 'wait 3 sec
CB 1;    'clear output 1
JP #main; 'start over again
```

XQ *Execute Program*



XQ #str,n_1
XQ n_0,n_1

Usage	XQ n ...	Arguments specified with an implicit, comma-separated order
Operands	_XQ0 _XQ1 _XQ2 _XQ3	Operand has special meaning, see Remarks

Description

The XQ command begins execution of a program residing in the program memory of the controller. Execution will start at the label or line number specified.

Up to 4 programs may be executed simultaneously to perform multitasking.

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
str	1 char	7 chars	See Notes	String	Label to begin code execution	If omitted, start from line 0 (n_0=0)
n_0	0	199	0	1	Line number to begin code execution	For RIO-47xx0
	0	399	0	1	Line number to begin code execution	For RIO-47xx2 and RIO-473xx
n_1	0	3	0	1	Thread number to execute code	

Remarks

- _XQn contains the current line number of execution for thread n, and -1 if thread t is not running.
- If using ED to add code, you must exit ED mode before executing code.

Examples

```
'Galil DMC Code Example
XQ #apple,0;'   Start execution at label apple, thread zero
XQ #data,2;'    Start execution at label data, thread two
XQ ;'           Start execution at line 0
```

ZC *User Variable, ZC*

ZC n

Usage	ZC n ...	Arguments specified with an implicit, comma-separated order
Operands	_ZC	Operand holds the value last set by the command

Description

ZC sets the first user variable. This variable provides a method for specific board information to be passed using the data record.

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
n	-2,147,483,648	2,147,483,647	0	1	Value of first User variable for the data record	

Remarks

- n is an integer and can be a number, controller operand, variable, mathematical function, or string.
- Only 4 bytes are available for n. Fractional values are not stored or sent via the data record

Examples

```
'Galil DMC Code Example
ZC 2343;' Sets the first user variable to a number (2343)
ZC "YO";' Sets the first user variable to a string (YO)
```

ZC applies to RIO

ZD *User Variable, ZD*

ZD n

Usage	ZD n ...	Arguments specified with an implicit, comma-separated order
Operands	_ZD	Operand holds the value last set by the command

Description

ZD sets the second user variable. This variable provides a method for specific board information to be passed using the data record.

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
n	-2,147,483,648	2,147,483,647	0	1	Value of second user variable for the data record	

Remarks

- n is an integer and can be a number, controller operand, variable, mathematical function, or string.
- Only 4 bytes are available for n. Fractional values are not stored or sent via the data record

Examples

```
'Galil DMC Code Example
ZD "INPT";'  Sets the second user variable to the string "INPT"
ZD 1234567;' Sets the second user variable to the number 1,234,567
```

ZD applies to RIO

ZS *Zero Subroutine Stack*

ZS n

Usage	ZS n ...	Arguments specified with an implicit, comma-separated order
Operands	_ZS0 _ZS1 _ZS2 _ZS3	Operand has special meaning, see Remarks

Description

The ZS command is used to clear the stack when finishing or leaving a subroutine. This command is used to avoid returning from an interrupt (either input or error). This turns the jump to subroutine into a jump. The status of the stack can be interrogated with the operand _ZS, see Remarks.

Arguments

Argument	Min	Max	Default	Resolution	Description	Notes
n	0	1	0	1	Sets zero stack operation	n = 0 clears the entire stack. n = 1 clears one level of the stack.

Remarks

- Do not use RI (Return from Interrupt) when using ZS.
  - To re-enable interrupts, you must use II command again.

Operand Usage

- _ZSn contains the stack level for the specified thread where n = 0 to 3.
  - The response, an integer between zero and sixteen, indicates zero for beginning condition and sixteen for the deepest value.

Examples

```
'Galil DMC Code Example
II 0,1,7;'       Input Interrupt on 7
#a;JP #a;EN;'   Main program
#ININT0;'        Input Interrupt
MG "INTERRUPT";'Print message
s= _ZS0;'          Interrogate stack before ZS
s= ?;'             Print stack
ZS;'             Zero stack
s= _ZS0;'          Interrogate stack after ZS
s= ?;'             Print stack
EN
```