

# QuickMotion Reference Guide

---

**Doc. No. 951-530017-019**

© 2007 - 2018 Control Technology Corp.

25 South Street  
Hopkinton, MA 01748

Phone: 508.435.9595  
Fax: 508.435.2373

Monday, March 5, 2018





# Table of Contents

|          |  |           |
|----------|--|-----------|
| <b>1</b> | <b>Chapter 1: Introduction and Overview</b>              | <b>7</b>  |
|          | <b>Guide to Symbols</b>                                  | <b>7</b>  |
|          | <b>Brief Overview of Motion Control</b>                  | <b>8</b>  |
|          | Servo Motor Applications                                 | 8         |
|          | Stepper Motor Applications                               | 9         |
|          | <b>Brief Overview of M3-40/41 Motion Module Features</b> | <b>10</b> |
|          | M3-40 & M3-41/IncentiveECAT Motion Module Features       | 12        |
|          | Special M3-40 I/O Functions                              | 13        |
|          | Drives & M3-41 IO  | 13        |
|          | QuickBuilder Motion Control Features                     | 14        |
|          | IO Assignments   | 15        |
|          | IO Assignments - M3-40A                                  | 15        |
|          | IO Assignments - M3-40B                                  | 16        |
|          | IO Assignments - M3-40C                                  | 17        |
|          | IO Assignments - M3-41A                                  | 18        |
| <b>2</b> | <b>Chapter 2: Motion Architecture</b>                    | <b>19</b> |
|          | <b>QuickBuilder</b>                                      | <b>20</b> |
|          | <b>QuickStep</b>   | <b>21</b> |
|          | <b>QuickMotion</b>                                       | <b>22</b> |
|          | Adding Motion to the 5300/Incentive Application          | 23        |
|          | The Axis Module  | 24        |
|          | The Axis Object  | 25        |
|          | The Motion Sequence Block                                | 26        |
|          | <b>Controlling Motion from QuickStep</b>                 | <b>27</b> |
|          | QS4 start Statement                                      | 27        |
|          | QS4 stop Statement                                       | 27        |
|          | Motion Architecture Summary Diagram                      | 28        |
| <b>3</b> | <b>Chapter 3: QuickMotion Axis Setup</b>                 | <b>31</b> |
|          | <b>Axis Properties</b>                                   | <b>32</b> |
|          | Basic Tuning   | 33        |
|          | Fine Tuning  | 34        |
|          | <b>Tuning an axis (5300 M3-40 Only)</b>                  | <b>35</b> |
| <b>4</b> | <b>Chapter 4: QuickMotion Programming</b>                | <b>37</b> |
|          | <b>Operating Modes</b>                                   | <b>37</b> |
|          | <b>Expressions</b>                                       | <b>38</b> |
|          | <b>Utility Statements</b>                                | <b>39</b> |
|          | <b>Program Flow Statements</b>                           | <b>44</b> |
|          | <b>Set Statements</b>                                    | <b>48</b> |
|          | <b>Common bits and variables</b>                         | <b>51</b> |
|          | <b>I/O Statements</b>                                    | <b>54</b> |
|          | <b>Simple Motion</b>                                     | <b>62</b> |
|          | <b>Gearing</b>   | <b>72</b> |
|          | <b>Position Capture &amp; Registration</b>               | <b>76</b> |
|          | <b>S-Curve</b>   | <b>78</b> |
|          | <b>Linear and Circular Interpolation (Vectors)</b>       | <b>80</b> |

|           |  |            |
|-----------|--|------------|
| <b>5</b>  | <b>Chapter 5: Camming and Data Tables</b> .....          | <b>81</b>  |
|           | <b>Loading Tables</b> .....                              | <b>84</b>  |
|           | <b>Using Tables for Spline/CAM</b> .....                 | <b>88</b>  |
|           | <b>Accessing Table Data</b> .....                        | <b>92</b>  |
|           | Diagnosing Table Issues.....                             | 93         |
|           | <b>Microsoft Excel as Table Data</b> .....               | <b>94</b>  |
|           | <b>Virtual Master</b> .....                              | <b>95</b>  |
|           | Broadcasting (M3-40 only).....                           | 96         |
|           | <b>Segmented Moves and Examples</b> .....                | <b>97</b>  |
|           | Concept .....  | 97         |
|           | Commands.....  | 98         |
|           | Examples.....  | 100        |
| <b>6</b>  | <b>Chapter 6: Motion Variables</b> .....                 | <b>105</b> |
|           | <b>QuickMotion User-defined Variables</b> .....          | <b>105</b> |
|           | <b>QuickMotion Pre-defined Variables</b> .....           | <b>107</b> |
|           | <b>Host Register Access</b> .....                        | <b>137</b> |
| <b>7</b>  | <b>Chapter 7: Quickstep Support</b> .....                | <b>139</b> |
|           | <b>Registers</b> .....                                   | <b>140</b> |
|           | <b>Quickstep Variables</b> .....                         | <b>145</b> |
|           | <b>Input Mapping (M3-40 Only)</b> .....                  | <b>148</b> |
| <b>8</b>  | <b>Chapter 8: Fault Codes &amp; MSB Debugging</b> .....  | <b>149</b> |
|           | <b>Fault Codes</b> .....                                 | <b>150</b> |
|           | <b>MSB Status/Control Monitor Fault Processing</b> ..... | <b>154</b> |
|           | <b>MSB Monitor</b> .....                                 | <b>156</b> |
| <b>9</b>  | <b>Appendix: Sample Code</b> .....                       | <b>159</b> |
| <b>10</b> | <b>Appendix: Command Hyperlinks</b> .....                | <b>163</b> |
|           | <b>Index</b>   | <b>167</b> |

## QuickMotion Reference Guide

Copyright © 2007-2018 Control Technology Corp. All Rights Reserved.

Control Technology Corp.  
25 South Street  
Hopkinton, MA 01748  
Phone: 508.435.9595 • Fax 508.435.2373

Document No. 951-530017-019

**⚠ WARNING:** Use of CTC Controllers and software is to be done only by experienced and qualified personnel who are responsible for the application and use of control equipment like the CTC controllers. These individuals must satisfy themselves that all necessary steps have been taken to assure that each application and use meets all performance and safety requirements, including any applicable laws, regulations, codes and/or standards. The information in this document is given as a general guide and all examples are for illustrative purposes only and are not intended for use in the actual application of CTC product. CTC products are not designed, sold, or marketed for use in any particular application or installation; this responsibility resides solely with the user. CTC does not assume any responsibility or liability, intellectual or otherwise for the use of CTC products.

The information in this document is subject to change without notice. The software described in this document is provided under license agreement and may be used and copied only in accordance with the terms of the license agreement. The information, drawings, and illustrations contained herein are the property of Control Technology Corporation. No part of this manual may be reproduced or distributed by any means, electronic or mechanical, for any purpose other than the purchaser's personal use, without the express written consent of Control Technology Corporation. Products that are referred to in this document may be either trademarks and/or registered trademarks of the respective owners. The publisher and the author make no claim to these trademarks.

While every precaution has been taken in the preparation of this document, the publisher and the author assume no responsibility for errors or omissions, or for damages resulting from the use of information contained in this document or from the use of programs and source code that may accompany it. In no event shall the publisher and the author be liable for any loss of profit or any other commercial damage caused or alleged to have been caused directly or indirectly by this document.

The information in this document is current as of the following Hardware and Firmware revision levels. Some features may not be supported in earlier revisions. See [www.ctc-control.com](http://www.ctc-control.com) for the availability of firmware updates or contact CTC Technical Support.

| Model Number | QuickBuilder Revision    | Controller Firmware Revision | M3-40 Firmware Revision | M3-41 Firmware Revision | IncentiveECAT Embedded PC |
|--------------|--------------------------|------------------------------|-------------------------|-------------------------|---------------------------|
| 5300         | >=1.2.6620<br>02/15/2018 | >=<br>5.00.90R70.11          | >= 1.45                 | >= 1.84                 | >=1.84                    |



# 1 Chapter 1: Introduction and Overview

This document provides details about adding motion control to a QuickBuilder project. QuickBuilder is CTC's integrated desktop development environment for the 5300 and Incentive PC series automation controllers. The primary programming language used in QuickBuilder is QuickStep4 (QS4). The QuickStep multi-tasking state language was invented by CTC in the 1980s to simplify the process of programming high performance machine control applications. Over the years QuickStep has been continually refined, and now it has been extended with the addition of QuickMotion to be able to easily handle even the most demanding motion control applications in a very intuitive manner.

The focus of this document is the QuickMotion extension to QuickBuilder. It is assumed that the reader is already familiar with the QuickBuilder environment and programming language. This document should be used in conjunction with the QuickBuilder Reference Guide.

This document is valid for use with the following motion modules:

- M3-40A: 2 Axis Servo Module
- M3-40B: 3 axis Stepper/High-speed Counter Module (24V)
- M3-40C: 3 axis Stepper/High-speed Counter Module (5V)
- M3-41A: 5300 Hardware Module for EtherCAT (reference this guide and EtherCAT Application Guide for added features)
- IncentiveECAT: Embedded PC Real-time Software for EtherCAT (reference this guide and EtherCAT Application Guide for added features)

Detailed data sheets for these motion modules may be found on CTC's website, [www.ctc-control.com](http://www.ctc-control.com).

**⚠** Note: The M3-41A is available both as hardware, for the 5300 PLC, and as a software component as part of a PC based EtherCAT master, IncentiveECAT. IncentiveECAT executes the exact same M3-40 motion control code except with enhancements for a virtual hardware environment. IncentivePLC runs on the PC as well, running the same QuickBuilder software, hence full compatibility with their hardware (5300 PLC) counterpart. From a software perspective almost all of the commands used on the M3-40 module apply directly to the M3-41A and IncentiveECAT. References to software features and language instructions that follow for the M3-40 can be assumed to apply to the M3-41A/IncentiveECAT except as noted.

## 1.1 Guide to Symbols

Features that warrant caution or special consideration are denoted by a **⚠**.

A command or statement that is supported by a given mode or block is denoted by a checked box . Unsupported commands and statements are denoted by an empty checkbox .

## 1.2 Brief Overview of Motion Control

### 1.2.1 Servo Motor Applications

---

#### Background

---

A servo motor is used in a closed loop control system, where the controller has information about both the actual position and velocity of the motor as well as the desired position (or velocity). The controller then adjusts the motor's output to remove the difference between the actual and desired values. Because this system has information about the error, and the output (which is usually proportional to the motor power) increases as the error increases, it can require very little power when the error is small.

This means that the average power needed for a high performance application may be considerably less than the peak power, so smaller motors and drives may be used.

There is usually a Servo Drive module between the motion controller and the motor that accepts the control signal (torque or velocity command) from the motion controller (a low current signal in the range -10 Volts to +10 Volts) and converts it into the high power (depending on the motor, several amps of current at 24V to 200+V) signals required by the motor. The Servo Drive must usually be configured to match the Motor (or is designed specifically for the motor). The drive and the motor are often, but not necessarily, made by the same manufacturer. The motor may be a simple brush type DC motor (which is low cost but requires periodic replacement of brushes) or a Brushless DC or AC motor, which requires additional circuitry in the Servo Drive to handle electronic commutation and will generally require additional sensors and signals from the motor to the driver.

---

#### Controlling the Servo Motor

---

The Model 5300 automation controller can be used to control up to 64 axes of servo motors. To control motion, an M3-40A motion module is added to the system. The M3-40A module is a dual axis servo controller that can control 1 or 2 servo motor systems with Analog Torque or Velocity command and Quadrature encoder feedback. Additionally M3-41 EtherCAT modules can be add network based drives and IO.

---

#### Servo Command Output

---

The output of the Servo Controller is an Analog signal that can vary from -10V to 10V with 16 bit resolution. The analog output is used, via a servo amplifier, to control the current in a DC motor generating torque at the shaft. The amplifier may also handle other functions such as commutation for a brushless motor or it may use the analog input to control the velocity. Care must be taken in the wiring to minimize the possibility of errors being introduced into the signal by noise induced from any high power switching circuitry near to the system, since this will directly affect the quality of the control.

 Shielded cabling must be used between the Servo Controller and the Servo Drive and the distance between them should be minimized.

---

#### Encoder Feedback

---

An encoder mounted to the motor generates two pulse signals (A, B) that are used by the M3-40A module to track the motor position. The M3-40A module can also accept a third encoder channel (the Z axis or Index) that can be used to identify a specific point in the motor rotation. This Z pulse is typically used for accurate homing of the motor.

The M3-40A encoder inputs accept a quadrature differential signal for the A and B encoder channels. The index pulse, or Z channel, is also accepted as a differential signal. The direction is counted positive, or clockwise (CW)

when the A encoder phase leads the B encoder phase. Indicator LEDs for each servo axis on the module indicate the states of the A and B channels.

For some Brushless Servo systems, the Servo Drive also uses an encoder for information about the position and will provide a set of suitable encoder outputs for connection to the Servo Controller. In this case the power for the encoder is usually provided by the Servo Drive and it is not necessary to connect power for the encoder, but it is recommended that the controller's 5V return be connected to the common or return for the servo drive's encoder outputs. This limits the common mode voltage between the drive and controller and helps protect the encoder input circuits from damage caused by over voltage.

⚠ 5 VDC power is available from a dedicated 5V connector on the Model 5300 power supply modules. This connector also has a 5V return that is common to the controller's 24V return.

⚠ Shielded cabling should be used for the encoder wiring between the Servo Controller and the Servo Drive and the distance between them should be minimized.

⚠ *When the encoder output is provided by the Servo Drive, care must be taken that the signals are actually encoder signals and are not a simulated encoder generated by the Servo Drive from other signals. When the outputs are simulated encoder signals, there is generally a delay between the movement of the motor and the encoder signal generation. When this delay is small this is not a concern, but since the M3-40A updates the servo command at a rate of over 1250Hz, delays as small as 200µs can be significant.*

⚠ *Reference the EtherCAT Application Guide for details on the M3-41 and IncentiveECAT modules.*

The M3-40A module also has five high speed inputs and five high speed outputs that can be configured for a wide variety of functions via software. See [IO Assignments](#) later in this chapter and the [Model 5300 module data sheets](#) at <http://www.etc-control.com/customer/techinfo/idxdocs5300.asp> for more details.

## 1.2.2 Stepper Motor Applications

---

### Background

---

Stepper motors are typically used in open loop applications. A stepper motor has a fixed number of magnetic poles that determine how many steps the motor will move through during one revolution. Most stepping motors have 200 full steps that can be subdivided into smaller increments via microstepping technology built into the stepper drive. Microstepping drives can boost the number of steps per revolution to 50,000 or more providing smoother motion and more precise positioning.

---

### Controlling the Stepper Motor

---

The Model 5300 automation controller can be used to control up to 64 axes of stepper motors. The motors are connected to a matched stepper drive, and then the stepper drive is commanded by the Model 5300 motion module. To control motion, an M3-40B or M3-40C stepper motion control module is added to the system. These modules are configured in QuickBuilder to match the steps per revolution of the stepper drive so that programming can be done in user units. The M3-40B/C module is a dual axis stepper controller that can control up to three stepper axes by putting out a step and direction command to the drive.

---

## Encoder Feedback (optional)

---

Normally, stepper motor applications are designed to operate in an open-loop mode where there is no encoder feedback. However the M3-40B/C modules have one encoder input for each primary axis and they can be configured to monitor position via the encoder as a check on the commanded position. The encoder inputs accept a quadrature differential signal for the A and B encoder channels. The index pulse, or Z channel, is also accepted as a differential signal. The direction is counted positive, or clockwise (CW) when the A encoder phase leads the B encoder phase. Indicator LEDs for each servo axis on the module indicate the states of the A and B channels.

⚠ 5 VDC power for encoders is available from a dedicated 5V connector on the Model 5300 power supply modules. This connector also has a 5V return that is common to the controller's 24V return.

⚠ Shielded cabling should be used for the encoder wiring and the distance should be minimized.

⚠ *When the encoder output is provided by the Stepper Drive, care must be taken that the signals are actually encoder signals and are not a simulated encoder generated by the Stepper Drive from other signals. When the outputs are simulated encoder signals, there is generally a delay between the movement of the motor and the encoder signal generation. When this delay is small this is not a concern, but since the M3-40B/C updates the stepper command at a rate of over 1250Hz, delays as small as 200µs can be significant.*

The M3-40B/C modules also have five high speed inputs and five high speed outputs that can be configured for a wide variety of functions via software. See [IO Assignments](#) later in this chapter and the [Model 5300 module data sheets](#) at <http://www.ctc-control.com/customer/techinfo/idxdocs5300.asp> for more details.

### 1.3 Brief Overview of M3-40/41 Motion Module Features

High performance motion control can be easily achieved with Blue Fusion Model 5300 automation controllers by adding one or more M3-40 motion modules. The M3-40 series modules are two axis motion control modules specifically designed for the Blue Fusion Model 5300 controller. They can be used to command motion on both servo and stepper motor drive systems. The M3-40 uses space saving design features that enable it to fit into a single rack slot in the Model 5300 controller. Up to 32 of the M3-40 modules can be installed into a single Model 5300 system, allowing for up to 64 axes of motion control.

Motion performance is maintained even as axes are added because each M3-40 has its own on-board processors that handle all motion related processing for two axes. CTC has fitted each dual axis module with a powerful RISC processor as well as CTC's new Motion Accelerator Chip (MAC). This gives the M3-40 modules the ability to run CTC's latest 64-bit floating point motion loops and handle local high-speed I/O events.

There are currently three M3-40 modules that can be used in the Model 5300 automation controller and one M3-41:

- M3-40A: 2 Axis Servo Module
- M3-40B: 3 Axis Stepper / High Speed Counter Module, 24V command
- M3-40C: 3 Axis Stepper / High Speed Counter Module, 5V command
- M3-41A: EtherCAT Master for both motion and IO automation control

---

## Hardware Features

---

Each module is capable of controlling two axes of closed loop motion. The M3-40A can be connected to either stepper or servo drives. Each M3-40A axis has a precision 16-bit analog command signal that can command both torque and velocity mode drives, giving the designer great flexibility in motor and drive selection. Alternatively, each axis can also be set up to output step and direction signals to interface to stepper drives or intelligent servo indexers. The M3-40B and M3-40C do not have analog command capability and therefore are best suited for stepper applications.

All modules have two primary axes of control and most hardware and software functionality is divided accordingly. Each primary axis has encoder feedback inputs that operate at rates up to 17.5 MHz, accommodating even the fastest linear motors. Each primary axis has five fast user assignable inputs and five fast user assignable outputs. In addition, it is possible to configure two of the outputs on the M3-40 module (40A/B/C) to command a third open loop stepper. See the [Alternative Stepper Output](#) statement in the I/O Statements section of Chapter 4 for more on this topic.

---

## Software Features

---

While the M3-40's hardware is impressive, its software capabilities are what really set it apart from the competition. The software has been designed to simplify and speed every step of the machine development process. To set up a motion axis, simply "drop" an axis object into the QuickBuilder Resource Manager. Then it can be easily configured using convenient user-units and other fill-in-the-blank properties. Dialog boxes and tuning wizards de-mystify the whole servo setup and tuning process.

CTC has taken a very modular approach to QuickBuilder's motion control capabilities. To create motion on an axis, one or more motion commands are placed in an object called a Motion Sequence Block (MSB). After creation, that MSB can be used by any of the axes at any time. A simple example would be a homing MSB – write it once, and then use it on as many axes as desired.

To further simplify the motion programming process, CTC has created an extension to the QuickStep language within QuickBuilder called QuickMotion, which has more than 50 new commands and more than 100 specialized motion variables. QuickMotion makes programming motion applications very intuitive. For example, if one wanted to move an actuator 3.76 inches in 1.25 seconds the command would be:

*Move to 3.76 in 1.25*

Of course, 3.76 could just as easily be a variable or an expression that is calculated on the fly.

---

## M3-40 and M3-41 Module Data sheets

---

Refer to Document No. 950-534001: [Model M3-40A data sheet](http://www.ctc-control.com/customer/techinfo/docs/5300_950/950-534001.pdf) at [http://www.ctc-control.com/customer/techinfo/docs/5300\\_950/950-534001.pdf](http://www.ctc-control.com/customer/techinfo/docs/5300_950/950-534001.pdf) for more detailed information on the M3-40A module.

Refer to Document No. 950-534002: [Model M3-40B data sheet](http://www.ctc-control.com/customer/techinfo/docs/5300_950/950-534002.pdf) at [http://www.ctc-control.com/customer/techinfo/docs/5300\\_950/950-534002.pdf](http://www.ctc-control.com/customer/techinfo/docs/5300_950/950-534002.pdf) for more detailed information on the M3-40B module.

Refer to Document No. 950-534003: [Model M3-40C data sheet](http://www.ctc-control.com/customer/techinfo/docs/5300_950/950-534003.pdf) at [http://www.ctc-control.com/customer/techinfo/docs/5300\\_950/950-534003.pdf](http://www.ctc-control.com/customer/techinfo/docs/5300_950/950-534003.pdf) for more detailed information on the M3-40C module.

Refer to Document No. 950-534101: [Model M3-41 data sheet](http://www.ctc-control.com/customer/techinfo/docs/5300_950/950-534101.pdf) at [http://www.ctc-control.com/customer/techinfo/docs/5300\\_950/950-534101.pdf](http://www.ctc-control.com/customer/techinfo/docs/5300_950/950-534101.pdf) for more detailed information on the M3-41 module.

### 1.3.1 M3-40 & M3-41/IncentiveECAT Motion Module Features

#### M3-40

- Two axes of servo or stepper control per module
- Up to 64 axes per Model 5300 system
- Position loop update times of 800µs / 2 axes (as fast as 500µs under software selection)
- Encoder feedback up to 17.5 MHz
- 64-bit floating point loop control
- 16-bit analog command (M3-40A only)
- 5 user assignable inputs / axis
- 5 user assignable outputs / axis
- High speed registration capture
- High speed PLS outputs
- 48 user variables per axis

#### M3-41/IncentiveECAT

- 64-bit floating point loop control
- Up to 16 axes per network. 64 axis with IncentiveECAT. Multiple networks supported as well as redundant master (PC only) and secondary master
- Virtual axis/master support
- Up to 2000 I/O points using remote I/O
- 500µs, 1 mS, 2 mS, or 4 mS updates on all axes
- Any axis can track/gear/cam off any other
- Registration Capability
- Commands: linear, S-curve, Cam, Spline, Gear, Move on a gear, Segmented moves
- Syncs master to slaves - provides simultaneous motions
- EtherCAT motion modes:
  - Cyclic Sync Position
  - Interpolated Position
  - Profile Position
  - Profile Velocity
- Network auto configuration
- Support for absolute encoding
- Link software counters to any input
- Link PWM outputs to any output
- 48 user variables per axis
- M3-41 has 3 encoder inputs which can also be used as a master encoder for EtherCAT axis
- Segmented EtherCAT packets for large networks

### 1.3.2 Special M3-40 I/O Functions

- **16 HS Counters (10 MHz):** All five inputs as well as the A, B, and Z signal pins on each axis connector can be configured as high-speed counters.
- **Period Measurement (0.1  $\mu$ sec accuracy):** Two pairs of inputs on each axis can be set up to measure the time between activation of the first and second input in the pair. Ideal for high-speed measurement and frequency measurement.
- **Frequency Outputs:** Three outputs on each axis can generate a programmable frequency up to 500 KHz.
- **Pulse Outputs:** All ten outputs can be pulsed for a programmable time value with an accuracy of 0.5 msec.
- **Programmable Limit Switch Outputs:** Three outputs on each axis can be configured to automatically turn on and off as a function of the encoder position. Up to sixteen on/off positions can be configured per axis. The on/off positions can be changed programmatically on-the-fly. This is especially useful to compensate for lead or lag time based on operating speed.

### 1.3.3 Drives & M3-41 IO

Some drives support inputs and outputs at the remote drive level. The MSB property 'dins' represents the raw inputs provided by the drive, up to 32 inputs (EtherCAT object 0x60FD.0). The first 10 inputs may be accessed using 'din1' to 'din10' bit properties; as with the M3-40 modules.

Outputs operate as they do on the M3-40 module, limited to 8 outputs at the remote drive level (object 0x60FE.1). Use the 'setout' and 'clout' MSB instructions for access, where the first output is 1.

Local I/O is also present on the 5300 M3-41 EtherCAT module. This module has 6 inputs and 2 outputs which are global to all MSBs. The outputs are referenced as 9 and 10 when using the 'setout'/'clout' instructions. The MSB property 'global\_inputs' is used to read the 6 inputs, with the first bit being the first input. The MSB property 'global\_outputs' can be used in addition to 'setout'/'clout' for read/write operations of the local outputs.

Local global Inputs, P1 connector pins:

|       |      |
|-------|------|
| P1-11 | DIN1 |
| P1-13 | DIN2 |
| P1-15 | DIN3 |
| P1-12 | DIN4 |
| P1-14 | DIN5 |
| P1-16 | DIN6 |

Local global Outputs, P1 connector pins:

|       |       |
|-------|-------|
| P1-9  | DOUT1 |
| P1-10 | DOUT2 |



1. 'global\_inputs' and 'global\_outputs' axis properties may be accessed by QuickBuilder using the Axis name/property method: `axisname.property`. These two properties will contain the same value on all EtherCAT axes.

2. Chapter 6 discusses additional IO capabilities available from the MSB language using various IO arrays. These arrays give access not only to drive and module based IO but remote EtherCAT IO blocks such as those from Wago, Turck and Beckhoff. Some of the features include PLS, PWM, pulse, and atomic multi-bit access of 32 drive inputs/outputs, local and remote IO.

3. IncentiveECAT Version only supports drive I/O.

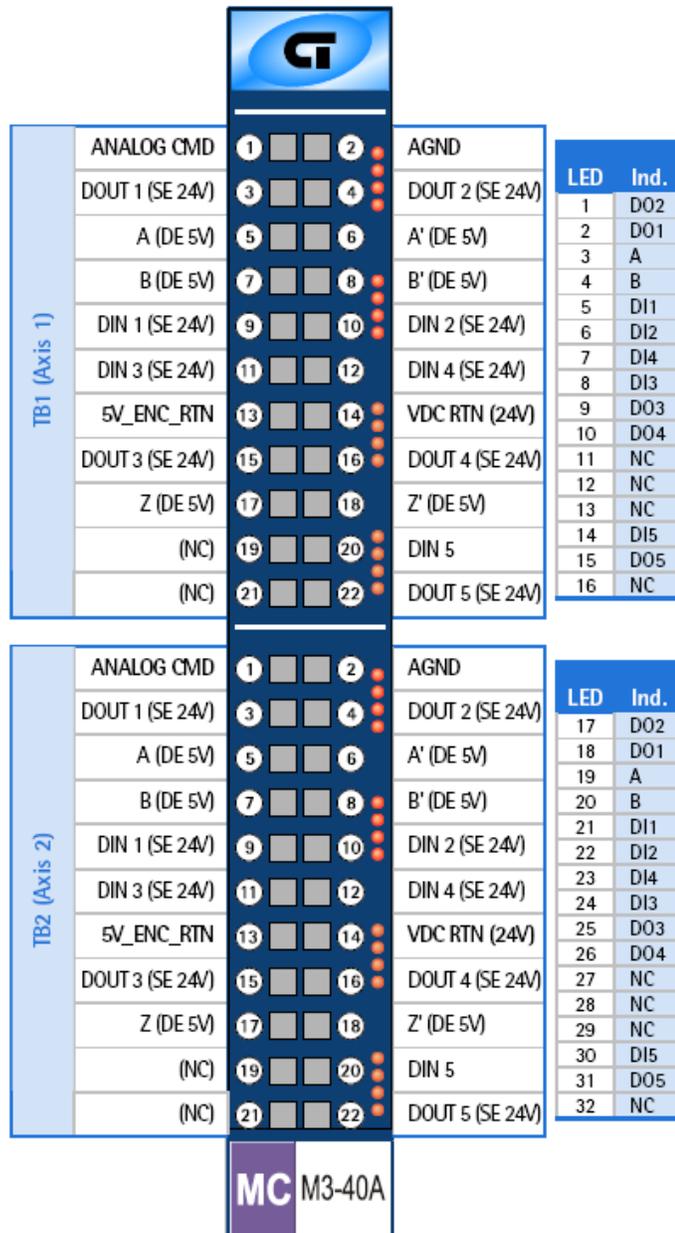
#### 1.3.4 QuickBuilder Motion Control Features

- Axis objects configured in the Resource Manager
- New tuning wizard simplifies tuning
- Monitor motion parameters in multiple watch windows
- Use QuickScope to chart motion and I/O timing
- Simple English commands
- Over 100 new motion variables
- Full user-unit support
- Soft limits and hard limits
- Asynchronous event handlers

### 1.3.5 IO Assignments

#### 1.3.5.1 IO Assignments - M3-40A

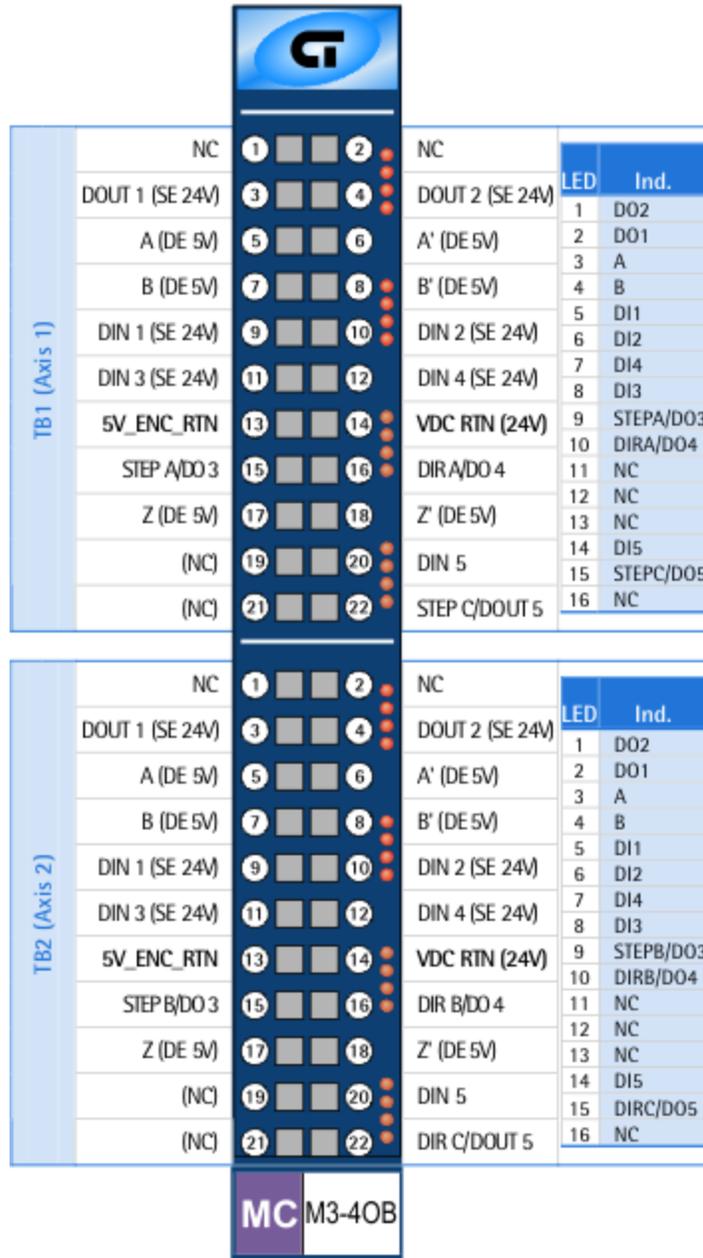
### Terminal block connections



⚠ Any two digital inputs can be configured in QuickBuilder to function as *registration inputs* 1 and 2. These digital inputs still function as general purpose inputs even when configured as *registration inputs*.

1.3.5.2 IO Assignments - M3-40B

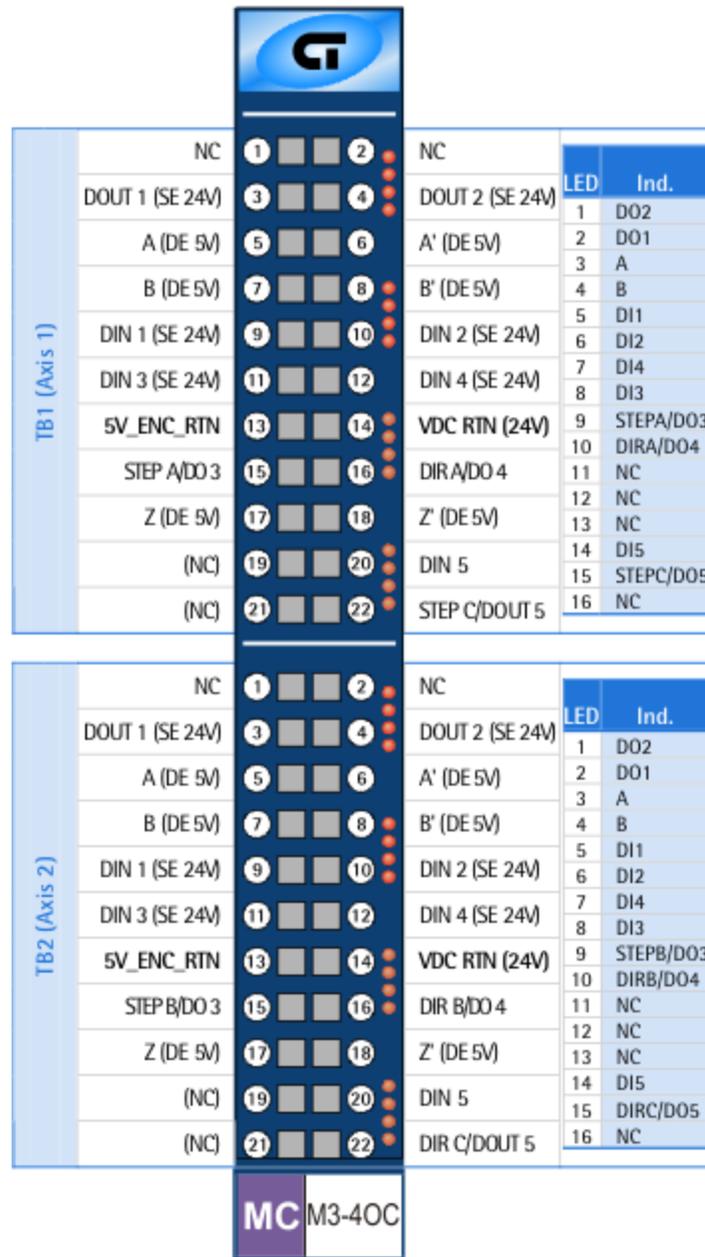
### Terminal block connections



1. All step and dir connections are single-ended 24V.

## 1.3.5.3 IO Assignments - M3-40C

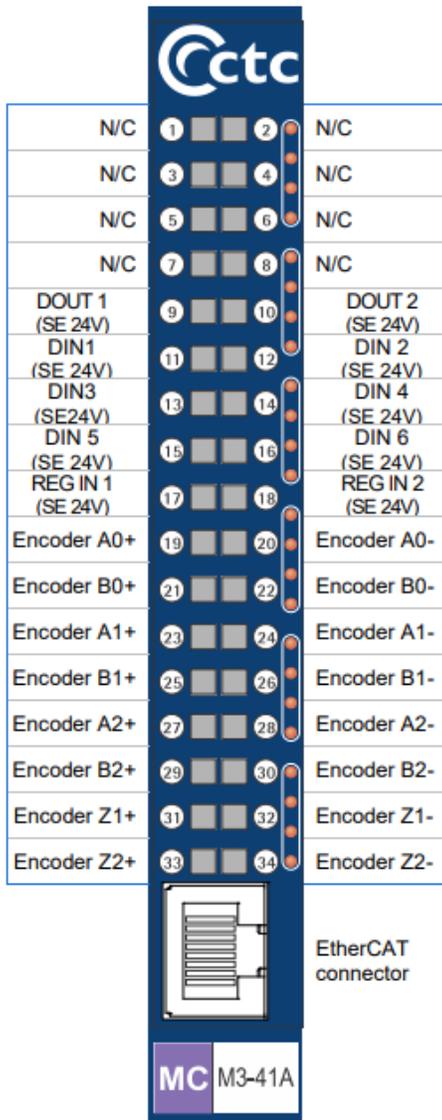
## Terminal block connections



- Step A/B and Dir A/B connections are single-ended 5V.  
Step/Dir C connections are single-ended 24V.

## 1.3.5.4 IO Assignments - M3-41A

## Terminal block connections



## Special I/O Functions

- **Three encoder inputs.** May be used as a master to any EtherCAT axis or as a general encoder
- **Six digital inputs**
- **Two digital outputs**
- **Two registration inputs**
- **Software counters**
- **PWM outputs**
- **Up to 16 RFID channels**

For more information refer to the [CTC EtherCAT Applications Guide](#)

## 2 Chapter 2: Motion Architecture

The Model 5300 PLC uses a powerful distributed architecture approach to solving machine control applications. The overall machine control program – called a QuickBuilder project – runs on the main CPU of the Model 5300 Automation Controller. It provides the primary guidance for the application and is in charge of communications with the outside world and the local Model 5300 I/O, motion, and specialty modules. The distributed nature of the Model 5300 design allows portions of the project to be passed to intelligent Model 5300 modules for local processing. This distribution of processing tasks and the overall coordination between modules and the main CPU is taken care of automatically by QuickBuilder.

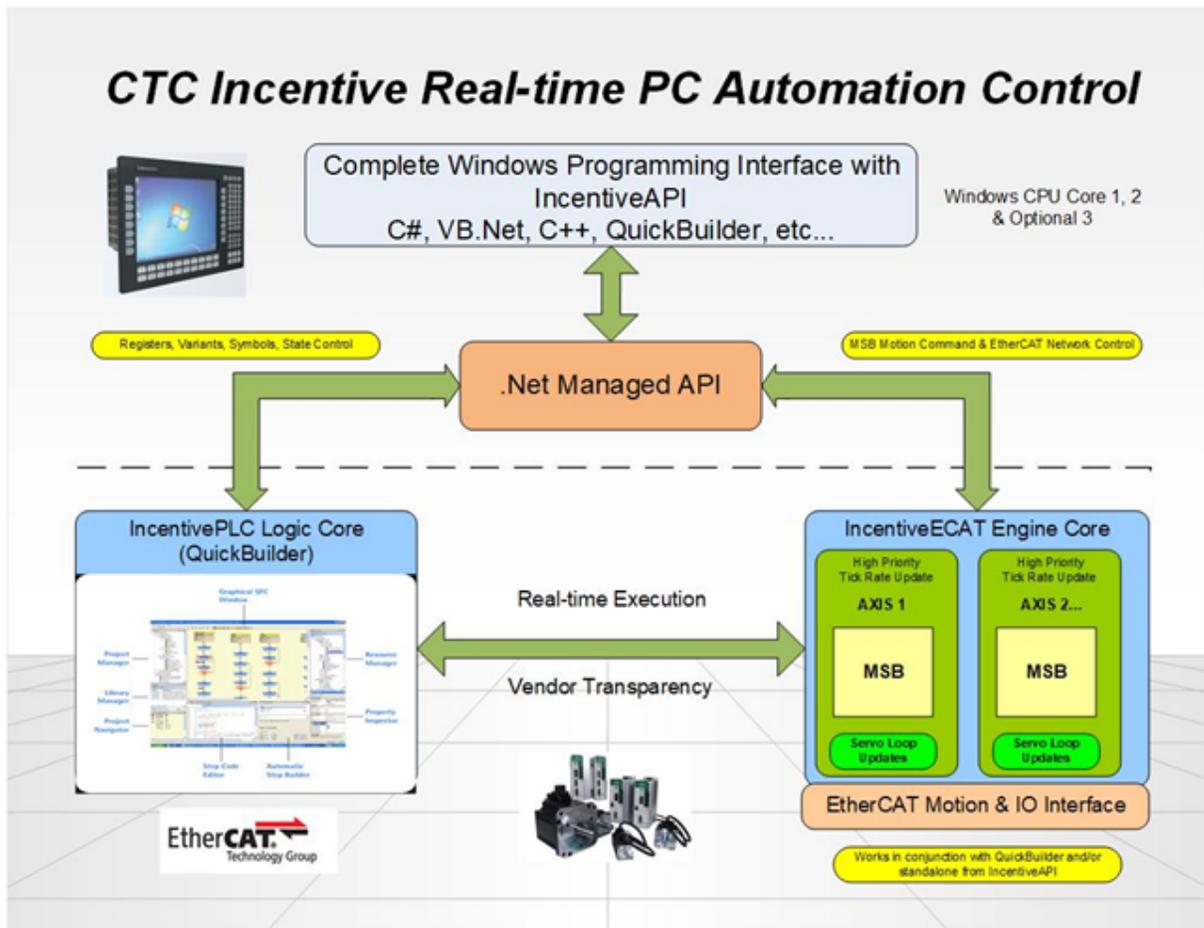
The result is a significant improvement in machine performance by off loading demanding processor-intensive functions like motion control tasks to specialized motion control processors on the Model 5300 Motion Modules. Even though this process takes place automatically, it's important for the automation engineer to have a basic understanding of the architecture of the Model 5300 controller and how it interacts with the QuickBuilder project.

The 5300 backplane can accommodate multiple modules of the following type:

- M3-40A: 2 Axis Servo Module
- M3-40B: 3 axis Stepper/High-speed Counter Module (24V)
- M3-40C: 3 axis Stepper/High-speed Counter Module (5V)
- M3-41A: 5300 Hardware Module for EtherCAT (reference this guide and EtherCAT Application Guide for added features)

With the release of EtherCAT motion support for the 5300 a new architecture was introduced, that of virtual network based devices. Once perfected it became apparent that there was a strong industry need to move the PLC and motion architecture to an embedded PC platform where a seamless interface could be provided to .Net programmers. This is known as the IncentivePLC and IncentiveECAT PC based software modules. These modules run the exact same environment as the 5300 PLC, in real-time, using dedicated cores of the PC. Both a real-time operating system and Windows run in parallel, communicating through shared memory. IncentiveAPI is provided to provide a seamless interface to the real-time world from programming languages such as C#, VB.NET, and C++.

The structure of the virtual PLC environment looks something like the following:

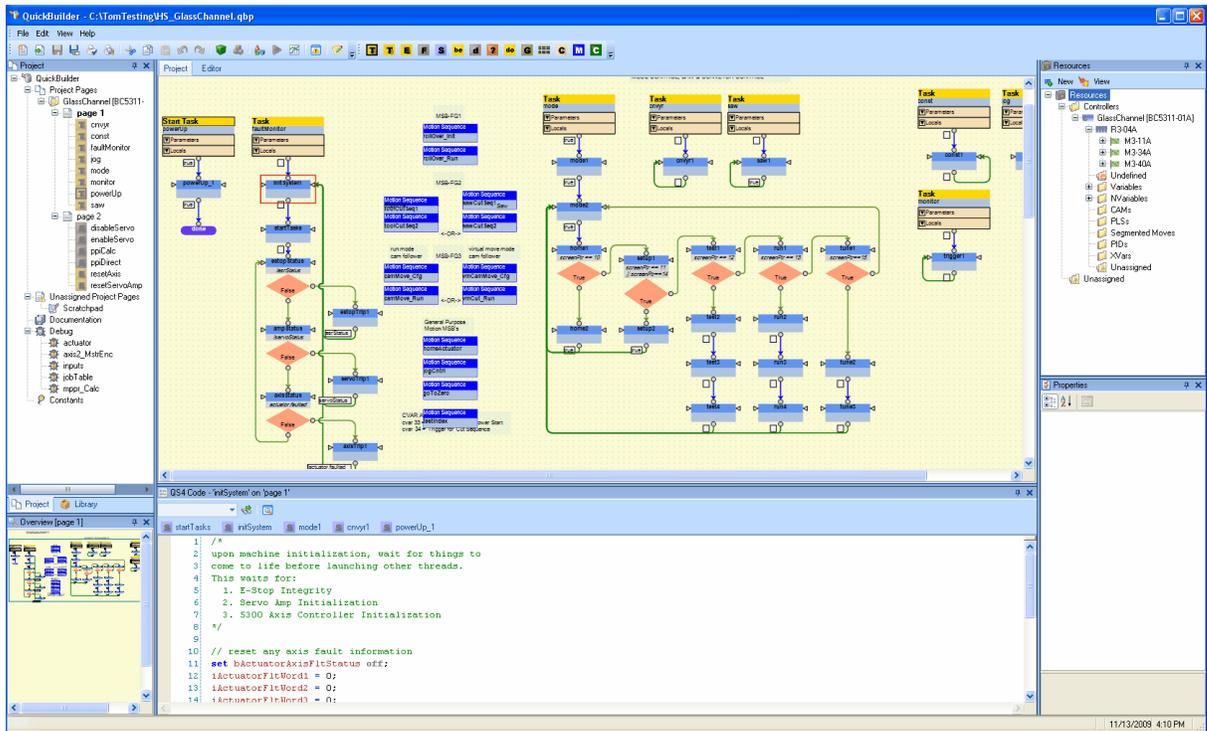


Both the 5300 PLC and Incentive products are programmed using the exact same tools. Before we get into the details of how to add motion to a QuickBuilder project, we'll first review the major elements of the software architecture:

- [QuickBuilder](#), the software application used to program Model 5300 controllers
- [QuickStep](#), the programming language used in QuickBuilder
- [QuickMotion](#), an extension to the QuickBuilder application that is tailored to handling motion control.

## 2.1 QuickBuilder

QuickBuilder is CTC's innovative graphical development environment built using the latest .NET technology, making it very intuitive to use. It combines all the aspects of an automation project into one easy to use desktop application. This holistic approach to solving automation projects leads to quicker machine startups and simpler understanding of even the most advanced automation tasks. The key to simplifying the automation process is to break the overall process down into the operating states of each of its elements.



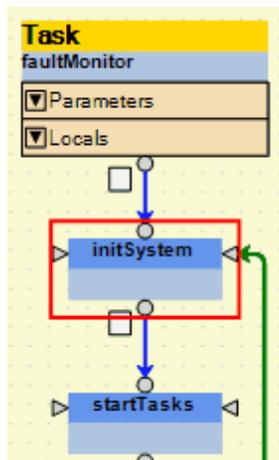
QuickBuilder desktop showing three tasks. A single step is highlighted in red.

A QuickBuilder project is comprised of one or more tasks. Breaking the program into separate easily defined tasks greatly simplifies the programming process. A task contains multiple steps – where the steps represent a given operating state of the machine. Within the step are the actual instructions such as *wait for input*, *turn on output*, *move an actuator*, etc. It is also here at the instruction level that motion is initiated.

## 2.2 QuickStep

QuickStep is CTC's programming language used for the instructions within the steps. QuickStep was originally invented by CTC in the 1980's and has been proven in thousands of automation projects. Over the years CTC has continually refined and upgraded the language. The current version of QuickStep is QuickStep4 (QS4). The screen captures below show a highlighted step from the flow chart window that is automatically linked to the QS4 editor.

The use of QuickBuilder and QuickStep are covered in their respective manuals, and the user should be familiar with their use prior to starting a motion application.



```

QS4 Code - 'initSystem' on 'page 1'
startTasks  initSystem  mode1  cnvyr1  powerUp_1

1  /*
2  upon machine initialization, wait for things to
3  come to life before launching other threads.
4  This waits for:
5     1. E-Stop Integrity
6     2. Servo Amp Initialization
7     3. 5300 Axis Controller Initialization
8  */
9
10 // reset any axis fault information
11 set bActuatorAxisFltStatus off;
12 iActuatorFltWord1 = 0;
13 iActuatorFltWord2 = 0;
14 iActuatorFltWord3 = 0;

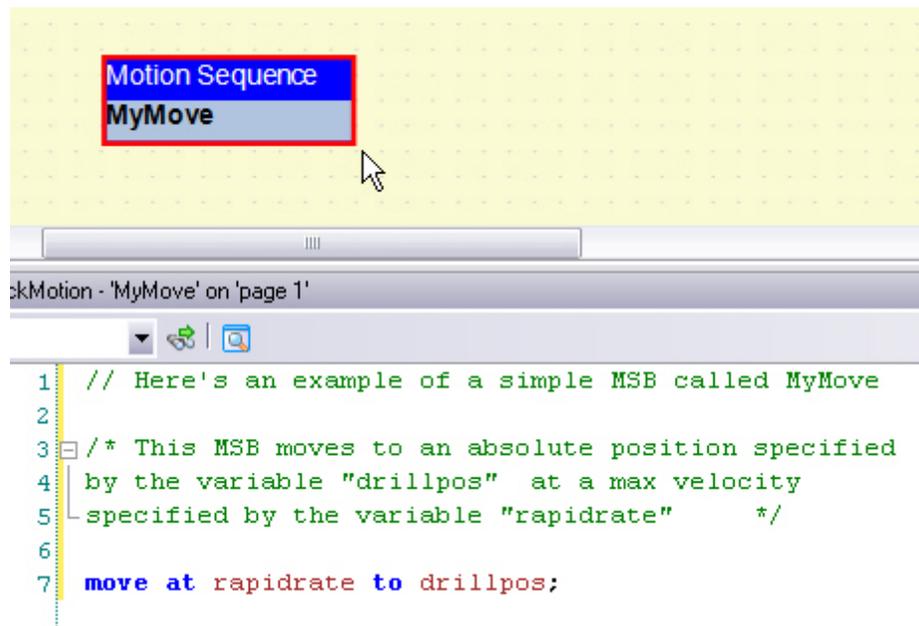
```

## 2.3 QuickMotion

QuickMotion is a specialized extension of QuickBuilder that is designed for motion control applications. It has been optimized to simplify the motion control process and to take advantage of the distributed architecture. QuickMotion instructions are entered into specialized tasks called Motion Sequence Blocks (MSBs).

The MSBs are coded within the QuickBuilder environment in the same way as steps are coded in QuickStep: Drag the MSB symbol onto the graphical desktop, give it a name, then use the editor to add the appropriate instructions. But there are two big differences:

1. an MSB is both a step and a task
2. a single MSB may be used by any number of axes.



By way of a practical example, think of the common motion control operation of homing an axis. In older control schemes, designers were either forced to write this homing code over and over in the program or call some generic homing routine hard coded by the motion control manufacturer. With QuickMotion, it is easy to create a customized homing MSB once, give it a name, and then use a QuickStep statement to start that MSB on any axis whenever an axis needs to be homed.

### 2.3.1 Adding Motion to the 5300/Incentive Application

The main components used in motion control are:

- The [Axis Module](#): The physical motion module in the rack
- The [Axis Object](#): The QuickBuilder Resource representing an axis on that physical module.
- The [MSB](#): The Motion Sequence Block, which contains one or more motion statements that execute on the Axis Module's CPU under the supervision of QuickStep.

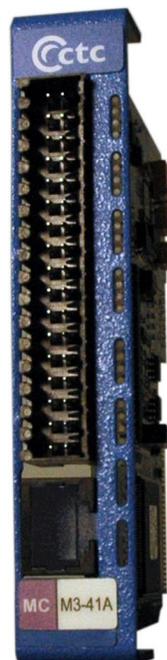
### 2.3.1.1 The Axis Module

A Model 5300 axis module is inserted into the Model 5300 rack just like any other I/O module. CTC offers axis modules that can control one or more motion axes. Each motion module contains its own CPU and Motion Accelerator Chip (MAC), ensuring consistent high performance motion control regardless of the number of axes to be controlled.

*M3-40A: Example of a Model 5300 Axis Module*



*M3-41A: Example of a Model 5300 EtherCAT Module*



IncentiveECAT is a software module running on an embedded PC that is responsible for all the motion control. IncentivePLC runs the main QuickBuilder logic application. Something called MSB's, or Motion Sequence Blocks executes in real-time within the IncentiveECAT process, detailed later. A popular choice for an embedded PC integrates the HMI with automation control as shown below:



### 2.3.1.2 The Axis Object

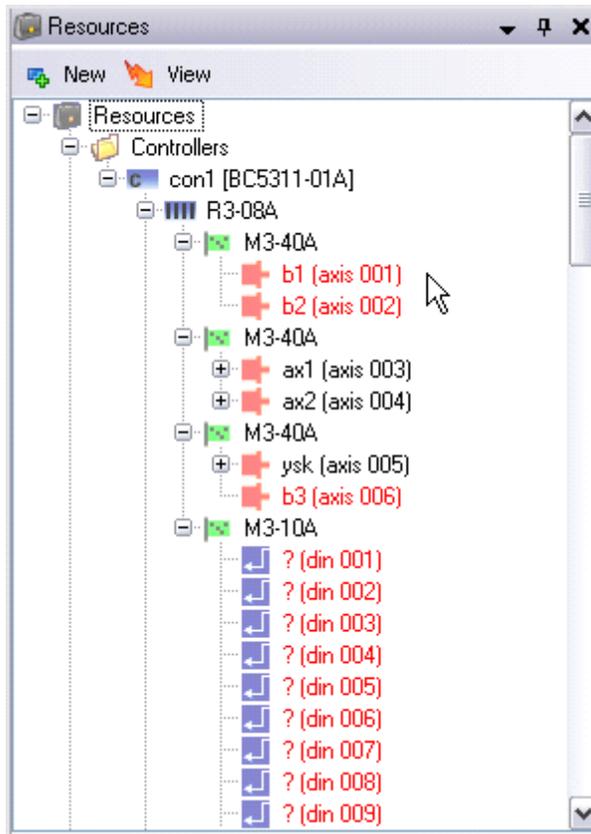
The *Axis* object represents a hardware-based or virtual axis associated with a servo or stepper drive. It is automatically created when a motion module is added to a rack in the Resource Manager. It typically consists of a controller module with various inputs and outputs that control the servo (or stepper) and usually feedback signals that are used to monitor position. Each axis can be commanded to perform some sequence of motion commands by the use of motion sequence blocks (MSBs). These MSBs appear in the QS4 program as stand-alone graphical elements.

*Axis* objects have many specialized properties that can be configured using the Property Inspector. Most of these properties can also be changed dynamically in the QuickBuilder project. Axis Objects have various inputs and outputs that control the servo (or stepper) and usually feedback signals that are used to monitor position.

When an MSB is selected, the programmed motion command sequence appears in the text editor window – the same window that is also used to edit QS4 code.

QuickStep4 can only start one motion sequence at a time for a given axis, but the active motion sequence can start other motion sequences (with some exceptions) that can run in parallel.

An MSB is not associated with any particular axis, which allows the same sequence to be reused many times for different axes.



### 2.3.1.3 The Motion Sequence Block

The Motion Sequence Block (MSB) element holds QuickMotion statement sequences. MSBs appear in the QuickBuilder project as stand-alone graphical elements. MSBs are not associated with any particular axis. This allows the same sequence to be reused many times for different axes, much like how a function works. MSBs are programmed using the QuickMotion language. An MSB may have only one QuickMotion statement, or it may have hundreds of statements.

The MSB is started on a given axis from QuickStep by using the *Start MSB* statement.

Once started, an MSB can start another MSB on its own that can run in parallel on the same axis. An MSB cannot start an MSB on another axis. This can only be done by QuickStep.

Up to 4 foreground MSBs can be running simultaneously. This limitation is imposed to guarantee high performance deterministic execution. A foreground MSB executes each of its statements at the loop update time of the Axis Module. This keeps them fast and in sync with the position loop.

In addition to the foreground MSBs, any number of background MSBs can be running simultaneously. The number of background MSBs is limited only by available memory on the Axis Module.

## Motion Sequence

### home

## 2.4 Controlling Motion from QuickStep

As mentioned earlier, QuickStep is in overall control of the project and as such, QuickStep has the ability to start and stop MSBs. There are actually only two Quickstep instructions pertaining to motion: *Start* and *Stop*.

- *Start*: Begins execution of the named motion sequence block (MSB) on the specified axis as a background MSB. This background MSB can then launch foreground MSBs on that axis. QuickStep can also directly launch foreground MSBs by using the FG option (start <axis> <msb> {optional FG/BG}, where FG is foreground and BG is background task.
- *Stop*: Stops execution of all foreground and background MSBs and thereby all motion.

In addition to these commands, QuickStep has extensive abilities to monitor and control MSBs on the axes while they are running via pre-defined and user-defined variables.

### 2.4.1 QS4 start Statement

This statement begins execution of the named motion sequence block (MSB) on the specified axis.

It is not an error to start another MSB when there is one already running for a given axis – however, if the named MSB is already running on a given axis, the start is effectively ignored.

```
start axis1 MSB1;           // start MSB1 on the axis called 'axis1', as
                             a background thread.

start axis1 MSB1 BG;       // start MSB1 on the axis called 'axis1', as
                             a background thread.

start axis1 MSB1 FG;       // start MSB1 on the axis called 'axis1', as
                             a foreground thread (run on each loop ticks, limited to 4).
```

### 2.4.2 QS4 stop Statement

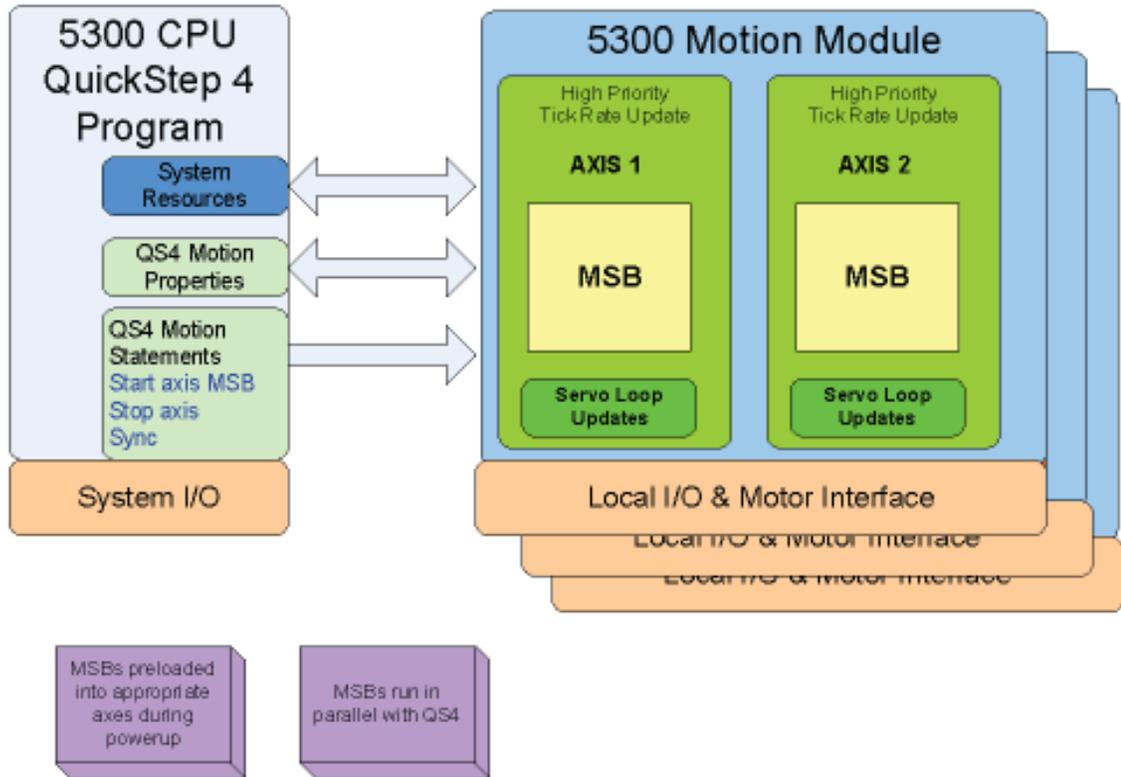
This statement stops execution of all MSBs on the named axis.

Example:

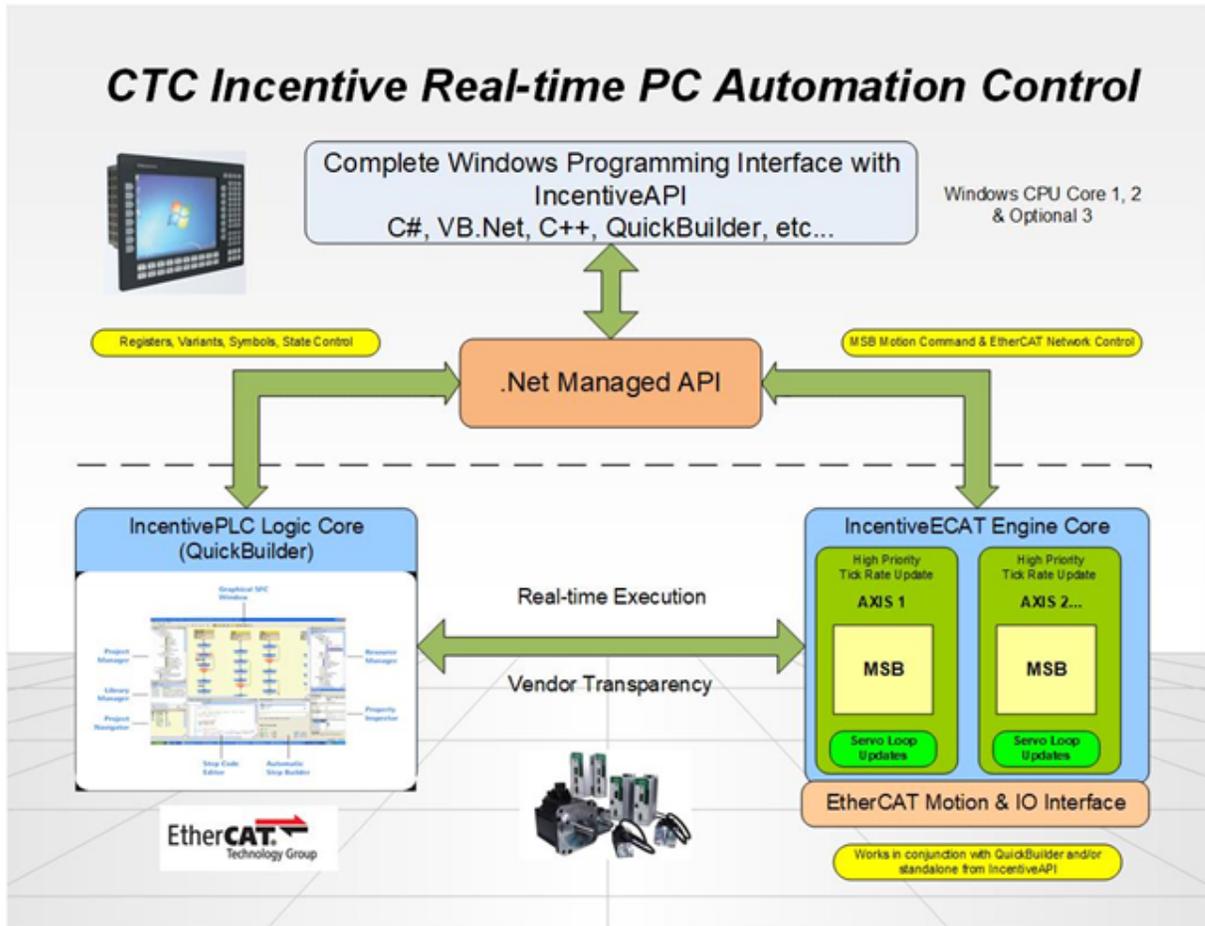
```
stop axis1;                // stop execution of all MSBs on 'axis1', this
                             stops immediately

stop axis1 slewed using 100; // stop execution of all MSBs on
                             'axis1', slewed stop at 100 user-units/sec/sec.
```

## 2.4.3 Motion Architecture Summary Diagram

**5300 PLC (M3-40/41)**

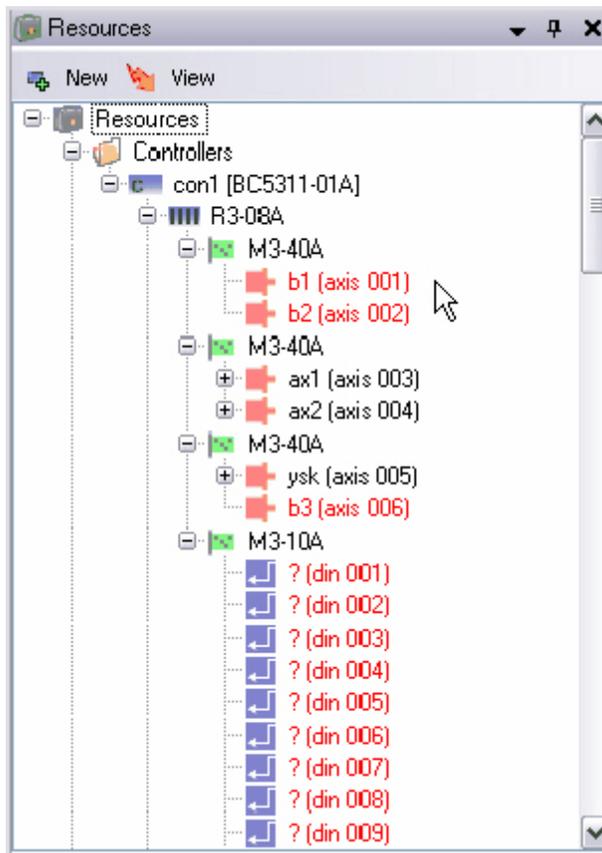
## IncentivePLC & IncentiveECAT Soft PC





### 3 Chapter 3: QuickMotion Axis Setup

Adding a motion axis to a QuickBuilder project is very similar to adding any other resource. The first thing that needs to be done is to add the axis module to the appropriate rack in the controller. This is done by right clicking the rack and selecting the appropriate module. For this discussion we will be adding a third M3-40A module to our first 8-slot rack. As with other module types, axes are automatically numbered from left to right starting at the CPU. So in this case the two axes on the third module are numbered 5 and 6.

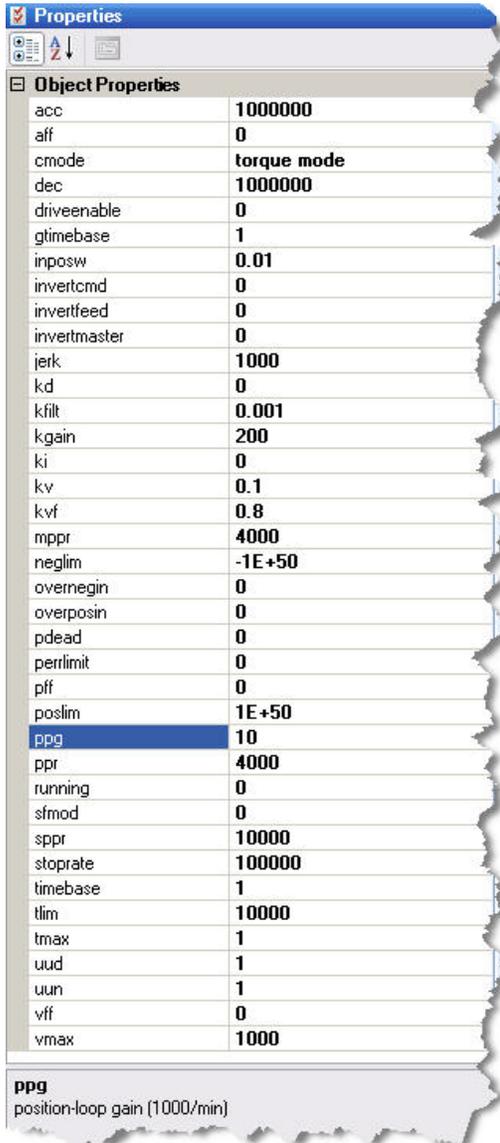


The axes first appear with question marks in their names, which must each be edited to a unique name. It is an error to have unnamed axes in a project. Right click and name the axis.

If the project changes, or the physical connection of the axes to the modules changes, axes can easily be rearranged in the Resource Manager. A single axis may be moved in the tree or a whole module can be moved as needed so that the named axes in the Resource Manager correspond to the actual wired axes.

After placing the *Axis* object in the proper place and naming it, the axis properties should be checked and updated as necessary. This is done in the property inspector window.

### 3.1 Axis Properties



| Object Properties |             |
|-------------------|-------------|
| acc               | 1000000     |
| aff               | 0           |
| cmode             | torque mode |
| dec               | 1000000     |
| driveenable       | 0           |
| gtimebase         | 1           |
| inposw            | 0.01        |
| invertcmd         | 0           |
| invertfeed        | 0           |
| invertmaster      | 0           |
| jerk              | 1000        |
| kd                | 0           |
| kfilt             | 0.001       |
| kgain             | 200         |
| ki                | 0           |
| kv                | 0.1         |
| kvf               | 0.8         |
| mppr              | 4000        |
| neglim            | -1E+50      |
| overnegin         | 0           |
| overposin         | 0           |
| pdead             | 0           |
| perlimit          | 0           |
| pff               | 0           |
| poslim            | 1E+50       |
| <b>ppg</b>        | <b>10</b>   |
| ppr               | 4000        |
| running           | 0           |
| sfmod             | 0           |
| sppr              | 10000       |
| stoprate          | 100000      |
| timebase          | 1           |
| tlim              | 10000       |
| tmax              | 1           |
| uud               | 1           |
| uun               | 1           |
| vff               | 0           |
| vmax              | 1000        |

**ppg**  
position-loop gain (1000/min)

When an *Axis* object is highlighted in QuickBuilder's Resource Manager, the following alphabetical property list for the axis is displayed. Required and Recommended properties to set up are reviewed below. Default values are given in [ ]. To learn more about these as well as the other properties, see the Variables Chapter later in this guide.

**Required**— When setting up an axis, the following properties must be set up in order for the Servo or Stepper Control module to properly interface with the connected motor and drive:

- **cmode:** Determines the command signal the controller sends out. Set to [Torque], Velocity, or Stepper.
- **tmax / vmax:** Depending on the drive type set, the maximum torque or velocity that will be realized by a 10V command from the controller. [1Nm/ 1000RPM]
- **ppr:** The number of feedback counts per revolution [4000]
- **sppr:** When operating in stepper mode, this value must be set to correspond to the steps/rev of the controlled stepper drive.

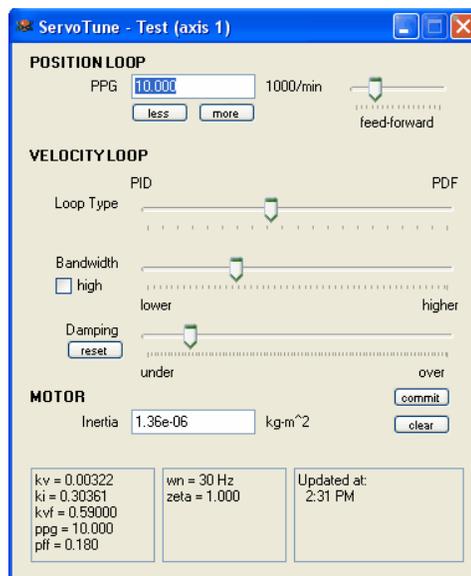
**Recommended**— Once the required properties have been entered, the axis can be tuned. However, it is recommended that the following properties also be checked and adjusted as necessary.

- **acc / dec:** Check that the acceleration / deceleration rates are appropriate. [10000000/10000000]
- **driveenable:** Set this to the output number that will be used to enable the servo drive. (Highly recommended that this be used. Use positive input number for true state=high; use negative number for true state=low.) [0=not used]

- **inposw:** The in-position window scaled in user units. This is used to determine when the drive has reached the commanded position. Use positive input number for true state=high; use negative number for true state=low. [0.01]
- **overnegin / overposin:** (Hardware over-travel limits) Set these to the input number to be used to signal positive and negative over-travel. Use positive input number for true state=high; use negative number for true state=low. [0=not used]
- **neglim / poslim:** (Software over-travel limits) Set these to the input number to be used to signal positive and negative overtravel. [-1E+50 / 1E+50]
- **perlimit:** This is the maximum allowed following error in user units before a fault is generated. [0=disable checking]
- **uun/uud:** User-units numerator and denominator. This fraction is used to convert revolutions to user units. [1/1]

**Other** — Many of the other properties are either automatically adjusted by the tuning wizard or are used for more specialized functions. Refer to [Chapter 5: Variables](#) for more details.

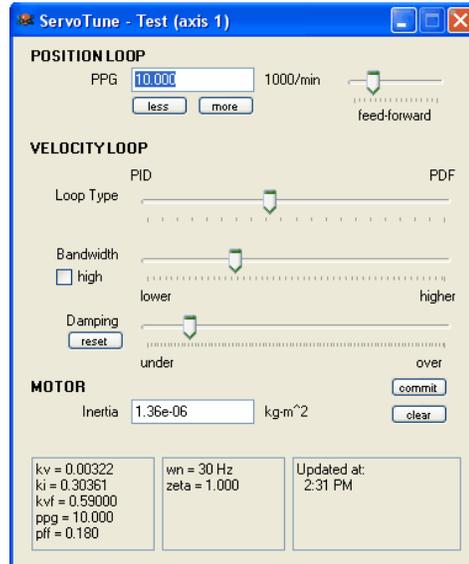
### 3.1.1 Basic Tuning



For basic tuning of an axis there is only one adjustment needed: adjust the Bandwidth slider until the desired performance is reached. Moving the slider to the right increases the servo loop bandwidth and hence the move performance. By checking the *high* box, the slider impact is doubled. If moved too far, the motor will become unstable and begin to emit a buzzing sound and vibration even with the motor at rest. If this occurs, move the slider back to the left until this condition is eliminated.

**⚠ Note:** Tuning parameters adjusted using the wizard are updated in volatile memory. To save them to the non-volatile memory of the controller it is necessary to download the project to the controller after tuning.

### 3.1.2 Fine Tuning



While the Basic Tuning method just discussed works well for most general purpose applications, higher performance applications or those with unusual loads or friction will typically require more adjustments. For best results in fine tuning an axis, it is useful to observe the velocity profile of the axis and how it responds to various adjustments to the tuning properties. This can be done by using QuickScope within QuickBuilder or by using an external oscilloscope to monitor the velocity output signal of the drive. The other wizard adjustment items are listed below:

**PPG:** This is the position loop proportional gain scaled in 1000/min units. This increases the response of the position loop and stiffness.

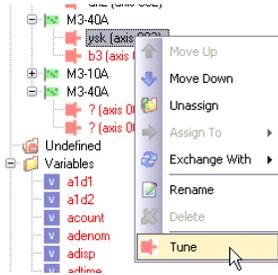
**Feed-forward:** This increases the position loop velocity feed-forward gain.

**Loop Type:** Adjust the loop type from 100% PID to 100% PDF structure.

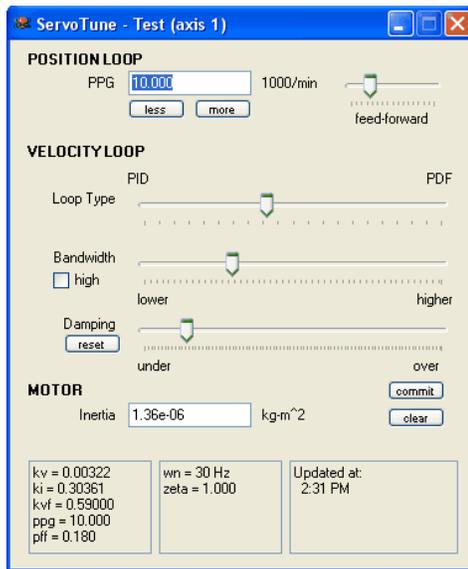
**Damping:** This has the effect similar to adding or removing friction from the system.

For advanced applications, all of these parameters with the exception of motor inertia can be changed programmatically or interactively through a QuickBuilder Watch Window. There are also several other tuning variables available for the experienced motion engineer. Refer to *Chapter 5: Variables* for details.

### 3.2 Tuning an axis (5300 M3-40 Only)



QuickBuilder simplifies the tuning process by utilization of an innovative new tuning wizard for each axis. To access the tuning wizard, simply right click on the axis and select *Tune*. Doing so will bring up a window like the one shown below. Note that each axis has its own tuning wizard window. Multiple windows may be active and displayed simultaneously.



To tune an axis with the wizard, the first step is to enter the motor inertia in the bottom box of the wizard. Once this is entered, the wizard is set up to critically damp the motor. Since the wizard adjusts tuning parameters in real time, the best way to use it is to set up a safe repeating move for the axis and then make adjustments in the wizard to optimize the motion profile.

Once tuning has been configured it may be save to the axis non-volatile memory but clicking on the 'commit' button. To remove tuning parameters from non-volatile motion board storage click the 'clear' button. By default the tuning parameters are saved with the QuickBuilder program and re-written each time the project is loaded. Committing the parameters to the motion board will override those in the program. This will set the nonvolatile axis variable to 1 when active.



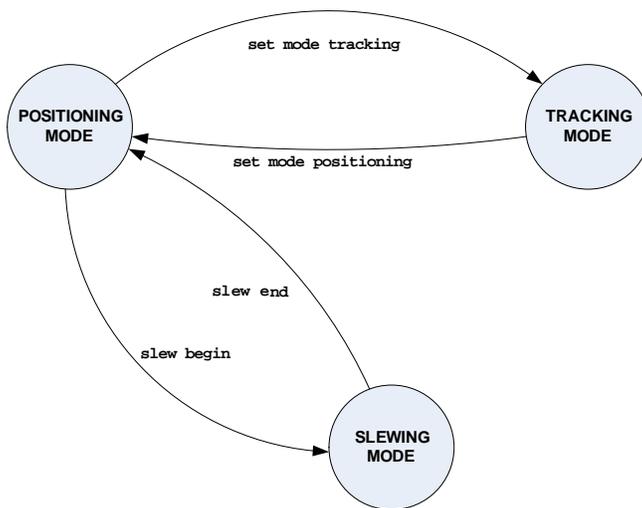


## 4 Chapter 4: QuickMotion Programming

This chapter covers the QuickMotion commands and their usage with MSBs.

⚠ These statements cannot be used in a QuickStep step! The MSB statement set has been created to simplify the motion programming process and make powerful motion control applications accessible to a wide range of users. These statements are optimized for high performance execution on motion modules. In addition to the motion statement set, CTC has provided over 100 pre-defined motion variables that greatly simplify development. The motion related variables are covered within their own chapter, later in this guide.

### 4.1 Operating Modes



---

#### Positioning

---

In this mode, the axis is able to perform absolute and incremental time-based motion, including *SegmentedMoves* and time-based CAMs.

The axis must have completed any pending positioning operations before changing to a different operating mode.

---

#### Slewing

---

In this mode, the axis generates a series of interpolated positions based upon a constant (but alterable) velocity.

The axis must be stopped by using `slew end` in order to perform any positioning operations.

---

#### Tracking

---

The axis is able to perform position-tracking in this mode. This includes following, gearing and position-based CAMs. The axis must complete all pending tracking operations before changing to a different operating mode.

## 4.2 Expressions

In QuickMotion, expressions consist of *variables*, *constants*, and *operators*. Variables are listed in [Chapter 6: Variables](#).

The following *operators*, listed in order of grouped precedence, are available in QuickMotion:

|     |                       |
|-----|-----------------------|
| ( ) | parenthesis           |
|     | logical-or            |
| &&  | logical-and           |
|     | bitwise-or            |
| &   | bitwise-and           |
| !=  | not-equal             |
| ==  | equal                 |
| <=  | less-than-or-equal    |
| <   | less-than             |
| >   | greater-than          |
| >=  | greater-than-or-equal |
| +   | add                   |
| -   | subtract              |
| *   | multiply              |
| /   | divide                |
| %   | modulo                |
| !   | logical-not           |
| ~   | bitwise-not           |
| -   | negate                |

## 4.3 Utility Statements

Summary:

```

stop { slewed using rate }
drive enable
drive disable
delay time ms
variable = expression
zero feedback position
zero target position
zero following error
reset
if condition then variable = expression
wait until condition

```

| Stop  | <input checked="" type="checkbox"/> Positioning      | <input checked="" type="checkbox"/> Slewing | <input checked="" type="checkbox"/> Tracking | <input checked="" type="checkbox"/> BG MSB<br><input checked="" type="checkbox"/> FG MSB |
|---|--|---|--|--|
| <i>syntax</i>                               |  |   |  |  |
| <code>stop { slewed using variable }</code> |  |   |  |  |
| <i>parameters</i>                           |  |   |  |  |
| variable                                    | optional rate at which to stop the axis in user unit |   |  |  |

```

stop; // stop the axis
stop slewed using rate; // stop the axis by slewing to 0 at
specified rate

```

In positioning mode:

*Non-slewed* – This statement immediately aborts the present motion operation as well as halts the target position generator from updating the target position (*tpos*), thereby (eventually) stopping motion. This form of *stop* may not be desirable in all cases (such as when the axis has excessive following error), since the target position may be greatly different than the feedback position and the feedback position will still seek the target position.

*Slewed* – This statement first copies the current feedback position (*fps*) into the target position (*tpos*) and then generates a controlled deceleration by *slewing* to zero velocity using the rate specified.

If the axis is in *slewing* mode, a *slew end* is issued thereby placing the axis in *positioning* mode. The optional stop mode *slewed* is ignored in this mode.

If the axis is in *tracking* mode, the numerator of the gear ratio is set to zero – but the axis remains in *tracking* mode. The optional stop mode *slewed* is ignored in this mode.

| Enable/Disable Drive       | <input checked="" type="checkbox"/> Positioning | <input checked="" type="checkbox"/> Slewing | <input checked="" type="checkbox"/> Tracking | <input checked="" type="checkbox"/> BG MSB<br><input type="checkbox"/> FG MSB |
|----------------------------|---|---|--|---|
| <i>syntax</i>              |   |   |  |   |
| <code>drive enable</code>  |   |   |  |   |
| <code>drive disable</code> |   |   |  |   |

Enables or disables the drive associated with the axis, thereby allowing motion to occur. If the *driveenable* variable has been set to an output number, that output is automatically turned on when the `drive enable` command is encountered or turned off when the `drive disable` command is encountered. In some cases, the motor may slowly decelerate to a zero velocity when disabling.

```
drive enable;           // enable the drive for this axis
drive disable;         // disable the drive for this axis
```

⚠ Invoking the `drive enable` command sets the target position (*tpos*) to the feedback position (*fpos*).

| Time Delay                 | <input checked="" type="checkbox"/> Positioning | <input checked="" type="checkbox"/> Slewing | <input checked="" type="checkbox"/> Tracking | <input checked="" type="checkbox"/> BG MSB<br><input checked="" type="checkbox"/> FG MSB |
|----------------------------|---|---|--|--|
| <i>syntax</i>              |   |   |  |  |
| <code>delay time ms</code> |   |   |  |  |
| <i>parameters</i>          |   |   |  |  |
| time                       | an expression representing time in milliseconds |   |  |  |

This statement delays execution of the active MSB for the specified number of milliseconds.

```
delay 2500 ms;           // delay for 2.5 seconds
```

| Timeout Initialization         | <input checked="" type="checkbox"/> Positioning   | <input checked="" type="checkbox"/> Slewing | <input checked="" type="checkbox"/> Tracking | <input checked="" type="checkbox"/> BG MSB<br><input checked="" type="checkbox"/> FG MSB |
|--------------------------------|---|---|--|--|
| <i>syntax</i>                  |   |   |  |  |
| <code>set timeout ticks</code> |   |   |  |  |
| <i>parameters</i>              |   |   |  |  |
| ticks                          | Number of ticks until a timeout occurs causing any active 'on timeout' event handlers to take action. |   |  |  |

This command initializes a private msb timer which is decremented on every tick if the 'on timeout' command is active. To disable execute an 'on timeout ignore' command. The timeout value must be set after every timeout, it acts as a down counter, invoking the event handler when 0 is reached. .

```
set timeout 100; // Set timeout to 100 ticks
```

| Assignment                         |                                   | <input checked="" type="checkbox"/> Positioning | <input checked="" type="checkbox"/> Slewing | <input checked="" type="checkbox"/> Tracking | <input checked="" type="checkbox"/> BG MSB<br><input checked="" type="checkbox"/> FG MSB |
|------------------------------------|-----------------------------------|---|---|--|--|
| <i>syntax</i>                      |                                   |   |   |  |  |
| <code>variable = expression</code> |                                   |   |   |  |  |
| <i>parameters</i>                  |                                   |   |   |  |  |
| variable                           | a variable to change the value of |   |   |  |  |
| expression                         | an expression                     |   |   |  |  |

The value of the specified expression is evaluated and stored to the named variable.

```
//calculate a new value for result
result = 34.857 * oldresult;
```

| Zero Feedback Position              |  | <input checked="" type="checkbox"/> Positioning | <input type="checkbox"/> Slewing | <input type="checkbox"/> Tracking | <input checked="" type="checkbox"/> BG MSB<br><input checked="" type="checkbox"/> FG MSB |
|-------------------------------------|--|---|----------------------------------|-----------------------------------|--|
| <i>syntax</i>                       |  |   |                                  |                                   |  |
| <code>zero feedback position</code> |  |   |                                  |                                   |  |

Zeros the target position, but maintains following error ( $fpsc = fpsc - (ppr * tpos)$  then  $tpos = 0$ ). Operates the same as *zero target position*.

```
//set the current position as zero
zero feedback position;
```

| Zero Target Position              |  | <input checked="" type="checkbox"/> Positioning | <input type="checkbox"/> Slewing | <input type="checkbox"/> Tracking | <input checked="" type="checkbox"/> BG MSB<br><input checked="" type="checkbox"/> FG MSB |
|-----------------------------------|--|---|----------------------------------|-----------------------------------|--|
| <i>syntax</i>                     |  |   |                                  |                                   |  |
| <code>zero target position</code> |  |   |                                  |                                   |  |

Zeros the target position, but maintains following error. Operates the same as *zero feedback position*, but is more readable in stepper mode.

```
//set the current position as zero
zero target position;
```

| Zero Following Error              |  | <input checked="" type="checkbox"/> Positioning | <input type="checkbox"/> Slewing | <input type="checkbox"/> Tracking | <input checked="" type="checkbox"/> BG MSB<br><input checked="" type="checkbox"/> FG MSB |
|-----------------------------------|--|---|----------------------------------|-----------------------------------|--|
| <i>syntax</i>                     |  |   |                                  |                                   |  |
| <code>zero following error</code> |  |   |                                  |                                   |  |

This statement zeros the feedback position (fpos/fposc) and target position (tpos), thereby removing any following error.

```
// relax the system by zeroing the following error
zero following error;
```



*Unless you are current limiting and driving into a hard stop (or similar application), there is no reason to use "zero following error" (and it's probably wrong in most applications to use it). Zero position feedback is what should normally be used. Remember that following error is maintained when zeroing the position*

*feedback and 99.99% of the time that is what is desired. Think of it like this:*

```
tpos = 1.000
```

```
fpos = 0.999
```

*After "zero feedback position":*

```
tpos = 0.000
```

```
fpos = -0.001
```

*You don't want to lose that 0.001 of error, but you still want to call wherever you are zero — that is generally the case. Because tpos (the target to seek) runs the show, that is what you want to be precisely zero. All motion is relative/absolute to the target position, NOT the feedback position, as that wouldn't make sense.*

*Zero following error is used, for example, in nut-driving applications where one limits the torque, drives to an unreachable position (because as the nut is torqued, the torque limit is hit), and then watches for current limit and then zeroes the following error — thus, removing the torque, etc.*

| Reset Faults | <input checked="" type="checkbox"/> Positioning | <input checked="" type="checkbox"/> Slewing | <input checked="" type="checkbox"/> Tracking | <input checked="" type="checkbox"/> BG MSB<br><input checked="" type="checkbox"/> FG MSB |
|--------------|---|---|--|--|
| syntax       |   |   |  |  |
| <b>reset</b> |   |   |  |  |

Resets any fault (if possible to).

```
reset; // reset axis faults
```

| If/Assignment | <input checked="" type="checkbox"/> Positioning | <input checked="" type="checkbox"/> Slewing | <input checked="" type="checkbox"/> Tracking | <input checked="" type="checkbox"/> BG MSB<br><input checked="" type="checkbox"/> FG MSB |
|---------------|---|---|--|--|
| syntax        |   |   |  |  |

```
if condition then variable = expression
```

*parameters*

|            |                          |
|------------|--------------------------|
| condition  | a Boolean test condition |
| variable   | a variable               |
| expression | an expression            |

This statement evaluates the specified *condition*. If *true*, the *expression* is evaluated and *variable* is set to the resulting value. If *false*, MSB program flow continues at the next MSB statement.

```
// if the position error for the axis exceeds
// 0.25 set a variable 'fault' to 2
if perr > .25 then fault = 2;
```

|                                    |   |   |  |  |
|------------------------------------|---|---|--|--|
| <b>Wait Until</b>                  | <input checked="" type="checkbox"/> Positioning | <input checked="" type="checkbox"/> Slewing | <input checked="" type="checkbox"/> Tracking | <input checked="" type="checkbox"/> BG MSB<br><input checked="" type="checkbox"/> FG MSB |
| <i>syntax</i>                      |   |   |  |  |
| <b>wait until</b> <i>condition</i> |   |   |  |  |
| <i>parameters</i>                  |   |   |  |  |
| condition                          | condition to test                               |   |  |  |

This statement waits for until the specified *condition* is *true*.

```
// wait here until chamber temp exceeds min
wait until temp > 32.849;
```

## 4.4 Program Flow Statements

Summary:

```

[ label ]
start MSB mode
end { and start MSB mode }
abort MSB
goto label
if condition goto label
on asynchevent asynchhandler

```

| Statement Label | <input checked="" type="checkbox"/> Positioning | <input checked="" type="checkbox"/> Slewing | <input checked="" type="checkbox"/> Tracking | <input checked="" type="checkbox"/> BG MSB<br><input checked="" type="checkbox"/> FG MSB |
|-----------------|---|---|--|--|
| <i>syntax</i>   |   |   |  |  |
| [ label ]       |   |   |  |  |

A label within an MSB is used as a marker for the destination of a *goto* or similar statement.

It is often required to *iterate* or *branch* depending on the state of some external input/output or internal condition – a label is used to mark the destination.

```

// this label is called Top
[Top]

```

| Start                 | <input checked="" type="checkbox"/> Positioning | <input checked="" type="checkbox"/> Slewing | <input checked="" type="checkbox"/> Tracking | <input checked="" type="checkbox"/> BG MSB<br><input checked="" type="checkbox"/> FG MSB |
|-----------------------|---|---|--|--|
| <i>syntax</i>         |   |   |  |  |
| <b>start</b> MSB mode |   |   |  |  |
| <i>parameters</i>     |   |   |  |  |
| MSB                   | the name of the MSB to start                    |   |  |  |
| mode                  | <b>FG</b>                                       | start as a high-priority (tick) MSB         |  |  |
|                       | <b>BG</b>                                       | start as a low-priority (non-tick) MSB      |  |  |

This statement activates an MSB – if the MSB is already active, this statement is effectively ignored.

Up to 4 foreground (FG) MSBs may be running simultaneously.

There is no logical limit to the number of active background (BG) MSBs.

```

// start the MSB called PressCap and run as a foreground MSB
start PressCap FG;

```

| End   |                              | <input checked="" type="checkbox"/> Positioning | <input checked="" type="checkbox"/> Slewing | <input checked="" type="checkbox"/> Tracking | <input checked="" type="checkbox"/> BG MSB<br><input checked="" type="checkbox"/> FG MSB |
|---|------------------------------|---|---|--|--|
| <i>syntax</i>                                   |                              |   |   |  |  |
| <b>end</b> { <b>and start</b> <i>MSB mode</i> } |                              |   |   |  |  |
| <i>parameters</i>                               |                              |   |   |  |  |
| MSB   | the name of the MSB to start |   |   |  |  |
| mode  | <b>FG</b>                    | start as a high-priority (tick) MSB             |   |  |  |
|   | <b>BG</b>                    | start as a low-priority (non-tick) MSB          |   |  |  |

This statement ends execution of this MSB. An optional MSB can be specified to start after this one completes.

An *end* or *goto* statement should be the last statement in any MSB.

```
// this is the end of the MSB
end;

// end the current MSB and then start the MSB called WeldCap
// as a foreground MSB
end and start WeldCap FG;
```

| Abort                   |  | <input checked="" type="checkbox"/> Positioning | <input checked="" type="checkbox"/> Slewing | <input checked="" type="checkbox"/> Tracking | <input checked="" type="checkbox"/> BG MSB<br><input checked="" type="checkbox"/> FG MSB |
|-------------------------|--|---|---|--|--|
| <i>syntax</i>           |  |   |   |  |  |
| <b>abort</b> <i>MSB</i> |  |   |   |  |  |
| <i>parameters</i>       |  |   |   |  |  |
| MSB                     | the name of the MSB to abort (stop) the execution of |   |   |  |  |

This statement ends execution of another MSB. If the named MSB is not active, the statement is effectively ignored.

```
// kill only the WeldCap MSB
abort WeldCap;
```

| Goto                     |                                    | <input checked="" type="checkbox"/> Positioning | <input checked="" type="checkbox"/> Slewing | <input checked="" type="checkbox"/> Tracking | <input checked="" type="checkbox"/> BG MSB<br><input checked="" type="checkbox"/> FG MSB |
|--------------------------|------------------------------------|---|---|--|--|
| <i>syntax</i>            |                                    |   |   |  |  |
| <b>goto</b> <i>label</i> |                                    |   |   |  |  |
| <i>parameters</i>        |                                    |   |   |  |  |
| label                    | the name of the label to branch to |   |   |  |  |

This statement changes program flow to the specified label.

```
// jump to the MSB label called Top
goto Top;
```

| If/Goto                              |                                    | <input checked="" type="checkbox"/> Positioning | <input checked="" type="checkbox"/> Slewing | <input checked="" type="checkbox"/> Tracking | <input checked="" type="checkbox"/> BG MSB<br><input checked="" type="checkbox"/> FG MSB |
|--------------------------------------|------------------------------------|---|---|--|--|
| <i>syntax</i>                        |                                    |   |   |  |  |
| <code>if condition goto label</code> |                                    |   |   |  |  |
| <i>parameters</i>                    |                                    |   |   |  |  |
| condition                            | a Boolean test condition           |   |   |  |  |
| label                                | the name of the label to branch to |   |   |  |  |

This statement evaluates the specified *condition*. If *true*, MSB program flow continues at the specified *label*. If *false*, MSB program flow continues at the next MSB statement.

```
// If the axis's input1 is on goto the label MakeMove
if din1 goto MakeMove;
```

| Asynchronous Event Handling               |  | <input checked="" type="checkbox"/> Positioning | <input checked="" type="checkbox"/> Slewing | <input checked="" type="checkbox"/> Tracking | <input checked="" type="checkbox"/> BG MSB<br><input checked="" type="checkbox"/> FG MSB |
|---|--|---|---|--|--|
| <i>syntax</i>                             |  |   |   |  |  |
| <code>on asynchevent asynchhandler</code> |  |   |   |  |  |
| <i>parameters</i>                         |  |   |   |  |  |
| asynchevent                               | One of the following:<br><b>riseof</b> <i>n</i> Rise of specified general purpose input.<br><b>fallof</b> <i>n</i> Fall of specified general purpose input.<br><b>hardfault</b> When a non-recoverable fault occurs.<br><b>capture</b> Capture of specified input trigger.<br><b>pls</b> <i>output</i> PLS output 1 to 5 activated.<br><b>timeout</b> 'timerticks' variable decrements to 0 (use 'set timeout' to initialize msb private value). |   |   |  |  |
| asynchhandler                             | One of the following:<br><b>ignore</b> Cancel asynchronous event monitoring.<br><b>start</b> <i>MSB</i> { <i>FG/BG</i> }{ <i>arm</i> } Starts the specified MSB in BG (background) mode unless FG is   |   |   |  |  |

```
specified, if capture then optional
{arm} at end of statement.
goto label {arm} Branch on event, if capture
then optional {arm} at end of
statement.
```

This statement controls asynchronous event handling.

If *asynchhandler* is set to *start...*, then an MSB is started automatically when the specified event occurs. If the MSB is already active when the event occurs, a second instance is *not* started. If not specified background mode is used (BG).

If *asynchhandler* is set to *goto...*, then a branch to that label occurs upon the event, within the same MSB.

If *asynchhandler* is set to *cancel*, then no operation will occur upon event. Each event is unique to a specific MSB although only one MSB may monitor a capture or specific pls output event.

If *asynchevent* is set to *timeout* then the 'set timeout <ticks>' command must be set for down counting to begin (500uS/tick). Branching based upon a timeout will occur regardless of motor operations and it is up to the MSB to properly recover and/or stop motors.

Example 'on timeout':

```
x=0;
y=0;
set timeout 5000 * 2; // 5 second timeout
on timeout goto timedout;
[top]
// x will increment for 5 seconds and then a branch to [timedout] will occur
x = x + 1;
delay 100 ms;
goto top;
[timedout]
// y will increment after 5 seconds and continue forever
y = y + 1;
delay 100 ms;
goto timedout;
```

## 4.5 Set Statements

Summary:

[set common bit number state](#)  
[set common var number value](#)  
[set looperperiod value](#)  
[set mode positioning](#)  
[set mode tracking](#)  
[set timeout ticks](#)  
[set target position value](#)  
[set feedback position value](#)  
[set target position counts vcounts](#)  
[set feedback position counts vcounts](#)  
[set simulated feedback on/off](#)  
[offset position value](#)  
[offset position counts vcounts](#)  
[set master mode { using global }](#)

| Set Loop Period                     |  | <input checked="" type="checkbox"/> Positioning | <input checked="" type="checkbox"/> Slewing | <input checked="" type="checkbox"/> Tracking | <input checked="" type="checkbox"/> BG MSB<br><input checked="" type="checkbox"/> FG MSB |
|-------------------------------------|--|---|---|--|--|
| <i>syntax</i>                       |  |   |   |  |  |
| <code>set looperperiod value</code> |  |   |   |  |  |
| <i>parameters</i>                   |  |   |   |  |  |
| value                               | The desired loop time in uS, default value is .0008 (800uS). The minimum is 500uS. |   |   |  |  |

This statement sets motion interrupt loop period. The current loop period and rate are available via the axis 'looperperiod' and 'looprate' variables (looptime group). The period selected should be evenly divisible for accuracy. Thus .0005 has a rate of 2000 ticks/second, .0008 is 1250 ticks/second (1/.008). Setting one axis sets the other and it is recommended to only change the loop time at initialization, prior to the 'drive enable' command.

```
set looperperiod 800; // Set looperperiod to the default, 800 uS
                    // (not needed since powerup default
```

| Set Positioning Mode              |  | <input type="checkbox"/> Positioning | <input type="checkbox"/> Slewing | <input checked="" type="checkbox"/> Tracking | <input checked="" type="checkbox"/> BG MSB<br><input checked="" type="checkbox"/> FG MSB |
|-----------------------------------|--|--------------------------------------|----------------------------------|--|--|
| <i>syntax</i>                     |  |                                      |                                  |  |  |
| <code>set mode positioning</code> |  |                                      |                                  |  |  |

Sets the operating mode of the axis to *positioning*.

```
set mode positioning; // switch to positioning mode
```

| Set Tracking Mode              | <input checked="" type="checkbox"/> Positioning | <input type="checkbox"/> Slewing | <input type="checkbox"/> Tracking | <input checked="" type="checkbox"/> BG MSB<br><input checked="" type="checkbox"/> FG MSB |
|--------------------------------|---|----------------------------------|-----------------------------------|--|
| <i>syntax</i>                  |   |                                  |                                   |  |
| <code>set mode tracking</code> |   |                                  |                                   |  |

Sets the operating mode of the axis to *tracking*.

```
set mode tracking;           // switch to tracking mode
```

| Set/Offset Target/Feedback Position(s)  | <input checked="" type="checkbox"/> Positioning   | <input type="checkbox"/> Slewing | <input type="checkbox"/> Tracking | <input checked="" type="checkbox"/> BG MSB<br><input checked="" type="checkbox"/> FG MSB |
|---|---|----------------------------------|-----------------------------------|--|
| <i>syntax</i>   |   |                                  |                                   |  |
| <pre>set target position value set feedback position value set target position counts vcounts set feedback position counts vcounts offset position value offset position counts vcounts</pre> |   |                                  |                                   |  |
| <i>parameters</i>   |   |                                  |                                   |  |
| value   | new or offset for the named position (user-units) |                                  |                                   |  |
| vcounts   | new or offset for the named position (counts)     |                                  |                                   |  |

These statements modify the target and/or feedback positions. The new value (or offset) may be specified in user-units, or in feedback counts (by use of the keyword `counts`). The first two forms set the target or feedback position to a specific absolute value in user-units. The third and fourth forms set the target or feedback position to a specific absolute value in counts. The last two forms modify the target and feedback positions simultaneously by adding the specified offset to both.

 Following error is maintained when these statements are executed.

 The axis must not be active (i.e. actively generating a target position by use of a move statement) when any of these statements are executed.

```
// set the feedback position (fpos) to 2.149
set feedback position 2.149;

// offset both the target and feedback positions by 1100 counts
offset position counts 1100;
```

| Set simulated feedback | <input checked="" type="checkbox"/> Positioning | <input type="checkbox"/> Slewing | <input type="checkbox"/> Tracking | <input checked="" type="checkbox"/> BG MSB<br><input checked="" type="checkbox"/> FG MSB |
|------------------------|---|----------------------------------|-----------------------------------|--|
| <i>syntax</i>          |   |                                  |                                   |  |

|  |   |
|--|---|
| <code>set simulated feedback on/off</code> |   |
| <i>parameters</i>                          |   |
| on/off                                     | off - normal operation, feedback from encoder. on - feedback simulated and from tposc on each servo loop. |

Enables or disables simulated feedback, setting fposc to originate from the encoder (off) or tposc (on). 'tposc' is the incremental amount to move on the next servo loop. Thus when simulated the desired increment will be achieved on each loop. This command is useful for both test purposes and when using a virtual master. The simulated axis can publish its master position across the controller backplane, based upon its moves. See the 'Virtual Master' section. This command is also useful during open loop stepper operation when using the pls functionality.

`set simulated feedback on;` // this will cause fposc to = tposc after each loop period, drive must not be enabled

|   |                  |   |   |  |  |
|---|------------------|---|---|--|--|
| <b>Set Master Encoder Source</b>              |                  | <input checked="" type="checkbox"/> Positioning   | <input checked="" type="checkbox"/> Slewing | <input checked="" type="checkbox"/> Tracking | <input checked="" type="checkbox"/> BG MSB<br><input checked="" type="checkbox"/> FG MSB |
| <i>syntax</i>                                 |                  |   |   |  |  |
| <code>set master mode { using global }</code> |                  |   |   |  |  |
| <i>parameters</i>                             |                  |   |   |  |  |
| mode  | <b>feedback1</b> | master position sourced from axis 1 feedback  |   |  |  |
|   | <b>feedback2</b> | master position sourced from axis 2 feedback  |   |  |  |
|   | <b>target1</b>   | master position sourced from axis 1 target  |   |  |  |
|   | <b>target2</b>   | master position sourced from axis 2 target  |   |  |  |
|   | <b>feedbackZ</b> | master position comes from axis 1&2 Z-inputs  |   |  |  |
|   | <b>virtual</b>   | master position on this axis is to be calculated as a virtual source, reference 'move master at' for setup (master axis).                               |   |  |  |
|   | <b>common</b>    | master position from controller backplane as determined by variant register 36827 (slave axis)  |   |  |  |
| global  | <b>global</b>    | (optional) This position information is made public to the controller backplane. Distributed to 'common' nodes as determined by variant register 36827. |   |  |  |

This statement sets the source of the axis master encoder. The default source for MSBs executing on the first axis is *feedback2*. This means the first axis is using the second axis as the master. This command executes independently on each access thus to change axis 1 to be the master a 'set master feedback1' must be executed by MSB's on both axis. The default for the second axis is *feedback1*.

The source *feedbackZ* is derived by using the first axis' Z-channel input as the "A"-channel for the master encoder and the second axis' Z-channel input as the "B"-channel for the master encoder.

For an axis to make its master public the 'using global' option is used. This allows the axis to publish its position information to other axis that executes the 'set master common' command.

Variant register 36827 is used to define how global master information is distributed amongst slaves. The variant is a 4 row, 3 column array with the first 4 rows defining possible global master sources to reference and the columns referenced as follows:

[0] – enabled position information updates (every 4 mS to all slaves), set 1 to enable, 0 to disable.

[1] – master axis whose position information is to be distributed to slaves, 1 to N where N is all the axis in a controller rack. Note that the master axis MSB must have executed the ‘set master global’ command.

[2] – 32 bit field with each bit representing a slave axis to whom the master axis information is to be distributed. Bit 0 would be axis 1, Bit 31 is axis 32.

## 4.6 Common bits and variables

Summary:

[set common bit number state](#)  
[wait common bit number state](#)  
[set common var number value](#)  
[wait common var number range](#)

Common bits and common vars are used to communicate state information:

- a. between QuickMotion based modules
- b. between QuickMotion and QuickStep 4
- c. between axes on a single module such as an M3-40A

There are 256 common bits and 256 common vars. Common bits are Boolean, and common vars are bytes and therefore have values from 0 through 255.

The common bits are globally shared between all QuickMotion modules as well as QuickStep 4. Any changes made to common bits are “seen” by all QuickMotion modules and the main CPU running QuickStep 4.

The first 32 common vars are *overlaid* on top of the 256 common bits – changes made to a common var may alter up to 8 common bits.

The remaining 244 common vars are *module-local* – changes are only seen local to the module. This is useful to communicate state information between axes on a two-axis QuickMotion module such as an M3-40A.

A user may decide whether to use just common bits or just common vars or even a combination of the two depending on the application.

From QS4, common bits are accessed via the \$CBITS[ ] system variable and common variables are accessed via the \$CVARS[ ] system variable.

There are several QuickMotion instructions that deal with common bits and vars:

- *set common bit*
- *wait common bit*
- *set common var*
- *wait common var*

Within QuickMotion, common bits and vars can be used in expressions through the notation:

`cbit[n]`      where n is 0 through 255

`cvar[n]`      where n is 0 through 255

For example:

```
[top]
if cbit[10] goto op10;
if cbit[11] goto op11;
if cbit[12] goto op12;
goto top;
```

```
[op10]
move to 1.0;
wait for in position;
goto top;
```

```
[op11]
move to 0.0;
wait for in position;
goto top;
```

```
[op12]
move to 2.25;
wait for in position;
goto top;
```

| Set Common Bit                           |                    | <input checked="" type="checkbox"/> Positioning | <input checked="" type="checkbox"/> Slewing | <input checked="" type="checkbox"/> Tracking | <input checked="" type="checkbox"/> BG MSB<br><input checked="" type="checkbox"/> FG MSB |
|--|--------------------|---|---|--|--|
| <i>syntax</i>                            |                    |   |   |  |  |
| <code>set common bit number state</code> |                    |   |   |  |  |
| <i>parameters</i>                        |                    |   |   |  |  |
| number                                   | bit number (0-255) |   |   |  |  |
| state                                    | true or false      |   |   |  |  |

This statement sets the specified “common bit” to the given state.

| Wait For Common Bit                       |                    | <input checked="" type="checkbox"/> Positioning | <input checked="" type="checkbox"/> Slewing | <input checked="" type="checkbox"/> Tracking | <input checked="" type="checkbox"/> BG MSB<br><input checked="" type="checkbox"/> FG MSB |
|---|--------------------|---|---|--|--|
| <i>syntax</i>                             |                    |   |   |  |  |
| <code>wait common bit number state</code> |                    |   |   |  |  |
| <i>parameters</i>                         |                    |   |   |  |  |
| number                                    | bit number (0-255) |   |   |  |  |
| state                                     | true or false      |   |   |  |  |

This statement waits until the specified “common bit” is at the desired state.

| Set Common Var                           |                          | <input checked="" type="checkbox"/> Positioning | <input checked="" type="checkbox"/> Slewing | <input checked="" type="checkbox"/> Tracking | <input checked="" type="checkbox"/> BG MSB<br><input checked="" type="checkbox"/> FG MSB |
|--|--------------------------|---|---|--|--|
| <i>syntax</i>                            |                          |   |   |  |  |
| <code>set common var number value</code> |                          |   |   |  |  |
| <i>parameters</i>                        |                          |   |   |  |  |
| number                                   | variable number (0-255)  |   |   |  |  |
| value                                    | an integer value (0-255) |   |   |  |  |

This statement sets the specified “common state variable” to the given value.

| Wait For Common Var                       |                         | <input checked="" type="checkbox"/> Positioning | <input checked="" type="checkbox"/> Slewing | <input checked="" type="checkbox"/> Tracking | <input checked="" type="checkbox"/> BG MSB<br><input checked="" type="checkbox"/> FG MSB |
|---|-------------------------|---|---|--|--|
| <i>syntax</i>                             |                         |   |   |  |  |
| <code>wait common var number range</code> |                         |   |   |  |  |
| <i>parameters</i>                         |                         |   |   |  |  |
| number                                    | variable number (0-255) |   |   |  |  |
| range                                     | x                       | a value of x                                    |   |  |  |
|   | x-y                     | a value of x through y inclusive                |   |  |  |
|   | ! x                     | a value other than x                            |   |  |  |
|   | ! x-y                   | a value outside the range of x through y        |   |  |  |

This statement waits until the specified “common state variable” is within/outside the given range.

## 4.7 I/O Statements

Summary:

[setout outputlist](#)  
[clrout outputlist](#)  
[pulse output for n](#)  
[pls output using reference definitions](#)  
[pls output state](#)  
[wait for\[\\*\\*\\*\]transition\[\\*\\*\\*\]of\[\\*\\*\\*\]input { or\[\\*\\*\\*\]condition }](#)  
[generate output output rate freq](#)  
[generate n steps on pair](#)  
[variable = ctr\[n\]](#)  
[ctr\[n\] = expression](#)  
[ctr\[n\] = offset](#)  
[generate alternate mode](#)

| Set Output(s)                  | <input checked="" type="checkbox"/> Positioning | <input checked="" type="checkbox"/> Slewing | <input checked="" type="checkbox"/> Tracking | <input checked="" type="checkbox"/> BG MSB<br><input checked="" type="checkbox"/> FG MSB |
|--------------------------------|---|---|--|--|
| <i>syntax</i>                  |   |   |  |  |
| <code>setout outputlist</code> |   |   |  |  |
| <i>parameters</i>              |   |   |  |  |
| outputlist                     | a comma delimited list of outputs to set        |   |  |  |

This statement sets one or more outputs to the *on* state.

The output number can be 1-5 (dual axis mode) or 1-10 (1½ axis mode).

```

setout 2;           // turns on the second output on the module
setout 1, 3;       // turns on the first and third outputs

```

| Clear Output(s)                | <input checked="" type="checkbox"/> Positioning | <input checked="" type="checkbox"/> Slewing | <input checked="" type="checkbox"/> Tracking | <input checked="" type="checkbox"/> BG MSB<br><input checked="" type="checkbox"/> FG MSB |
|--------------------------------|---|---|--|--|
| <i>syntax</i>                  |   |   |  |  |
| <code>clrout outputlist</code> |   |   |  |  |
| <i>parameters</i>              |   |   |  |  |
| outputlist                     | a comma delimited list of outputs to clear      |   |  |  |

This statement sets one or more outputs to the *off* state.

The output number can be 1-5 (dual axis mode) or 1-10 (1½ axis mode).

```

clrout 2;           // turns off the second output on the module

```

```
clROUT 1, 3; // turns off the first and third outputs
```

| Pulse Output              |  | <input checked="" type="checkbox"/> Positioning | <input checked="" type="checkbox"/> Slewing | <input checked="" type="checkbox"/> Tracking | <input checked="" type="checkbox"/> BG MSB<br><input checked="" type="checkbox"/> FG MSB |
|---------------------------|--|---|---|--|--|
| <i>syntax</i>             |  |   |   |  |  |
| <b>pulse</b> output for n |  |   |   |  |  |
| <i>parameters</i>         |  |   |   |  |  |
| output                    | the output to pulse<br>1-5 (dual axis mode)<br>1-10 (1½ axis mode) |   |   |  |  |
| n                         | the time to pulse the output, an expression as milliseconds        |   |   |  |  |

This statement causes the specified *output* to pulse for the specified duration. If the output is already *on* when this statement executes, the output state is unchanged – however it will be turned *off* after the specified time.

If another statement changes the state of the output to off before the allotted duration, the generation of the pulse is aborted.

The generated pulse is accurate within ½ of a millisecond.

```
// turns on the 2nd output on the module for 500ms
pulse 2 for 500;
```

| PLS Define                                    |  | <input checked="" type="checkbox"/> Positioning | <input checked="" type="checkbox"/> Slewing | <input checked="" type="checkbox"/> Tracking | <input checked="" type="checkbox"/> BG MSB<br><input checked="" type="checkbox"/> FG MSB |
|---|--|---|---|--|--|
| <i>syntax</i>                                 |  |   |   |  |  |
| <b>pls</b> output using reference definitions |  |   |   |  |  |
| <i>parameters</i>                             |  |   |   |  |  |
| output  | the output (1-5) to control via a PLS                      |   |   |  |  |
| reference                                     | the encoder count scaled reference variable to compare to: |   |   |  |  |
|   | <b>fposc</b>   | Feedback position of axis msb                   |   |  |  |
|   | <b>mposc1 - mposc5</b>                                     | Master position counters #1 through #5          |   |  |  |
|   | <b>mposc</b>   | Master position counter                         |   |  |  |
|   | <b>smodc</b>   | Slave position (modulo)                         |   |  |  |
|   | <b>smark</b>   | Slave marked position                           |   |  |  |
|   | <b>tmc1 tmc2</b>   | Temporary master counters #1 & #2               |   |  |  |
|   | <b>tsc1 tsc2</b>   | Temporary slave counters #1 & #2                |   |  |  |
|   | <b>sdsc</b>  | Slave decrement counter                         |   |  |  |
|   | <b>fposc1</b>  | Feedback position of axis 1 (fposcA)            |   |  |  |

|             |   |   |
|-------------|---|---|
|             | <b>fposc2</b>   | Feedback position of axis 2<br>(fposcB) |
|             | <b>tmodc</b>  | Temporary master counter mod mmc        |
|             | <b>sfposc</b>   | Secondary feedback position of<br>axis  |
| definitions | a comma-separated list of up to 16 PLS definitions:<br><b>on x to y</b> Turn output on when the reference<br>is within the bounds specified<br>by x through y (may be<br>expressions) |   |

The first statement defines or redefines a PLS (software-based programmable limit switch) associated with a given output. A definition over-writes the previous definition for an output (if one was defined already).

⚠ When a PLS is defined/re-defined it will be disabled and will not compute the state for the output. To enable a PLS after it is defined/re-defined, a *pls on* statement must be issued:

```
// define a PLS for output #1
// output will be on when fposc is within 10-200 or 400-430
pls 1 using fposc on 10 to 200, on 400 to 430;

// enable the PLS for output #1
pls 1 on;
```

⚠ When using open loop stepper tposc is not available for PLS thus issue the command 'set simulated feedback on' to have tposc copied to fposc, on each control loop, allowing the use of this command.

|                           |  |   |   |  |  |
|---------------------------|--|---|---|--|--|
| <b>PLS Enable/Disable</b> |  | <input checked="" type="checkbox"/> Positioning | <input checked="" type="checkbox"/> Slewing | <input checked="" type="checkbox"/> Tracking | <input checked="" type="checkbox"/> BG MSB<br><input checked="" type="checkbox"/> FG MSB |
| <i>syntax</i>             |  |   |   |  |  |
| <b>pls output state</b>   |  |   |   |  |  |
| <i>parameters</i>         |  |   |   |  |  |
| output                    | the output to control via a PLS<br>1-5 (dual axis mode)<br>1-10 (1½ axis mode) |   |   |  |  |
| state                     | <b>on</b> or <b>off</b>  |   |   |  |  |

This statement enables (“on”) or disables (“off”) a PLS for an output.

On - Enables the pls functionality initialized for a particular output with the PLS Define statement.

Off – Disables the pls functionality initialized for a particular output with the PLS Define statement.

⚠ If the output is on when a PLS is disabled, it will remain on – unless the user re-enables the PLS (to re-compute the PLS output), or they *clrout* the output.

| Wait For Input   |   | <input checked="" type="checkbox"/> Positioning | <input checked="" type="checkbox"/> Slewing | <input checked="" type="checkbox"/> Tracking | <input checked="" type="checkbox"/> BG MSB<br><input checked="" type="checkbox"/> FG MSB |
|--|---|---|---|--|--|
| <i>syntax</i>  |   |   |   |  |  |
| <code>wait for transition of input { or condition }</code> |   |   |   |  |  |
| <i>parameters</i>  |   |   |   |  |  |
| transition   | rise or fall  |   |   |  |  |
| input  | the general purpose input to wait upon<br>1-5 (dual axis mode)<br>1-10 (1½ axis mode) |   |   |  |  |
| condition  | an optional exit condition  |   |   |  |  |

This statement waits for the specified *transition* of the specified general purpose *input* to occur.

The MSB will not continue execution until the transition occurs – unless there was a *condition* specified and the condition evaluated to *true*.

```
// delay execution of MSB until input1 transitions from off to on
wait for rise of 1;
```

⚠ When this statement is used with the optional exit condition and the statement is part of a BGMSB, it is possible to miss transitions of the general purpose input. Therefore, the optional exit condition form should be used with care in BGMSBs.

| Generate Pulses                               |   | <input checked="" type="checkbox"/> Positioning | <input checked="" type="checkbox"/> Slewing | <input checked="" type="checkbox"/> Tracking | <input checked="" type="checkbox"/> BG MSB<br><input checked="" type="checkbox"/> FG MSB |
|---|---|---|---|--|--|
| <i>syntax</i>                                 |   |   |   |  |  |
| <code>generate output output rate freq</code> |   |   |   |  |  |
| <i>parameters</i>                             |   |   |   |  |  |
| output  | 1-10  |   |   |  |  |
| freq  | the frequency (in Hz) to generate pulses; rounded to an integer |   |   |  |  |

This statement begins or ends generation of pulses using a specific output. If pulses are being generated on an output, then *setout*, *clout* and *pulse output* commands given to the same output have the following behavior:

|                     |   |
|---------------------|---|
| <i>setout</i>       | no pulse generation occurs; the output will be active       |
| <i>clout</i>        | pulse generation occurs for non-zero <i>freqs</i>           |
| <i>pulse output</i> | no pulse generation occurs until the pulse output completes |

When a frequency of 0 is specified, no pulse generation occurs. This effectively turns the output back into a general-purpose output.

The minimum frequency that can be generated is 1 Hz. The *maximum* frequency that can be generated is well over 500 kHz.

The accuracy of the generated signal varies by frequency (lower frequencies are more accurate). The following table summarizes the accuracy for several frequencies:

|         |              |
|---------|--------------|
| <100 Hz | +/- 0.001 Hz |
| 500 Hz  | +/- 0.005 Hz |
| 1 kHz   | +/- 0.02 Hz  |
| 2 kHz   | +/- 0.1 Hz   |
| 5 kHz   | +/- 0.5 Hz   |
| 10 kHz  | +/- 2 Hz     |
| 20 kHz  | +/- 8 Hz     |
| 50 kHz  | +/- 50 Hz    |
| 100 kHz | +/- 200 Hz   |
| 250 kHz | +/- 1.5 kHz  |
| 500 kHz | +/- 5 kHz    |

 Due to a hardware limitation, this statement is only usable with outputs 3, 4, 5 (Axis 1) and outputs 3, 4, 5 (Axis 2). The use of outputs other than those listed will be ignored.

 The number of generated pulses cannot be controlled – only the frequency of the generated pulses.

| Generate Steps                        |   | <input checked="" type="checkbox"/> Positioning | <input checked="" type="checkbox"/> Slewing | <input checked="" type="checkbox"/> Tracking | <input checked="" type="checkbox"/> BG MSB<br><input checked="" type="checkbox"/> FG MSB |
|---------------------------------------|---|---|---|--|--|
| <i>syntax</i>                         |   |   |   |  |  |
| <code>generate n steps on pair</code> |   |   |   |  |  |
| <i>parameters</i>                     |   |   |   |  |  |
| n                                     | the number of steps to generate in 500 µsec |   |   |  |  |
| pair                                  | the step/direction pair to output steps on: |   |   |  |  |

1. axis 1 step/direction pair (M3-40A/B/C outputs 3&4)
2. axis 2 step/direction pair (M3-40A/B/C outputs 3&4)
3. alternate step/direction pair (outputs 5 on each axis)

This statement generates step and direction pulses on the specified step and direction pair.

If the expression  $n$  evaluates to a negative number, then the direction will be negative.

All of the pulses will be emitted in the next 500 $\mu$ s loop period.

**⚠** Any *setout*, *pulse* or *generate output* used in parallel with this command will cause erroneous step/dir pulses to be emitted. One should not use these commands in conjunction with *generate steps*.

**⚠** This command when used with *cmode* set to *stepper* mode will command additional pulses out the step/dir outputs.

| Counter read, write, offset                                      | <input checked="" type="checkbox"/> Positioning                       | <input checked="" type="checkbox"/> Slewing | <input checked="" type="checkbox"/> Tracking | <input checked="" type="checkbox"/> BG MSB<br><input checked="" type="checkbox"/> FG MSB |
|--|---|---|--|--|
| <i>syntax</i>  |   |   |  |  |
| <pre>variable = ctr[n] ctr[n] = expression ctr[n] = offset</pre> |   |   |  |  |
| <i>parameters</i>  |   |   |  |  |
| n  | the counter number (0 through 7)                                      |   |  |  |
| variable   | the variable to store the current value of the counter to             |   |  |  |
| expression   | a new value for the counter   |   |  |  |
| offset   | an offset for the counter (subtracted from the current counter value) |   |  |  |

These specialized forms of the *assignment* statement give read/write/offset access to the axis counters.

On the M3-40A, -40B, and -40C, there are 8 counters/axis that accumulate off-to-on transitions of the following:

|        |                                    |
|--------|------------------------------------|
| ctr[0] | digital input 1                    |
| ctr[1] | digital input 2                    |
| ctr[2] | digital input 3                    |
| ctr[3] | digital input 4                    |
| ctr[4] | digital input 5                    |
| ctr[5] | 'A' channel input (non-quadrature) |
| ctr[6] | 'B' channel input (non-quadrature) |
| ctr[7] | 'Z' channel input (non-quadrature) |

The first form of the statement stores the current counter value in a variable.

The second form of the statement changes the current counter value.

The third form of the statement offsets the current counter value.

The first and third forms are often used together:

```
totalcounts = 0;
[top]
// wait until input #1 rises
wait for rise of 1;
// get the current counter value
x = ctr[7];
// accumulate
totalcounts = totalcounts + x;
// offset so no counts are missed
ctr[7] -= x;
goto top;
```

| Alternate Stepper Output       |            | <input checked="" type="checkbox"/> Positioning | <input checked="" type="checkbox"/> Slewing | <input checked="" type="checkbox"/> Tracking | <input checked="" type="checkbox"/> BG MSB<br><input checked="" type="checkbox"/> FG MSB |
|--------------------------------|------------|---|---|--|--|
| <i>syntax</i>                  |            |   |   |  |  |
| <b>generate alternate mode</b> |            |   |   |  |  |
| <i>parameters</i>              |            |   |   |  |  |
| mode                           | <b>on</b>  | generate stepper outputs on alternate pins      |   |  |  |
|                                | <b>off</b> | generate stepper outputs on standard pins       |   |  |  |

On a M3-40A/B/C, (and when in stepper mode in the case of the M3-40A), the step and direction outputs are normally output on axis (TBx) pin pairs (15, 16).

These cards also allow a third-axis to be controlled by temporarily outputting step and direction pulses on TB1 pin 22 (step) and TB2 pin 22 (direction).

To output on this alternate pair, the command *generate alternate on* should be issued. To output on the standard pair, the command *generate alternate off* should be issued.

**⚠** One needs to be careful as only the destination of the step and direction signals change – the axis still believes that motion is being commanded on the primary axis (and thus updates its idea of where the absolute stepper position is). Therefore, it is good practice to zero the target position (*zero target position*) before switching to or from this alternate mode:

```
// move my axis 30 revs
zero target position;
generate alternate off;
move at 5 for 30 using 10,10;
wait for in position;

// move axis #3 20 revs
zero target position;
generate alternate on;
move at 10 for 20 using 10,10;
wait for in position;
```

```
// move me again 10 revs  
zero target position;  
generate alternate off;  
move at 5 for 10 using 10,10;  
wait for in position;
```

## 4.8 Simple Motion

Summary:

```

move to position { using acc, dec }
move at maxvelocity to position { using acc, dec }
move trap to position using rate
move in time to position {mode n }
move for displacement { using acc, dec }
move at maxvelocity for displacement { using acc, dec }
move trap for displacement using rate
move in time for displacement {mode n }
wait for in position
new endposition position using rate
new endposition relative displacement using rate
slew begin
slew at velocity in time
slew for displacement
slew end

```

| Move Absolute, Triangular                        |                                       | <input checked="" type="checkbox"/> Positioning | <input type="checkbox"/> Slewing | <input type="checkbox"/> Tracking | <input checked="" type="checkbox"/> BG MSB<br><input type="checkbox"/> FG MSB |
|--|---------------------------------------|---|----------------------------------|-----------------------------------|---|
| <i>syntax</i>                                    |                                       |   |                                  |                                   |   |
| <code>move to position { using acc, dec }</code> |                                       |   |                                  |                                   |   |
| <i>parameters</i>                                |                                       |   |                                  |                                   |   |
| position   | absolute end position, user-units     |   |                                  |                                   |   |
| acc  | acceleration rate, user-units/sec/sec |   |                                  |                                   |   |
| dec  | deceleration rate, user-units/sec/sec |   |                                  |                                   |   |

This statement generates a triangular move to the specified end *position*. If the parameters *acc* and *dec* are omitted, then the default rates are used.

**⚠** Linear acceleration and deceleration is used (as programmed in the axis *acc* and *dec* properties) unless the property *jerk\_a\_req/jerk\_d\_req* is set to a non-zero value in which case an S-curve type profile is generated.

**Note:** The specified *position* may also be specified as **ZPULSE\_POS** or **ZPULSE\_NEG**, meaning the next encoder Z-pulse in the positive or negative directions, respectively.

**⚠** **ZPULSE\_POS** or **ZPULSE\_NEG** should only be used with absolute move commands.

```

/* Move to the absolute position specified by the variable
drillpos using default acceleration and deceleration rates. */

move to drillpos;

```

```
/* Move in the positive direction to the Z pulse using default
acceleration and deceleration rates. */
```

```
move to ZPULSE_POS;
```

| Move Absolute, Speed-limited                                    |   | <input checked="" type="checkbox"/> Positioning | <input type="checkbox"/> Slewing | <input type="checkbox"/> Tracking | <input checked="" type="checkbox"/> BG MSB<br><input type="checkbox"/> FG MSB |
|---|---|---|----------------------------------|-----------------------------------|---|
| <i>syntax</i>   |   |   |                                  |                                   |   |
| <code>move at maxvelocity to position { using acc, dec }</code> |   |   |                                  |                                   |   |
| <i>parameters</i>   |   |   |                                  |                                   |   |
| maxvelocity   | unsigned maximum velocity, user-units/sec |   |                                  |                                   |   |
| position  | absolute end position, user-units         |   |                                  |                                   |   |
| acc   | acceleration rate, user-units/sec/sec     |   |                                  |                                   |   |
| dec   | deceleration rate, user-units/sec/sec     |   |                                  |                                   |   |

This statement generates a trapezoidal move to the specified end *position*. If it is not possible to reach the specified maximum velocity *maxvelocity*, then a triangular move is generated. If the parameters *acc* and *dec* are omitted, then the default rates are used.

⚠ Linear acceleration and deceleration is used (as programmed in the axis *acc* and *dec* properties) unless the property *jerk\_a\_req/jerk\_d\_req* is set to a non-zero value in which case an S-curve type profile is generated.

**Note:** The specified *position* may also be specified as **ZPULSE\_POS** or **ZPULSE\_NEG**, meaning the next encoder Z-pulse in the positive or negative directions, respectively.

⚠ **ZPULSE\_POS** or **ZPULSE\_NEG** should only be used with absolute move commands.

```
/* Move to the absolute position specified by the variable
drillpos using default acceleration and deceleration rates and
the rapidrate variable for a max velocity. */
```

```
move at rapidrate to drillpos;
```

| Move Absolute, Trapezoidal                    |  | <input checked="" type="checkbox"/> Positioning | <input type="checkbox"/> Slewing | <input type="checkbox"/> Tracking | <input checked="" type="checkbox"/> BG MSB<br><input type="checkbox"/> FG MSB |
|---|--|---|----------------------------------|-----------------------------------|---|
| <i>syntax</i>                                 |  |   |                                  |                                   |   |
| <code>move trap to position using rate</code> |  |   |                                  |                                   |   |
| <i>parameters</i>                             |  |   |                                  |                                   |   |
| position                                      | absolute end position, user-units                  |   |                                  |                                   |   |
| rate  | acceleration/deceleration rate, user-units/sec/sec |   |                                  |                                   |   |

This statement generates a 1/3-1/3-1/3 trapezoidal move (1/3 of the time accelerating, 1/3 constant velocity, 1/3 decelerating) to the specified end *position*. The acceleration and deceleration rate must be specified.

⚠ Linear acceleration and deceleration is used (as programmed in the axis *acc* and *dec* properties) unless the property *jerk\_a\_req/jerk\_d\_req* is set to a non-zero value in which case an S-curve type profile is generated.

**Note:** The specified *position* may also be specified as **ZPULSE\_POS** or **ZPULSE\_NEG**, meaning the next encoder Z-pulse in the positive or negative directions, respectively.

⚠ **ZPULSE\_POS** or **ZPULSE\_NEG** should only be used with absolute move commands.

```
/* Move to the absolute position specified by the variable
drillpos using the variable rapidacc to set acceleration and
deceleration rates. The velocity used will be based on
the calculation to achieve a trap move. */
```

```
move trap to drillpos using rapidacc;
```

| Move Absolute, Time-limited                     |                                   | <input checked="" type="checkbox"/> Positioning | <input type="checkbox"/> Slewing | <input type="checkbox"/> Tracking | <input checked="" type="checkbox"/> BG MSB<br><input checked="" type="checkbox"/> FG MSB |
|---|-----------------------------------|---|----------------------------------|-----------------------------------|--|
| <i>syntax</i>                                   |                                   |   |                                  |                                   |  |
| <code>move in time to position {mode n }</code> |                                   |   |                                  |                                   |  |
| <i>parameters</i>                               |                                   |   |                                  |                                   |  |
| time  | time, sec                         |   |                                  |                                   |  |
| position  | absolute end position, user-units |   |                                  |                                   |  |
| n   | acc / dec ramp multiplier         |   |                                  |                                   |  |

This statement generates a 1/3-1/3-1/3 trapezoidal move to the specified end *position* in the specified *time*. The optional *mode* feature decreases the amount of time spent on acceleration and deceleration. The *n* parameter must be a positive, non-zero integer. By increasing the value of *n*, the acceleration and deceleration times are equally reduced, allowing more time at constant speed.

⚠ Linear acceleration and deceleration is used (as programmed in the axis *acc* and *dec* properties) unless the property *jerk\_a\_req/jerk\_d\_req* is set to a non-zero value in which case an S-curve type profile is generated.

**Note:** The specified *position* may also be specified as **ZPULSE\_POS** or **ZPULSE\_NEG**, meaning the next encoder Z-pulse in the positive or negative directions, respectively.

⚠ **ZPULSE\_POS** or **ZPULSE\_NEG** should only be used with absolute move commands.

```
/* Move to the absolute position specified by the variable
drillpos setting the calculated velocity, accel and decel rates
to make a trapezoidal move in the time specified by the variable
movetime. */
```

```
move in movetime to drillpos;
```

| Move Incremental, Triangular                          |                                       | <input checked="" type="checkbox"/> Positioning | <input type="checkbox"/> Slewing | <input type="checkbox"/> Tracking | <input checked="" type="checkbox"/> BG MSB<br><input type="checkbox"/> FG MSB |
|---|---------------------------------------|---|----------------------------------|-----------------------------------|---|
| <i>syntax</i>   |                                       |   |                                  |                                   |   |
| <code>move for displacement { using acc, dec }</code> |                                       |   |                                  |                                   |   |
| <i>parameters</i>                                     |                                       |   |                                  |                                   |   |
| displacement  | incremental position, user-units      |   |                                  |                                   |   |
| acc   | acceleration rate, user-units/sec/sec |   |                                  |                                   |   |
| dec   | deceleration rate, user-units/sec/sec |   |                                  |                                   |   |

This statement generates a triangular move for a specified *displacement*. If the parameters *acc* and *dec* are omitted, then the default rates are used.

⚠ Linear acceleration and deceleration is used (as programmed in the axis *acc* and *dec* properties) unless the property *jerk\_a\_req/jerk\_d\_req* is set to a non-zero value in which case an S-curve type profile is generated.

⚠ **ZPULSE\_POS** or **ZPULSE\_NEG** should not be used with incremental move commands.

```
/* Move an incremental distance specified by the variable
spanmove using default acceleration and deceleration rates */
```

```
move for spanmove;
```

| Move Incremental, Speed-limited                                      |   | <input checked="" type="checkbox"/> Positioning | <input type="checkbox"/> Slewing | <input type="checkbox"/> Tracking | <input checked="" type="checkbox"/> BG MSB<br><input type="checkbox"/> FG MSB |
|--|---|---|----------------------------------|-----------------------------------|---|
| <i>syntax</i>  |   |   |                                  |                                   |   |
| <code>move at maxvelocity for displacement { using acc, dec }</code> |   |   |                                  |                                   |   |
| <i>parameters</i>  |   |   |                                  |                                   |   |
| maxvelocity  | unsigned maximum velocity, user-units/sec |   |                                  |                                   |   |
| displacement   | incremental position, user-units          |   |                                  |                                   |   |
| acc  | acceleration rate, user-units/sec/sec     |   |                                  |                                   |   |
| dec  | deceleration rate, user-units/sec/sec     |   |                                  |                                   |   |

This statement generates a trapezoidal move for a specified *displacement*. If it is not possible to reach the specified maximum velocity *maxvelocity*, then a triangular move is generated. If the parameters *acc* and *dec* are omitted, then the default rates are used.

⚠ Linear acceleration and deceleration is used (as programmed in the axis *acc* and *dec* properties) unless the property *jerk\_a\_req/jerk\_d\_req* is set to a non-zero value in which case an S-curve type profile is generated.

⚠ **ZPULSE\_POS** or **ZPULSE\_NEG** should not be used with incremental move commands.

```
/* Move an incremental distance specified by the variable
spanmove using default acceleration and deceleration rates and
using the variable slowspeed as a max velocity. */
```

```
move at slowspeed for spanmove;
```

| Move Incremental, Trapezoidal                      |  | <input checked="" type="checkbox"/> Positioning | <input type="checkbox"/> Slewing | <input type="checkbox"/> Tracking | <input checked="" type="checkbox"/> BG MSB<br><input type="checkbox"/> FG MSB |
|--|--|---|----------------------------------|-----------------------------------|---|
| <i>syntax</i>                                      |  |   |                                  |                                   |   |
| <code>move trap for displacement using rate</code> |  |   |                                  |                                   |   |
| <i>parameters</i>                                  |  |   |                                  |                                   |   |
| displacement                                       | incremental position, user-units                   |   |                                  |                                   |   |
| rate   | acceleration/deceleration rate, user-units/sec/sec |   |                                  |                                   |   |

This statement generates a 1/3-1/3-1/3 trapezoidal move (1/3 of the time accelerating, 1/3 constant velocity, 1/3 decelerating) for a specified *displacement*. The acceleration and deceleration *rate* must be specified.

⚠ Linear acceleration and deceleration is used (as programmed in the axis *acc* and *dec* properties) unless the property *jerk\_a\_req/jerk\_d\_req* is set to a non-zero value in which case an S-curve type profile is generated.

⚠ **ZPULSE\_POS** or **ZPULSE\_NEG** should not be used with incremental move commands.

```
/* Move the incremental distance specified by the variable offset
using the variable rapidacc to set acceleration and deceleration
rates. The velocity used will be based on the calculation to
achieve a trap move. */
```

```
move trap for offset using rapidacc;
```

| Move Incremental, Time-limited                       |  | <input checked="" type="checkbox"/> Positioning | <input type="checkbox"/> Slewing | <input type="checkbox"/> Tracking | <input checked="" type="checkbox"/> BG MSB<br><input checked="" type="checkbox"/> FG MSB |
|--|--|---|----------------------------------|-----------------------------------|--|
| <i>syntax</i>  |  |   |                                  |                                   |  |
| <code>move in time for displacement {mode n }</code> |  |   |                                  |                                   |  |
| <i>parameters</i>                                    |  |   |                                  |                                   |  |

|              |                                  |
|--------------|----------------------------------|
| time         | time, sec                        |
| displacement | incremental position, user-units |
| n            | acc / dec ramp multiplier        |

This statement generates a 1/3-1/3-1/3 trapezoidal move for a specified *displacement* in the specified *time*. The optional *mode* feature decreases the amount of time spent on acceleration and deceleration. The *n* parameter must be a positive, non-zero integer. By increasing the value of *n*, the acceleration and deceleration times are equally reduced, allowing more time at constant speed.

⚠ Linear acceleration and deceleration is used (as programmed in the axis *acc* and *dec* properties) unless the property *jerk\_a\_req/jerk\_d\_req* is set to a non-zero value in which case an S-curve type profile is generated.

⚠ **ZPULSE\_POS** or **ZPULSE\_NEG** should not be used with incremental move commands.

```
/* Move the incremental distance specified by the variable offset
  setting the calculated velocity, accel and decel rates to make a
  trapezoidal move in the time specified by the variable
  movetime. */
```

```
move in movetime for offset;
```

|                      |   |                                  |                                   |  |
|----------------------|---|----------------------------------|-----------------------------------|--|
| Wait For In Position | <input checked="" type="checkbox"/> Positioning | <input type="checkbox"/> Slewing | <input type="checkbox"/> Tracking | <input checked="" type="checkbox"/> BG MSB<br><input checked="" type="checkbox"/> FG MSB |
| <i>syntax</i>        |   |                                  |                                   |  |
| wait for in position |   |                                  |                                   |  |

This statement temporarily stops the execution of the active MSB until the target generator has reached its final value and the position error, *per* is within the programmed in-position window.

```
// Move speed-limited
move at slowspeed for spanmove;

// Wait till motor is within the programmed in-position window
wait for in position;

// Turn on output 1 for 1 second
pulse 1 for 1000 ms;
```

|  |   |                                  |                                   |  |
|--|---|----------------------------------|-----------------------------------|--|
| Set New End Position                             | <input checked="" type="checkbox"/> Positioning | <input type="checkbox"/> Slewing | <input type="checkbox"/> Tracking | <input checked="" type="checkbox"/> BG MSB<br><input checked="" type="checkbox"/> FG MSB |
| <i>syntax</i>                                    |   |                                  |                                   |  |
| new endposition position using rate              |   |                                  |                                   |  |
| new endposition relative displacement using rate |   |                                  |                                   |  |

This statement modifies the end position for the active *move* command. If there is no active *move*, then this statement is effectively ignored. The first form of this statement changes the end position to a new *absolute* position. The second form of this statement changes the end position *relative to the current position*. Using a *displacement* of 0 effectively stops motion *here* without generating a fault (unlike the *stop* command). Both statements require a *rate* to be specified. This *rate* is used as the acceleration/deceleration rate for the modified profile.

The *newvel* variable may be set to a nonzero value in order to specify a velocity. A trapezoidal move will be done whenever possible, if the end position does not allow for that then a triangular move will result. S-curve is not supported when using *newvel* although you may start out with an S-curve move and it will change to a trapezoidal or triangular with the new target and if *newvel* is nonzero, velocity.

⚠ Linear acceleration and deceleration is used (as programmed in the axis *acc* and *dec* properties) unless the property *jerk\_a\_req/jerk\_d\_req* is set to a non-zero value in which case an S-curve type profile is generated.

⚠ **ZPULSE\_POS** or **ZPULSE\_NEG** should not be used with this motion command.

Example 1: After *din1* is activated change the end position to -3 mm.

```
/* This example demonstrates how a move can be modified
on-the-fly by using the new endposition command */

[top]
zero feedback position;

// start moving to 25 mm
move at 5 to 25;

// if din1 is activated during the move, change the end
// position of the move to -3 mm
wait for rise of 1;
new endposition -3 using 10;

wait for in position;
delay 3000;
goto top;
```

Example 2: The move will be terminated 3mm after *din1* is activated. Speed is only changed when it is time to decel to the new end position.

```
/* This example demonstrates how a move can be modified
on-the-fly by using the new endposition command. */

[top]
zero feedback position;

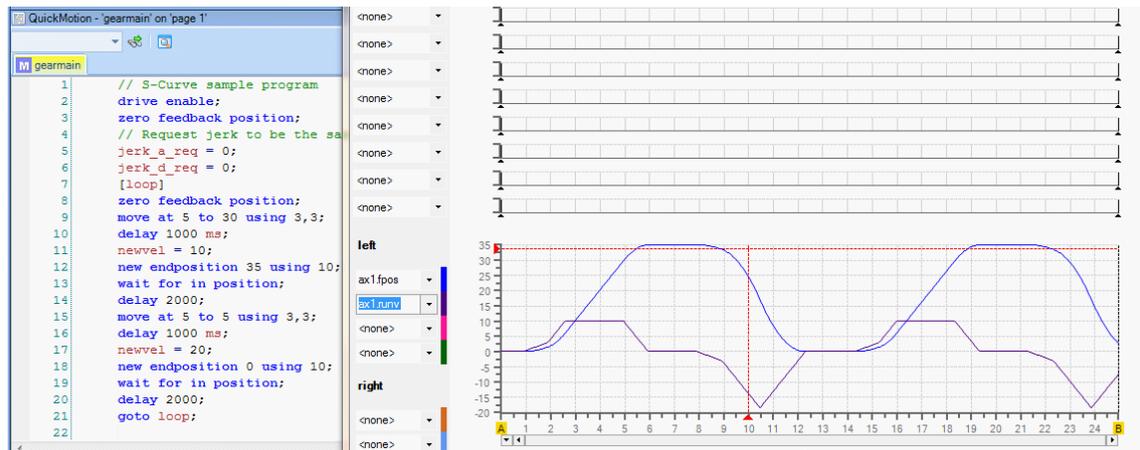
move at 5 to 25;
wait for rise of 1;

new endposition relative 3 using 10;
wait for in position;

delay 3000;
```

```
goto top;
```

Example 3: Change target from 30 to 35, acceleration from 3 to 10 and velocity from 5 to 10 during the acceleration phase of the move.



|                     |   |                                  |                                   |  |
|---------------------|---|----------------------------------|-----------------------------------|--|
| <b>Slew (begin)</b> | <input checked="" type="checkbox"/> Positioning | <input type="checkbox"/> Slewing | <input type="checkbox"/> Tracking | <input checked="" type="checkbox"/> BG MSB<br><input checked="" type="checkbox"/> FG MSB |
| <i>syntax</i>       |   |                                  |                                   |  |
| <b>slew begin</b>   |   |                                  |                                   |  |

This statement changes the operating mode of the axis to *slewing*.

```
slew begin; // change from position mode to slew mode
```

|                                 |                                      |   |                                   |  |
|---------------------------------|--------------------------------------|---|-----------------------------------|--|
| <b>Slew At</b>                  | <input type="checkbox"/> Positioning | <input checked="" type="checkbox"/> Slewing | <input type="checkbox"/> Tracking | <input checked="" type="checkbox"/> BG MSB<br><input checked="" type="checkbox"/> FG MSB |
| <i>syntax</i>                   |                                      |   |                                   |  |
| <b>slew at velocity in time</b> |                                      |   |                                   |  |
| <i>parameters</i>               |                                      |   |                                   |  |
| velocity                        | new slew velocity, user-units/sec    |   |                                   |  |
| time                            | time, sec                            |   |                                   |  |

This statement alters the current slew *velocity*. The velocity is changed smoothly over the specified *time*. For an immediate speed change, specify 0.0 for *time*.

```

// change from position mode to slew mode
slew begin;

```

```
// change from current speed to feedrate in 0.5 seconds
slew at feedrate in 0.5;
```

| Slew For                            | <input type="checkbox"/> Positioning      | <input checked="" type="checkbox"/> Slewing | <input type="checkbox"/> Tracking | <input checked="" type="checkbox"/> BG MSB<br><input checked="" type="checkbox"/> FG MSB |
|-------------------------------------|---|---|-----------------------------------|--|
| <i>syntax</i>                       |   |   |                                   |  |
| <b>slew for</b> <i>displacement</i> |   |   |                                   |  |
| <i>parameters</i>                   |   |   |                                   |  |
| displacement                        | ending relative slew position, user-units |   |                                   |  |

This statement alters the current slew velocity over time (to a slew velocity of 0.0) such that some *displacement* is consumed. If the current slew velocity is 0.0, then this statement is ignored.

The *displacement* should be unsigned, as the sign of the current slew velocity is used to sign the *displacement*.

```
// change from position mode to slew mode
slew begin;

// change from current speed to feedrate in 2 seconds
slew at feedrate in 2;

// delay execution of MSB until input3 transitions from off to on
wait for rise of 3;

// slew to a stop in the distance specified by the variable
// registrationoffset
slew for registrationoffset;
```

| Slew (end)      | <input type="checkbox"/> Positioning | <input checked="" type="checkbox"/> Slewing | <input type="checkbox"/> Tracking | <input checked="" type="checkbox"/> BG MSB<br><input checked="" type="checkbox"/> FG MSB |
|-----------------|--------------------------------------|---|-----------------------------------|--|
| <i>syntax</i>   |                                      |   |                                   |  |
| <b>slew end</b> |                                      |   |                                   |  |

This statement changes the operating mode of the axis to positioning. A zero-speed slew (in 0.0 *time*) is first generated if the axis is currently slewing at a non-zero velocity.

```
// change from position mode to slew mode
slew begin;

// change from current speed to slowjog in 0.5 seconds
slew at slowjog in 0.5;

// delay execution of MSB until input1 transitions from on to off
wait for fall of 1;
```

---

```
// stop motion and return to position mode  
slew end;
```

## 4.9 Gearing

Summary:

[gear at numerator : denominator](#)  
[gear at numerator : denominator in counts](#)  
[gear at numerator : denominator in counts after accounts](#)  
[gear for slavecounts in mastercounts](#)  
[gear for slavecounts in mastercounts after accounts](#)  
[offset slave by slavecounts in time](#)  
[wait master counts](#)  
[wait slave counts](#)  
[wait source within start , end](#)  
[wait source outside start , end](#)  
[zero masslv counters](#)

| Gear At                                      |                            | <input type="checkbox"/> Positioning | <input type="checkbox"/> Slewing | <input checked="" type="checkbox"/> Tracking | <input checked="" type="checkbox"/> BG MSB<br><input checked="" type="checkbox"/> FG MSB |
|--|----------------------------|--------------------------------------|----------------------------------|--|--|
| <i>syntax</i>                                |                            |                                      |                                  |  |  |
| <code>gear at numerator : denominator</code> |                            |                                      |                                  |  |  |
| <i>parameters</i>                            |                            |                                      |                                  |  |  |
| numerator                                    | new gear ratio numerator   |                                      |                                  |  |  |
| denominator                                  | new gear ratio denominator |                                      |                                  |  |  |

This statement *instantaneously* changes the gear ratio of the slaved axis to the specified values.

| Gear At In  |  | <input type="checkbox"/> Positioning | <input type="checkbox"/> Slewing | <input checked="" type="checkbox"/> Tracking | <input checked="" type="checkbox"/> BG MSB<br><input checked="" type="checkbox"/> FG MSB |
|---|--|--------------------------------------|----------------------------------|--|--|
| <i>syntax</i>   |  |                                      |                                  |  |  |
| <code>gear at numerator : denominator in counts</code>                |  |                                      |                                  |  |  |
| <code>gear at numerator : denominator in counts after accounts</code> |  |                                      |                                  |  |  |
| <i>parameters</i>   |  |                                      |                                  |  |  |
| numerator   | new gear ratio numerator   |                                      |                                  |  |  |
| denominator   | new gear ratio denominator   |                                      |                                  |  |  |
| counts  | counts of the master encoder   |                                      |                                  |  |  |
| accounts  | counts of the master encoder to "wait for" before applying the gear/at...in... |                                      |                                  |  |  |

This statement changes the gear ratio of the slaved axis to the specified values over some number of master *counts*. An optional *after* condition can be applied to delay application of the gear/at/in.

| Gear For In  |   | <input type="checkbox"/> Positioning | <input type="checkbox"/> Slewing | <input checked="" type="checkbox"/> Tracking | <input checked="" type="checkbox"/> BG MSB<br><input checked="" type="checkbox"/> FG MSB |
|--|---|--------------------------------------|----------------------------------|--|--|
| <i>syntax</i>  |   |                                      |                                  |  |  |
| <b>gear for slavecounts in mastercounts</b>                |   |                                      |                                  |  |  |
| <b>gear for slavecounts in mastercounts after accounts</b> |   |                                      |                                  |  |  |
| <i>parameters</i>  |   |                                      |                                  |  |  |
| slavecounts  | counts of the axis encoder  |                                      |                                  |  |  |
| mastercounts   | counts of the master encoder  |                                      |                                  |  |  |
| accounts   | counts of the master encoder to "wait for" before applying the gear/for...in... |                                      |                                  |  |  |

This statement temporarily modifies the gear ratio of the slave axis such that a *slavecounts* correction (offset) occurs over a master-feedback displacement of *mastercounts*. The *slavecounts* correction may be positive or negative. An optional after condition can be applied to delay application of the gear/for/in.

| Offset Slave Position                      |                            | <input type="checkbox"/> Positioning | <input type="checkbox"/> Slewing | <input checked="" type="checkbox"/> Tracking | <input checked="" type="checkbox"/> BG MSB<br><input checked="" type="checkbox"/> FG MSB |
|--|----------------------------|--------------------------------------|----------------------------------|--|--|
| <i>syntax</i>                              |                            |                                      |                                  |  |  |
| <b>offset slave by slavecounts in time</b> |                            |                                      |                                  |  |  |
| <i>parameters</i>                          |                            |                                      |                                  |  |  |
| slavecounts                                | counts of the axis encoder |                                      |                                  |  |  |
| time                                       | time, sec                  |                                      |                                  |  |  |

This statement offsets the position (and therefore phase) of the axis such that a *slavecounts* correction (the offset) occurs over a period of *time*. The *slavecounts* correction may be positive or negative.

| Wait for Counts of Master |                      | <input type="checkbox"/> Positioning | <input type="checkbox"/> Slewing | <input checked="" type="checkbox"/> Tracking | <input checked="" type="checkbox"/> BG MSB<br><input checked="" type="checkbox"/> FG MSB |
|---------------------------|----------------------|--------------------------------------|----------------------------------|--|--|
| <i>syntax</i>             |                      |                                      |                                  |  |  |
| <b>wait master counts</b> |                      |                                      |                                  |  |  |
| <i>parameters</i>         |                      |                                      |                                  |  |  |
| counts                    | counts of the master |                                      |                                  |  |  |

This statement waits until the specified number of master *encoder* counts has been generated.

| Wait for Counts of Slave |  | <input type="checkbox"/> Positioning | <input type="checkbox"/> Slewing | <input checked="" type="checkbox"/> Tracking | <input checked="" type="checkbox"/> BG MSB<br><input checked="" type="checkbox"/> FG MSB |
|--------------------------|--|--------------------------------------|----------------------------------|--|--|
| <i>syntax</i>            |  |                                      |                                  |  |  |

|                                |                            |
|--------------------------------|----------------------------|
| <code>wait slave counts</code> |                            |
| <i>parameters</i>              |                            |
| counts                         | counts of the axis (slave) |

This statement waits until the specified number of axis (slave, target-position) counts has been generated.

|   |   |                                  |  |  |
|---|---|----------------------------------|--|--|
| <b>Wait Within</b>                          | <input type="checkbox"/> Positioning                      | <input type="checkbox"/> Slewing | <input checked="" type="checkbox"/> Tracking | <input checked="" type="checkbox"/> BG MSB<br><input checked="" type="checkbox"/> FG MSB |
| <i>syntax</i>                               |   |                                  |  |  |
| <code>wait source within start , end</code> |   |                                  |  |  |
| <i>parameters</i>                           |   |                                  |  |  |
| source                                      | <b>master1, master2, master3, master4</b> or <b>slave</b> |                                  |  |  |
| start                                       | a modulo starting bound                                   |                                  |  |  |
| end   | a modulo ending bound                                     |                                  |  |  |

This statement waits for the *modulo position* (either *mposc1-4* or *sposc*) to lie within the specified bounds.

|  |   |                                  |  |  |
|--|---|----------------------------------|--|--|
| <b>Wait Outside</b>                          | <input type="checkbox"/> Positioning                      | <input type="checkbox"/> Slewing | <input checked="" type="checkbox"/> Tracking | <input checked="" type="checkbox"/> BG MSB<br><input checked="" type="checkbox"/> FG MSB |
| <i>syntax</i>                                |   |                                  |  |  |
| <code>wait source outside start , end</code> |   |                                  |  |  |
| <i>parameters</i>                            |   |                                  |  |  |
| source                                       | <b>master1, master2, master3, master4</b> or <b>slave</b> |                                  |  |  |
| start  | a modulo starting bound                                   |                                  |  |  |
| end  | a modulo ending bound                                     |                                  |  |  |

This statement waits for the *modulo position* (either *mposc1-4* or *sposc*) to lie outside the specified bounds.

|   |   |   |  |  |
|---|---|---|--|--|
| <b>Clear Temporary Gearing Counters</b> | <input checked="" type="checkbox"/> Positioning | <input checked="" type="checkbox"/> Slewing | <input checked="" type="checkbox"/> Tracking | <input checked="" type="checkbox"/> BG MSB<br><input checked="" type="checkbox"/> FG MSB |
| <i>syntax</i>                           |   |   |  |  |
| <code>zero masslv counters</code>       |   |   |  |  |
| <i>parameters</i>                       |   |   |  |  |
| masslv                                  | <b>master</b>                                   | clears tmc1 and tmc2                        |  |  |
|   | <b>slave</b>                                    | clears tsc1 and tsc2                        |  |  |

This statement atomically clears the temporary master or slave counters.

## 4.10 Position Capture & Registration

Summary:

```
set capture transition of input input { gate input gateinput gatestate }
set capwin range start, end using reference { arm }
wait capture { if limit of limit goto limitlabel }
```

(Also reference the EtherCAT Applications Guide for additional details pertaining to network drive control).

| Set Capture   |   | <input checked="" type="checkbox"/> Positioning | <input checked="" type="checkbox"/> Slewing | <input checked="" type="checkbox"/> Tracking | <input checked="" type="checkbox"/> BG MSB<br><input checked="" type="checkbox"/> FG MSB |
|---|---|---|---|--|--|
| <i>syntax</i>   |   |   |   |  |  |
| <code>set capture transition of input input { gate input gateinput gatestate }</code> |   |   |   |  |  |
| <i>parameters</i>   |   |   |   |  |  |
| transition  | rise, fall or edge (any)  |   |   |  |  |
| input   | the input# (1-10, representing all the inputs on the M3-40A card) |   |   |  |  |
| gateinput   | the input# (1-10, representing all the inputs on the M3-40A card) |   |   |  |  |
| gatestate   | on or off   |   |   |  |  |

This statement initializes the parameters to be used for all captures on this axis, specifying the input (*capInput*) to use and the optional gated input. If gating is specified, then the specified gating input (*capGate*) must be at the specified gating state (*capGateState*).

The following variables are computed and available after a successful capture:

|                     |                                    |
|---------------------|------------------------------------|
| <i>capposc</i>      | capture position in encoder counts |
| <i>cappos</i>       | capture position in user units     |
| <i>capTriggered</i> | flag set to 1 when capture occurs  |

Note: *capposc* and *cappos* are only valid when *capTriggered* is a 1. Once armed *capposc/cappos* will reflect the value latched when the capture input goes active but is not necessarily within the defined capture window. *capTriggered* verifies the capture window against the latched *capposc/cappos*, prior to setting.

If more than one running MSB on an M3-40A card arms the *same* input for capture, unexpected capture results may occur.

Only one input may be armed for capture at a time *per axis*. If another input is presently armed when this command is issued, the other input is effectively *disarmed*.

| Set Capture Window   |  | <input checked="" type="checkbox"/> Positioning | <input checked="" type="checkbox"/> Slewing | <input checked="" type="checkbox"/> Tracking | <input checked="" type="checkbox"/> BG MSB<br><input checked="" type="checkbox"/> FG MSB |
|--|--|---|---|--|--|
| <i>syntax</i>  |  |   |   |  |  |
| <code>set capwin range start, end using reference { arm }</code> |  |   |   |  |  |

| <i>parameters</i> |  |
|-------------------|--|
| start             | Start window position to compare against <i>reference</i> . <i>Reference</i> >= <i>start</i> .   |
| end               | End window position to compare against <i>reference</i> . If equals <i>start</i> then no window exists and capture will occur based on input. <i>Reference</i> <= <i>end</i> .   |
| reference         | the encoder count scaled reference variable to compare to:<br><b>fposc</b> feedback position<br><b>mposc1 - mposc5</b> master position counters #1 through #5<br><b>mposc</b> master position counter<br><b>smodc</b> slave position (modulo)<br><b>smark</b> slave marked position<br><b>tmc1 tmc2</b> temporary master counters #1 & #2<br><b>tsc1 tsc2</b> temporary slave counters #1 & #2<br><b>sdc</b> slave decrement counter<br><b>fposc1</b> feedback position of axis 1 (fposcA)<br><b>fposc2</b> feedback position of axis 2 (fposcB)<br><b>tmodc</b> temporary master counter mod mmc<br><b>sfposc</b> secondary feedback position of axis |
| arm               | If included will arm the capture, if not arm will need to be done by a Wait or On command.   |

This statement initializes a window to be monitored for valid captures to occur, anything outside this window is considered invalid and ignored. If the capture occurs outside this window it will automatically be re-armed within the loop period (default 800 uS). If 'arm' is specified this statement will automatically arm the capture prior to completing this instruction. The *capwinStart* variable is the start of range and the *capwinEnd* variable is the end of range, inclusive.

 When using open loop stepper tpsc is not available thus issue the command 'set simulated feedback on' to have tpsc copied to fposc, on each control loop, allowing the use of this command.

| Wait Capture  |  | <input type="checkbox"/> Positioning | <input type="checkbox"/> Slewing | <input checked="" type="checkbox"/> Tracking | <input checked="" type="checkbox"/> BG MSB<br><input checked="" type="checkbox"/> FG MSB |
|---|--|--------------------------------------|----------------------------------|--|--|
| <i>syntax</i>   |  |                                      |                                  |  |  |
| <code>wait capture { if limit of limit goto limitlabel }</code> |  |                                      |                                  |  |  |
| <i>parameters</i>   |  |                                      |                                  |  |  |
| limit   | optional master encoder count limit                    |                                      |                                  |  |  |
| limitlabel  | optional label to branch to if <i>limit</i> is reached |                                      |                                  |  |  |

This statement waits for the capture and arms the capture input. If the capture occurs the next statement in the MSB is executed. A maximum limit of counts prior to exiting (*capLimit/capLimitflag*) can be set. This limit references the 'reference' set by 'set capwin' and the sign must be adjusted accordingly. The *capWait* variable will be set to 1 while the 'wait capture' is active, 0 if not.

If a limit (*capLimit*) is specified, then the statement will branch to the specified goto *limitlabel* after that number of master encoder counts has passed.

## 4.11 S-Curve

S-Curve support is optionally available for the move commands, from a stopped position. When using timed commands the distance, acceleration, and velocity will be calculated for the given time and then translated to an S-Curve move. The time will not be the same as the non S-Curve move but all other parameters will be, including position. Variables of interest are:

'runv' - velocity fed to the PID algorithm internal use only, read only.

'jerk\_a/jerk\_d' - acceleration/deceleration actual jerk, read only .

'jerk\_a\_req/jerk\_d\_req' – requested acceleration/deceleration jerk in units/sec<sup>3</sup>, read/write. Set to 1 for automatic calculation.

'sign' – nonzero for S-Curve move, 1 for CCW rotation and -1 for CW rotation, read only.

The minimum jerk that can be used is calculated by the formula ( $a_{max} * a_{max} / v_{max}$ ), applied independently to the requested acceleration and deceleration jerk. The maximum velocity is the same as the non S-Curve move and defined by the expression:

```

sign = 1;
if (delta < 0) {
    sign = -1;
    delta = -delta;
}
a_max = sign * acceleration;
d_max = -sign * deceleration;
V_max = sqrt(2.0 * a_max * d_max * sign * delta / (d_max - a_max));

```

If 'jerk\_a\_req/jerk\_d\_req' is 0 then a normal move will be attempted. If only one is set then 'jerk\_a/jerk\_d' will be set equal. If the requested jerk is greater than the minimum then it will be used. The variables 'jerk\_a/jerk\_d' are the actual jerk used for the move. Also note that S-Curve uses twice the acceleration and deceleration specified by the non S-Curve move request.

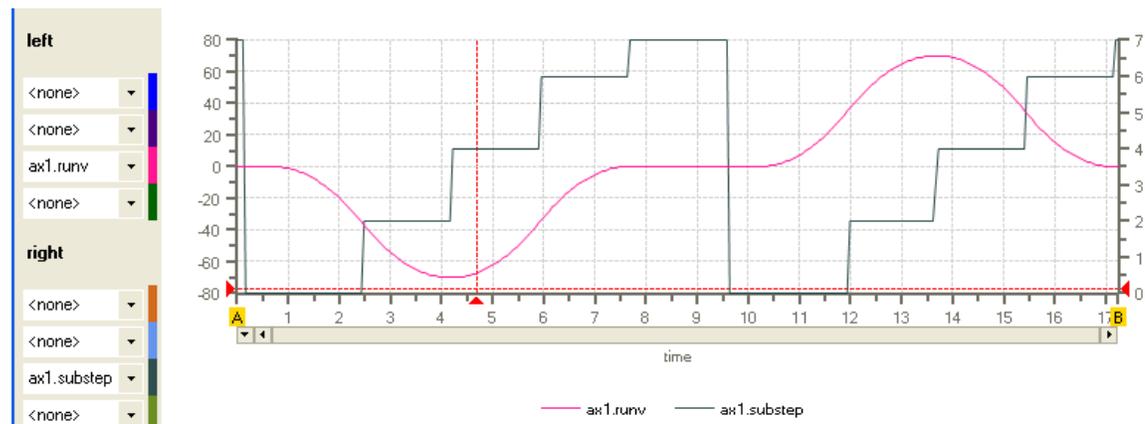
Below shows a sample S-Curve where the jerk is set to 1, thereby having the motion card calculate the optimum jerk and the velocity set to a large number so that the motion card will calculate the maximum velocity possible for the move. Note that the step graph is the segment (substep), 1 to 7, of the S-Curve, with 0 being segment 1. If for some reason the proper velocity or distance can not be attained by the parameters given, the non S-Curve curve move will be used. The end position can not be changed and a slew stop will do the non S-Curve stop. In the example below the motion card will calculate the maximum velocity and optimum jerk. Note there is little or no segment 4 (constant velocity). Also linear segments 2 and 6 are 0.

```

1 // S-Curve sample program
2 drive enable;
3 zero feedback position;
4 // Request jerk to be the same for acc/dec.
5 jerk_a_req = 1;
6 jerk_d_req = 1;
7 [loop]
8 move at 1000 for 246 using 20, 20; // turn CCW
9 wait for in position;
10 delay 1000;
11 move at 1000 for -246 using 20, 20; // turn CW
12 wait for in position;
13 delay 2000;
14 goto loop;

```

Resulting motion S-Curve using QuickScope:



⚠ 800uS is the default loop period. If 500uS is desired use the 'set looperiod .0005' command prior to drive enable.

## 4.12 Linear and Circular Interpolation (Vectors)

Reference the EtherCAT Applications Guide for details.

## 5 Chapter 5: Camming and Data Tables

Camming tables in QuickMotion are two-dimensional arrays of floating-point data. There are 6 tables available for use, numbered 0 through 5, each having up to 2000 rows and always 2 columns. These columns are named “x” and “y”. Although their primary use is to hold data for *spline*- and *CAM*-based motion, they can be used to hold arbitrary data such as positions for recipe-based motion. Although limited to 6 tables, these tables can also be swapped out dynamically and refreshed with new data when loaded from the controller file system.

*Spline* tables use the “x” column as time and the “y” column as a *relative* position. *CAM* tables use the “x” column as a *relative master* position and the “y” column as a *relative slave* position.

Since *spline* and *CAM* tables use *relative* position data, the first point pair in these tables must be 0.0, 0.0 (time/master-position of 0, position/slave-position of 0). The exception to this is with *CAM* tables where the y component can be non-zero in newer firmware revisions, thereby establishing an offset. In addition, for any tables used for *spline* and *CAM* operations, all “x” values must be increasing, that is: a given row’s “x” must be greater than the previous row’s “x”. Also, the minimum number of rows (pairs) in these tables is 3.

⚠ It is recommended that *CAM* tables and instructions be used whenever possible. Significant enhancements have been made to camming which have currently not been carried forward to splines. Some of this consists of the ability to start on non-zero y column values, ability to start anywhere within a table, and forward and reverse table traversing.

Points in a *spline* or *CAM* table are also referred to as *knots*, as they represent critical loci that must be passed through when interpolation occurs.

For example, in the following *spline* table:

|     |     |
|-----|-----|
| 0.0 | 0.0 |
| 1.5 | 2.0 |
| 2.0 | 2.5 |
| 3.0 | 3.0 |
| 4.0 | 2.0 |
| 5.0 | 0.0 |

there are 6 knots. Since this is a *spline* table, the last 5 knots are interpreted as follows:

At time = 1.5 seconds, the position of the axis should be 2.0 user-units beyond where the axis started this spline move.

At time = 2.0 seconds, the position of the axis should be 2.5 user-units beyond where the axis started this spline move.

At time = 3.0 seconds, the position of the axis should be 3.0 user-units beyond where the axis started this spline move.

At time = 4.0 seconds, the position of the axis should be 2.0 user-units beyond where the axis started this spline move.

At time = 5.0 seconds, the position of the axis should be back where the axis started this spline move.

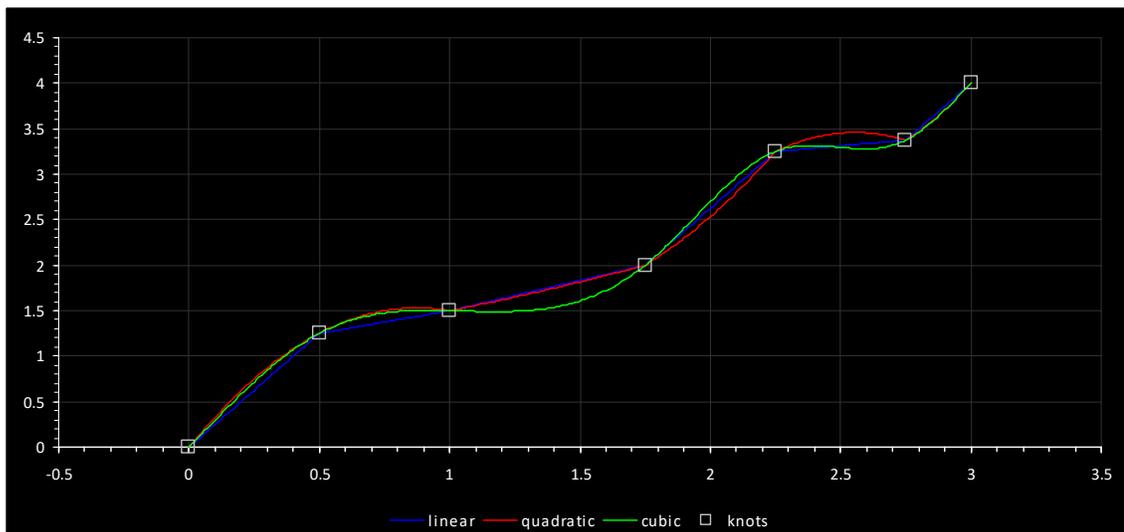
The position of the axis between these “knots” is determined by the interpolation method specified by the QM code when the table is *started*.

The three available interpolation methods in QM for *spline* (and *CAM* tables) are:

- linear** a straight-line joins each knot
- quadratic** a piecewise 2nd degree polynomial is fitted between this knot and the next; the first derivative of the first point is forced to 0.
- cubic** a piecewise 3rd degree polynomial is fitted between this knot and the next two knots; the first and second derivatives of the first point is forced to 0.

The following graph shows different interpolation methods using the following table of knots:

|       |       |
|-------|-------|
| 0.000 | 0.000 |
| 0.500 | 1.250 |
| 1.000 | 1.500 |
| 1.750 | 2.000 |
| 2.250 | 3.250 |
| 2.750 | 3.375 |
| 3.000 | 4.000 |



CAM tables are interpreted similar to their time-based *spline* counterparts. For example, in the following CAM table:

|     |      |
|-----|------|
| 0.0 | 0.0  |
| 2.5 | 1.0  |
| 4.0 | -1.0 |
| 5.0 | 0.0  |

the last 3 knots are interpreted as follows:

At a relative master position of 2.5 user-units, this (slave) axis should be 1.0 user-units beyond where it started.

At a relative master position of 4.0 user-units, this (slave) axis should be 1.0 user-units before where it started.

At a relative master position of 5.0 user-units, this (slave) axis should be where it started.

The master position is kept in the QM variable, `mpos` and is scaled to user-units by dividing by the axis parameter `mppr`. No other scaling occurs (i.e. `uun` and `uud` are not utilized). A raw (counts) variable is also available in `mposc`.

⚠ Unlike splines, Cam tables may start on a non-zero relative position (y). This position is used as an offset.

⚠ 'activeCAM\_row' may be set to any desired row upon which `mpos` will be initialized to that which is the 'x' value of that row, allowing the table to start in that position.

⚠ 'invertmaster' variable is by default set to 0, meaning the cam table is traversed moving from row 0 to N. If 'invertmaster' is set to 1 the cam table position will begin at the end of the table and traverse N to 0. 'activeCAM\_row' determines the start position, initialized by the `precompute` command either to the end or start of the table based upon 'invertmaster'. Prior to a 'table start' command 'activeCAM\_row' can be changed to a different start position. 'invertmaster', when set causes `mpos` to decrement on positive master pulses, thus the reverse traversing of the table.

⚠ 'camming\_invertend' variable is by default set to 0, meaning follow the logic described above for 'invertmaster'. If you wish to invert the logic of the 'invertmaster', with regards to camming table positioning only, set this flag. The 'invertmaster' variable will still control whether `mpos` is added or subtracted from based upon the master but 'camming\_invertend', if set, allows you to start at the other end of the camming table. The direction you traverse the camming table is important since if you are at the start of the table and go slightly negative you will hold position but if you go past the end of the table the command will be considered completed.

| invertmaster | camming_invertend |   |
|--------------|-------------------|---|
| 0            | 0                 | master difference added to <code>mpos</code> , assume moving from beginning of camming table to end (thus go beyond end COMPLETE).              |
| 0            | 1                 | master difference added to <code>mpos</code> , assume moving from end of camming table to beginning (thus go beyond beginning COMPLETE).        |
| 1            | 0                 | master difference subtracted from <code>mpos</code> , assume moving from end of camming table to beginning (thus go beyond beginning COMPLETE). |
| 1            | 1                 | master difference subtracted from <code>mpos</code> , assume moving from beginning of camming table to end (thus go beyond end COMPLETE).       |

## 5.1 Loading Tables

Summary:

[table n clear](#)

[table n addpair xexpression , yexpression](#)

[table n addseries pairs](#)

[table n copy from rowOffset1 to table m rowOffset2 numRows](#)

[table n loadoffset rowOffsetFile, numPairs,rowOffsetTable](#)

[table n loadseries source fileName](#)

In order to use a table, it must be loaded with point pairs. There are several QM statements which facilitate loading of tables. These statements allow tables to be loaded either directly from within program code, thus static data, or dynamically from binary table files which reside on the controller file system. The commands that effect table loading are:

| Table Clear          |                    | <input checked="" type="checkbox"/> Positioning | <input type="checkbox"/> Slewing | <input type="checkbox"/> Tracking | <input checked="" type="checkbox"/> BG MSB<br><input type="checkbox"/> FG MSB |
|----------------------|--------------------|---|----------------------------------|-----------------------------------|---|
| <i>syntax</i>        |                    |   |                                  |                                   |   |
| <b>table n clear</b> |                    |   |                                  |                                   |   |
| <i>parameters</i>    |                    |   |                                  |                                   |   |
| <i>n</i>             | the table to clear |   |                                  |                                   |   |

Clears a table of all of its points, thus setting the number of data points to 0, within a table.

```
table 1 clear;
```

There can be no active motion command when this statement is issued.

| Table Add Pair                                   |  | <input checked="" type="checkbox"/> Positioning | <input type="checkbox"/> Slewing | <input type="checkbox"/> Tracking | <input checked="" type="checkbox"/> BG MSB<br><input type="checkbox"/> FG MSB |
|--|--|---|----------------------------------|-----------------------------------|---|
| <i>syntax</i>                                    |  |   |                                  |                                   |   |
| <b>table n addpair xexpression , yexpression</b> |  |   |                                  |                                   |   |
| <i>parameters</i>                                |  |   |                                  |                                   |   |
| <i>n</i>   | the table to add a point pair to   |   |                                  |                                   |   |
| <i>xexpression</i>                               | an expression which when evaluated will be utilized as the value in the "x" column |   |                                  |                                   |   |
| <i>yexpression</i>                               | an expression which when evaluated will be utilized as the value in the "y" column |   |                                  |                                   |   |

This statement adds a point pair to a table. This statement is used when the table is computed at MSB runtime since the pair is computed by two expressions.

```
table 2 addpair 3.75 + ztime, q + zoffset;
```

⚠ There can be no active motion command when this statement is issued.

⚠ An error will occur if there are already 2000 rows in the table.

| Table Add Series                     |   | <input checked="" type="checkbox"/> Positioning | <input type="checkbox"/> Slewing | <input type="checkbox"/> Tracking | <input checked="" type="checkbox"/> BG MSB<br><input type="checkbox"/> FG MSB |
|--------------------------------------|---|---|----------------------------------|-----------------------------------|---|
| <i>syntax</i>                        |   |   |                                  |                                   |   |
| <code>table n addseries pairs</code> |   |   |                                  |                                   |   |
| <i>parameters</i>                    |   |   |                                  |                                   |   |
| <i>n</i>                             | the table to add a point pair to                                    |   |                                  |                                   |   |
| <i>pairs</i>                         | a series of one or more pairs (in the form of x,y), colon-delimited |   |                                  |                                   |   |

This statement adds constant point pairs to a table.

```
// add 4 point pairs to table 1
```

```
table 1 addseries 0.0,0.0 : 1.0,1.5 : 2.0,1.75 : 3.0,2.0;
```

⚠ There can be no active motion command when this statement is issued.

⚠ An error will occur if adding these pairs will result in a table with more than 2000 rows.

| Table Copy  |   | <input checked="" type="checkbox"/> Positioning | <input type="checkbox"/> Slewing | <input type="checkbox"/> Tracking | <input checked="" type="checkbox"/> BG MSB<br><input type="checkbox"/> FG MSB |
|---|---|---|----------------------------------|-----------------------------------|---|
| <i>syntax</i>   |   |   |                                  |                                   |   |
| <code>table n copy from rowOffset1 to table m rowOffset2 numRows</code> |   |   |                                  |                                   |   |
| <i>parameters</i>   |   |   |                                  |                                   |   |
| <i>n</i>  | The table which is source of the copy.                          |   |                                  |                                   |   |
| <i>rowOffset1</i>   | The source table row offset, 0 is no offset.                    |   |                                  |                                   |   |
| <i>m</i>  | The table which is destination of the copy.                     |   |                                  |                                   |   |
| <i>rowOffset2</i>   | The destination table row offset, 0 is no offset, -1 is append. |   |                                  |                                   |   |
| <i>numRows</i>  | The number of rows to copy, 0 is all.                           |   |                                  |                                   |   |

This statement allows for one table to be copy or appended to another table. The destination table does not need to exist. The offsets can be used to merge table data.

```
table 1 copy from 0 to table 2 0; // Copy all of table 1 to 2
```

| Table Loadoffset   |  | <input checked="" type="checkbox"/> Positioning | <input type="checkbox"/> Slewing | <input type="checkbox"/> Tracking | <input checked="" type="checkbox"/> BG MSB<br><input checked="" type="checkbox"/> FG MSB |
|--|--|---|----------------------------------|-----------------------------------|--|
| <i>syntax</i>  |  |   |                                  |                                   |  |
| <b>table n loadoffset</b> rowOffsetFile, numPairs,rowOffsetTable |  |   |                                  |                                   |  |
| <i>parameters</i>  |  |   |                                  |                                   |  |
| <i>n</i>   | The table to set the offset information on.                    |   |                                  |                                   |  |
| <i>rowOffsetFile</i>   | The file row offset to begin transfer on, 0 is no offset.      |   |                                  |                                   |  |
| <i>numPairs</i>  | The number of cam file pairs to transfer, 0 is all.            |   |                                  |                                   |  |
| <i>rowOffsetTable</i>  | The cam table row offset to begin storing file at, 0 is start. |   |                                  |                                   |  |

This statement works in conjunction with the 'loadseries' command, setting the offsets to be used. The offsets can be used to merge table data. This command only initializes parameters for 'loadseries' and does not directly effect the table.

```
table 1 loadoffset 0 0; // Default, transfer all from start .
```

| Table Loadseries                            |  | <input checked="" type="checkbox"/> Positioning | <input type="checkbox"/> Slewing | <input type="checkbox"/> Tracking | <input checked="" type="checkbox"/> BG MSB<br><input checked="" type="checkbox"/> FG MSB |
|---|--|---|----------------------------------|-----------------------------------|--|
| <i>syntax</i>                               |  |   |                                  |                                   |  |
| <b>table n loadseries</b> source fileNumber |  |   |                                  |                                   |  |
| <i>parameters</i>                           |  |   |                                  |                                   |  |
| <i>n</i>                                    | The table to load the cam file into.   |   |                                  |                                   |  |
| <i>source</i>                               | The location on disk where file will be found, 'flash' or 'ram' (/ _system/Datatables or /RAMDISK/Datatables).     |   |                                  |                                   |  |
| <i>fileNumber</i>                           | The file to transfer, 'camtable#.tbl', where # is any valid positive number. A variable may be referenced as well. |   |                                  |                                   |  |

This statement requests a cam file to be transferred from the controllers file system. The file is transferred to the MSB for local storage and must be precomputed prior to operation. The 'loadoffset' parameters are referenced for this command as to where within the file and table to begin the transfer.

```
table 1 loadseries ram 1; // Load file 'camtable1.tbl'
```

The file format of 'camtable#.tbl' consists of a binary file of 32 bit float pairs with a file record structure as:

```
float rows[NUMROWS][2];
```

Where NUMROWS is the number of cam file pair entries, with the first starting at 0, 0. The same rules as the 'addseries' command exists. Each float is stored in little endian format with X being the first float.

As an example of a 3 row table with the values of:

```
0, 0
250, 25.67
```

500, 50.48

The binary data within a file would consist of 24 bytes, 4 bytes per entry in little endian and IEEE-754 floating point format. Below is byte representation of the required file, in hex:

```
0x00 0x7A 0x43 0x29 0x5C 0xCD 0x41  
0x00 0x00 0xFA 0x43 0x85 0xEB 0x49 0x42
```

IEEE-754 conversion calculator is available at:

<http://babbage.cs.qc.cuny.edu/IEEE-754/Decimal.html>

For example, 50.48, is 0x4249EB85, reversed when stored in the file since in little endian format (low byte first).

## 5.2 Using Tables for Spline/CAM

Summary:

[table n continue](#)

[table n precompute](#)

[table n start imethod tscale , rpscale , repeatcount](#)

[table n start imethod cam mpscale , spscale , repeatcount](#)

[stop table](#)

| Table Continue          |  | <input checked="" type="checkbox"/> Positioning | <input type="checkbox"/> Slewing | <input type="checkbox"/> Tracking | <input checked="" type="checkbox"/> BG MSB<br><input checked="" type="checkbox"/> FG MSB |
|-------------------------|--|---|----------------------------------|-----------------------------------|--|
| <i>syntax</i>           |  |   |                                  |                                   |  |
| <b>table n continue</b> |  |   |                                  |                                   |  |
| <i>parameters</i>       |  |   |                                  |                                   |  |
| <i>n</i>                | The table to continue that was previously stopped. |   |                                  |                                   |  |

Continues a cam table that was stopped by the 'stop table' command. Note that this command should only be used if the master position stopped at the beginning of the next table row position otherwise any row that is currently being executed during a 'stop table' (immediate stop) will be re-executed. The master position allows for a slewed stop. Upon execution of 'stop table', with the servo not moving, would then save all the camming information so that you can exit camming, jog into position, and then continue with the same camming table from where left off with the 'table n continue' command.

```
table 1 continue;
```

 There can be no active motion command when this statement is issued.

 In many cases this command is no longer needed since the 'activeCAM\_row' can be set prior to 'table start'. Only supported in camming mode, not spline.

| Table Pre-compute for Spline/CAM |                          | <input checked="" type="checkbox"/> Positioning | <input type="checkbox"/> Slewing | <input type="checkbox"/> Tracking | <input checked="" type="checkbox"/> BG MSB<br><input type="checkbox"/> FG MSB |
|----------------------------------|--------------------------|---|----------------------------------|-----------------------------------|---|
| <i>syntax</i>                    |                          |   |                                  |                                   |   |
| <b>table n precompute</b>        |                          |   |                                  |                                   |   |
| <i>parameters</i>                |                          |   |                                  |                                   |   |
| <i>n</i>                         | the table to pre-compute |   |                                  |                                   |   |

This statement readies a table for use by a *spline/CAM* motion. After points have been added to a table, there are a series of computations that need to occur before the table can be utilized for spline and CAM motion operations. This statement causes those computations to occur.

There is no need to issue this command if a table is being utilized simply for data (i.e. for *tbln*, *tblx* or *tbly* operations).

Failure to *precompute* a table before *starting* the table will cause a *hard fault*.

⚠ It takes roughly 250ms to *precompute* a 1000 row table.

⚠ The table must contain at least 3 points and all 'x' column values must be *increasing* or an error will occur. The first point in the table must be 0.0,0.0 otherwise an error will occur.

⚠ In camming mode 'invertmaster' set to 0 will cause 'precompute' to initialize the table to move from start to end, if set then from end to start, with positive master position motion.

```
// prepare the table for CAM use
```

```
table 1 precompute;
```

| Table Start Spline Motion   |   | <input checked="" type="checkbox"/> Positioning | <input type="checkbox"/> Slewing | <input type="checkbox"/> Tracking | <input checked="" type="checkbox"/> BG MSB<br><input checked="" type="checkbox"/> FG MSB |
|---|---|---|----------------------------------|-----------------------------------|--|
| <i>syntax</i>   |   |   |                                  |                                   |  |
| <code>table n start imethod tscale , rpscale , repeatcount</code> |   |   |                                  |                                   |  |
| <i>parameters</i>   |   |   |                                  |                                   |  |
| <i>n</i>  | the table to utilize for motion   |   |                                  |                                   |  |
| <i>imethod</i>  | <b>linear</b> uses linear interpolation<br><b>quadratic</b> uses 2nd order interpolation<br><b>cubic</b> uses 3rd order interpolation   |   |                                  |                                   |  |
| <i>tscale</i>   | time scale factor: the values in the "x" (time) column in the table are effectively divided by this number                              |   |                                  |                                   |  |
| <i>rpscale</i>  | relative position scale factor: the values in the "y" (relative position) column in the table are effectively multiplied by this number |   |                                  |                                   |  |
| <i>repeatcount</i>  | the number of times to "run through" the table (0=forever)  |   |                                  |                                   |  |

This statement starts *spline* motion using the specified table.

The current (target) position is used as the starting relative-position for the motion.

The table must be *ready* for use (i.e. a *table precompute* operation has been successfully completed on the table).

⚠ "In position" will be *true* only when the table has completed all required repeats. If 0 (forever) is specified for the *repeatcount*, then "In position" will never be true unless a *stop table* is issued.

⚠ The scale factor *tscale* must evaluate to a value greater than 0 otherwise an error will occur.

⚠ The scale factor *rpscale* must evaluate to a value other than 0 otherwise an error will occur.

⚠ The scale factor *rpscale* is not affected by *uun* or *uud*. The generated position is also unaffected by *uun* or *uud*.

[top]

```
zero feedback position;
```

```
table 1 start quadratic 1.0, 1.0, 0; // run through the table
forever, 'table stop' command will cause the background motion
command to stop.
```

| Table Start CAM Motion   |   | <input checked="" type="checkbox"/> Positioning | <input type="checkbox"/> Slewing | <input type="checkbox"/> Tracking | <input checked="" type="checkbox"/> BG MSB<br><input checked="" type="checkbox"/> FG MSB |
|--|---|---|----------------------------------|-----------------------------------|--|
| <i>syntax</i>  |   |   |                                  |                                   |  |
| <code>table n start imethod cam mpscale , spscale , repeatcount</code> |   |   |                                  |                                   |  |
| <i>parameters</i>  |   |   |                                  |                                   |  |
| <i>n</i>   | the table to utilize for motion   |   |                                  |                                   |  |
| <i>imethod</i>   | <b>linear</b> uses linear interpolation<br><b>quadratic</b> uses 2nd order interpolation<br><b>cubic</b> uses 3rd order interpolation               |   |                                  |                                   |  |
| <i>mpscales</i>  | master-position scale factor: the values in the "x" (master-position) column in the table are effectively divided by this number                    |   |                                  |                                   |  |
| <i>spscales</i>  | relative slave-position scale factor: the values in the "y" (relative slave position) column in the table are effectively multiplied by this number |   |                                  |                                   |  |
| <i>repeatcount</i>   | the number of times to "run through" the table (0=forever)  |   |                                  |                                   |  |

This statement starts *CAM* motion using the specified table.

The master position (*mpos*, *mposc*) is not cleared when this statement is executed, the *activeCAM\_row* will be used to offset into the cam table and that position will become *mpos/mposc*. *'table precompute'* will set the *activeCAM\_row* to 0.

The current (target) position is used as the starting relative slave-position for the motion.

The table must be ready for use (i.e. a *table precompute* operation has been successfully completed on the table).

⚠ If the master position "backs up" past 0 (its initial position) and the "repeats left to do" counter is *greater than 1*, then the "repeats left to do" counter is decremented and the master-position wraps. If the *repeatcount* was specified as 0 (forever), then the master-position will always wrap.

⚠ “In position” will be *true* only when the table has completed all required repeats. If 0 (forever) is specified for the *repeatcount*, then “In position” will never be true unless a *stop table* is issued.

⚠ The scale factor *mpscale* must evaluate to a value greater than 0 otherwise an error will occur.

⚠ The scale factor *spscale* must evaluate to a value other than 0 otherwise an error will occur. The scale factor *rpscale* is not affected by *uun* or *uud*. The generated position is also unaffected by *uun* or *uud*.

[ top ]

```
zero feedback position;
```

```
table 1 start quadratic cam 1.0, 1.0, 1;
```

| Table Stop        | <input checked="" type="checkbox"/> Positioning | <input type="checkbox"/> Slewing | <input type="checkbox"/> Tracking | <input checked="" type="checkbox"/> BG MSB | <input checked="" type="checkbox"/> FG MSB |
|-------------------|---|----------------------------------|-----------------------------------|--|--|
| <i>syntax</i>     |   |                                  |                                   |  |  |
| <b>stop table</b> |   |                                  |                                   |  |  |

This statement stops *spline* or *CAM* motion. If in *CAM* motion then the current table state is saved in case a 'table continue' command is executed.

If there is no active `table start` (*spline/CAM*) motion, then this command is effectively ignored and no fault occurs.

Unlike other stop statements, `stop table` will never generate a *hard fault*.

```
wait until mpos > 9;
```

```
stop table;
```

### 5.3 Accessing Table Data

As mentioned earlier, tables may also be used to store/retrieve data. In QM, there are special array access operators called `tblx[ ]`, `tbly[ ]` and `tbln[ ]` that allow the user to retrieve information from a table.

`tblx[ ]` and `tbly[ ]` retrieve the “x” value (`tblx`) or “y” value (`tbly`) from a given row in a table. `tbln[ ]` retrieves the total number of rows in a table.

Their syntax is as follows:

```
tblx[table#, row]
```

```
tbly[table#, row]
```

```
tbln[table#]
```

⚠ Any attempt to read a value outside the bounds of the table will result in a value of 0.

They can be used in any QM expression, as show in the example QM code below:

```
// use table 1 for "move in time" pairs

// x will hold the move time (although it can hold anything we want)

// y holds an absolute position

// note that 'x' values in the table don't have to be

//   in increasing form as they do for spline/cam

//   since we are using the table just as data

// also note that there is no 'precompute' as the table is

//   just being used for data and not spline/cam

table 1 clear;

table 1 addseries 1.0,1.0 : 0.5,1.5 : 2.0,3.75 : 1.0,6.0;

[top]

zero feedback position;

// set index to 0 (indexes into tables are 0-based)

i = 0;
```

```

// grab how many pairs are in table 1

n = tbln[1];

[loop]

// done?

if i >= n goto top;

// grab data

move in tblx[1,i] to tbly[1,i];

wait for in position;

delay 1000;

// increment index

i = i + 1;

goto loop;

```

### 5.3.1 Diagnosing Table Issues

When table data is loaded by an MSB it can be difficult to determine if it is correct from a diagnostic viewpoint. Diagnostic variables exist that can be monitored to allow a user to walk through the table to visually or programmatically verify data from QuickBuilder. A Quickbuilder Debug Window can be used to view the Diagnostic Variables listed below:

| Diagnostic Variables | Description  | Type       |
|----------------------|--|------------|
| debugTable           | Cam table to view, from 0 to 5, representing table 1 to 6 since 0 based. | read-write |
| debugTableRows       | Number of rows presently in the selected cam table, debugTable.          | read-only  |
| debugTableRow        | Current row number to view in the selected cam table, debugTable.        | read-write |
| debugTableX          | X value for selected debugTableRow.                                      | read-only  |
| debugTableY          | Y value for selected debugTableRow.                                      | read-only  |

△ The above variable are only available from a QuickBuilder Debug Window, when executing an MSB use the tblx, tbly, and tbln commands discussed in the previous section.

## 5.4 Microsoft Excel as Table Data

It is relatively simple to use data from Microsoft Excel as table data.

One can easily create four columns with *x-data*, a column containing a comma (“,”), *y-data* and lastly a column containing a colon (“:”) as follows:

|    | A      | B | C      | D | E |
|----|--------|---|--------|---|---|
| 1  | 0.0000 | , | 0.0000 | : |   |
| 2  | 0.1000 | , | 0.0998 | : |   |
| 3  | 0.2000 | , | 0.1987 | : |   |
| 4  | 0.3000 | , | 0.2955 | : |   |
| 5  | 0.4000 | , | 0.3894 | : |   |
| 6  | 0.5000 | , | 0.4794 | : |   |
| 7  | 0.6000 | , | 0.5646 | : |   |
| 8  | 0.7000 | , | 0.6442 | : |   |
| 9  | 0.8000 | , | 0.7174 | : |   |
| 10 | 0.9000 | , | 0.7833 | : |   |
| 11 | 1.0000 | , | 0.8415 | : |   |
| 12 | 1.1000 | , | 0.8912 | : |   |
| 13 | 1.2000 | , | 0.9320 | : |   |
| 14 | 1.3000 | , | 0.9636 | : |   |
| 15 | 1.4000 | , | 0.9854 | : |   |
| 16 | 1.5000 | , | 0.9975 | : |   |
| 17 | 1.6000 | , | 0.9996 | : |   |
| 18 | 1.7000 | , | 0.9917 | : |   |
| 19 | 1.8000 | , | 0.9738 | : |   |
| 20 | 1.9000 | , | 0.9463 | : |   |
| 21 | 2.0000 | , | 0.9093 | : |   |
| 22 | 2.1000 | , | 0.8632 | : |   |
| 23 | 2.2000 | , | 0.8085 | : |   |
| 24 | 2.3000 | , | 0.7457 | : |   |
| 25 | 2.4000 | , | 0.6755 | : |   |

Since the QuickBuilder editor allows free-form lines, the data can simply be copied and pasted into QM code in an MSB such as:

```
table 1 clear;

table 1 addseries

// paste Excel cells here
;
```

⚠ The last colon (“:”) in the last row will need to be removed using this method.

⚠ Refer to the loadseries command to dynamically load tables from a binary file stored on the controller’s file system.

## 5.5 Virtual Master

At times a virtual master is required. This can be done in one of two ways:

1. Use the `move master` command to generate background pulses on the selected access based on timer loop tick counts. This allows the same access to operate normally, as an axis.
2. Setup a simulated axis, which runs as though it was receiving real encoder input, although it is not. The master position can then be published so others can track to it. Just about all motion commands are valid during a simulation, including s-curve.

Once a method of generating a master position is determined it can then be published across the backplane of the controller using variant 36827 (see Virtual Master Broadcasting).

| Move Master Position  | <input checked="" type="checkbox"/> Positioning   | <input checked="" type="checkbox"/> Slewing | <input checked="" type="checkbox"/> Tracking | <input checked="" type="checkbox"/> BG MSB<br><input checked="" type="checkbox"/> FG MSB |
|---|---|---|--|--|
| <i>syntax</i>   |   |   |  |  |
| <code>move master at rate for limit { using ramp }</code>     |   |   |  |  |
| <code>move master at rate forever limit { using ramp }</code> |   |   |  |  |
| <i>parameters</i>   |   |   |  |  |
| <i>rate</i>   | The pulse rate of the encoder in pulses added per position loop period (800us default on the M3-40A). |   |  |  |
| <i>limit</i>  | The total number of pulses to generate.   |   |  |  |
| <i>ramp</i>   | Optional ramp added or subtracted from rate at the position loop period (800us on the M4-40A).        |   |  |  |

This statement virtually “moves” the master encoder by changing its “position” at the specified *rate* for a certain number of generated pulses (first form, specified by *limit*). If the *limit* is set to 0 then just the *rate* will change, dynamically, using any specified *ramp*, from the current rate.

To generate a continuous stream of pulses, use the second form. `move_master_ramp` and `move_master_rate` variables can be referenced to check current settings of virtual master.

Reference [set master mode { using global }](#) for additional information.

Example:

```
// stop the virtual axis
move master at 0 forever using 1;
// set the virtual access global
set master virtual using global; // this will place the master information in dual ported memory for
broadcast to slave axis
```

```
// start the virtual axis
move master at 100000 forever using 1;
```

One of the drawbacks of the 'move master at' command is that it is based on the loop period and not user units. This can make things difficult to program. The benefit is the axis is available for motion. If an axis can be reserved and dedicated as a master then a simulated feedback can be used. In essence the axis becomes a virtual axis, responding to commands as it would on a real axis:

```
set simulated feedback on; // this will cause fposc to = tposc after each loop period, drive must not be
enabled
```

### 5.5.1 Broadcasting (M3-40 only)

When the 'set master virtual using global' command is given, mposc delta counts (mposc - last\_mposc) are placed in a dual ported memory for broadcast by the controller, across the backplane. This allows multiple axis to follow a master. Up to 4 masters are currently support with a broadcast update rate of 4ms. Prior to broadcasting, the controller must be initialized with the proper master/slave information

A special variant table located at 36827 supplies the interface to control virtual broadcasting. In Quickbuilder define a table of type 'int' with an override of 36827.



Once created the variable table columns are defined as follows where masterNum is 0 to 3 (up to 4 masters):

**MasterArray[masterNum][0]** - 0 disables broadcasting, non-zero enables.

**MasterArray[masterNum][1]** - Master axis number, 1 to 32.

**MasterArray[masterNum][2]** - Slave axis bit positions, up to 32 supported (16 2 axis cards). Which slaves to replicate master information to.

Example:

```
MasterArray[0][0] = 0; // disable any running master
```

```
MasterArray[0][1] = 1; // Axis number 1 will be a master
```

```
MasterArray[0][2] = 14; // Axis 2, 3, and 4 are slaves referencing master: 0x0000000E
```

## 5.6 Segmented Moves and Examples

Summary:

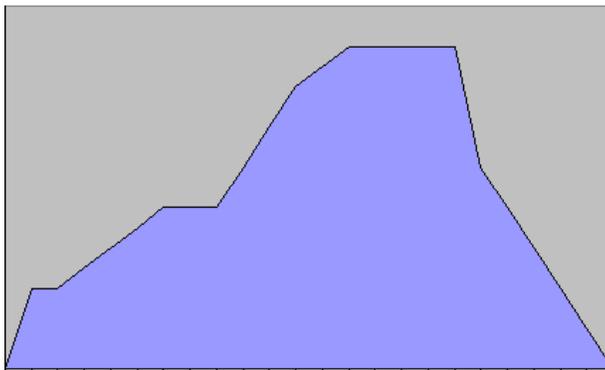
```
segmove table clear  
segmove table accdec to vel using rate  
segmove table accdec to vel for displacement  
segmove table slew until position  
segmove table stop at position using rate  
segmove table start relative
```

Topics:

- [Concept](#)
- [Commands](#)
- [Examples](#)

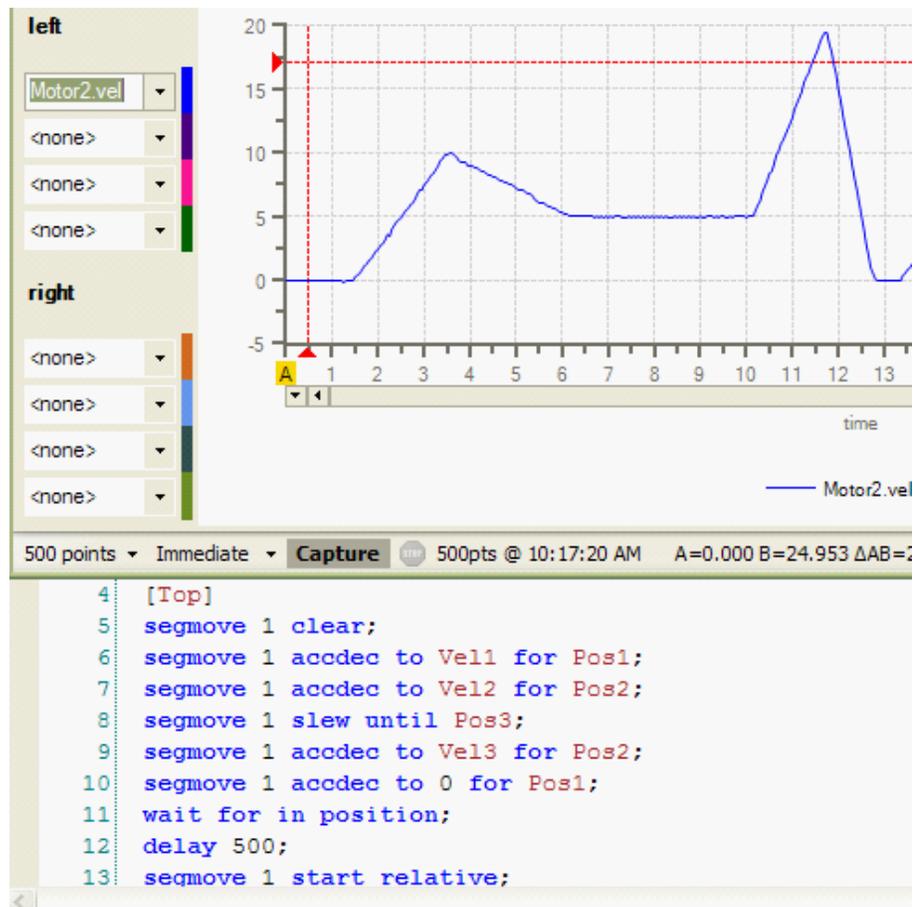
### 5.6.1 Concept

A segmented move is a precompiled move with multiple distances, acceleration, and velocities tied together. Below is the velocity profile of an example segmented move.



Up to 16 Segmented Move “tables” can be defined with up to 20 segments each residing within them. Once a segment table has been defined and then started, you can redefine that same table while it runs without affecting the segment table in progress.

Below is an example of a segmented move with 5 segments using table 1. You define each acceleration or deceleration ramp and each constant velocity ramp as a separate segment.



### 5.6.2 Commands

Creating and running a table is easy and uses the following procedure:

1. Clear the Table.
2. Create up to 20 acc/dec and constant velocity segments.
3. Start the Table.

|                                   |   |   |  |  |
|-----------------------------------|---|---|--|--|
| <b>Clear Segmented Move Table</b> | <input checked="" type="checkbox"/> Positioning | <input checked="" type="checkbox"/> Slewing | <input checked="" type="checkbox"/> Tracking | <input checked="" type="checkbox"/> BG MSB<br><input checked="" type="checkbox"/> FG MSB |
| <i>syntax</i>                     |   |   |  |  |
| <code>segmove table clear</code>  |   |   |  |  |
| <i>parameters</i>                 |   |   |  |  |
| <i>table</i>                      | what table to clear: 1 to 16                    |   |  |  |

This command clears any existing table information

Example: `segmove 1 clear;`

|  |   |   |  |  |
|--|---|---|--|--|
| <b>Add Segmented Move to Table at rate</b> | <input checked="" type="checkbox"/> Positioning | <input checked="" type="checkbox"/> Slewing | <input checked="" type="checkbox"/> Tracking | <input checked="" type="checkbox"/> BG MSB |
|--|---|---|--|--|

|   |  |  |
|---|--|--|
|   |  | <input checked="" type="checkbox"/> FG MSB |
| <i>syntax</i>                                       |  |  |
| <code>segmove table accdec to vel using rate</code> |  |  |
| <i>parameters</i>                                   |  |  |
| <i>table</i>  | Which table to add to: 1 to 16                     |  |
| <i>vel</i>  | Velocity, user-units/sec                           |  |
| <i>rate</i>   | Acceleration/deceleration rate, user-units/sec/sec |  |

This command adds an acc/dec segment from the current velocity to the new <vel> at the specified <rate>. Example: `segmove 1 accdec to Vel1 using Acc1;`

|   |   |   |  |  |
|---|---|---|--|--|
| <b>Add Segmented Move to Table over displacement</b>      | <input checked="" type="checkbox"/> Positioning | <input checked="" type="checkbox"/> Slewing | <input checked="" type="checkbox"/> Tracking | <input checked="" type="checkbox"/> BG MSB<br><input checked="" type="checkbox"/> FG MSB |
| <i>syntax</i>   |   |   |  |  |
| <code>segmove table accdec to vel for displacement</code> |   |   |  |  |
| <i>parameters</i>   |   |   |  |  |
| <i>table</i>  | Which table to add to: 1 to 16                  |   |  |  |
| <i>vel</i>  | Velocity, user-units/sec                        |   |  |  |
| <i>displacement</i>                                       | Incremental position, user-units                |   |  |  |

This command add an acc/dec segment from the current velocity to the new <vel> over some <displacement>. Note this is an incremental acc/dec segment.

Example: `segmove 1 accdec to Vel2 for Pos2;`

|  |   |   |  |  |
|--|---|---|--|--|
| <b>Add Segmented Move to Table (slew)</b>      | <input checked="" type="checkbox"/> Positioning | <input checked="" type="checkbox"/> Slewing | <input checked="" type="checkbox"/> Tracking | <input checked="" type="checkbox"/> BG MSB<br><input checked="" type="checkbox"/> FG MSB |
| <i>syntax</i>                                  |   |   |  |  |
| <code>segmove table slew until position</code> |   |   |  |  |
| <i>parameters</i>                              |   |   |  |  |
| <i>table</i>                                   | Which table to add to: 1 to 16                  |   |  |  |
| <i>position</i>                                | Velocity, user-units/sec                        |   |  |  |

This command adds a constant velocity segment until reaching some specified <position>. This is an absolute position from the start of the profile. Prior segments in table must represent movement before this command is accepted, otherwise a fault will occur as table is built

Example:

`segmove 1 slew until Pos3;`

|   |   |   |  |  |
|---|---|---|--|--|
| <b>Add Segmented Move to Table (stop)</b> | <input checked="" type="checkbox"/> Positioning | <input checked="" type="checkbox"/> Slewing | <input checked="" type="checkbox"/> Tracking | <input checked="" type="checkbox"/> BG MSB |
|---|---|---|--|--|

|  |  |  |
|--|--|--|
|  |  | <input checked="" type="checkbox"/> FG MSB |
| <i>syntax</i>                                    |  |  |
| <b>segmove table stop at position using rate</b> |  |  |
| <i>parameters</i>                                |  |  |
| <i>table</i>                                     | Which table to add to: 1 to 16                     |  |
| <i>position</i>                                  | Position to stop at, user-units                    |  |
| <i>rate</i>                                      | Acceleration/deceleration rate, user-units/sec/sec |  |

This command stops motion at the specified *position*, with a given *rate*. This will cause motion to stop at an absolute position at a specified deceleration rate. Prior segments in table must represent movement before this command is accepted, otherwise a fault will occur as table is built.

Example:

```
segmove 1 stop at Position using Accel;
```

|   |   |   |  |  |  |
|---|---|---|--|--|--|
| <b>Add Segmented Move to Table (relative)</b> | <input checked="" type="checkbox"/> Positioning | <input checked="" type="checkbox"/> Slewing | <input checked="" type="checkbox"/> Tracking | <input checked="" type="checkbox"/> BG MSB | <input checked="" type="checkbox"/> FG MSB |
| <i>syntax</i>                                 |   |   |  |  |  |
| <b>segmove table start relative</b>           |   |   |  |  |  |
| <i>parameters</i>                             |   |   |  |  |  |
| <i>table</i>                                  | Which table to add to: 1 to 16                  |   |  |  |  |

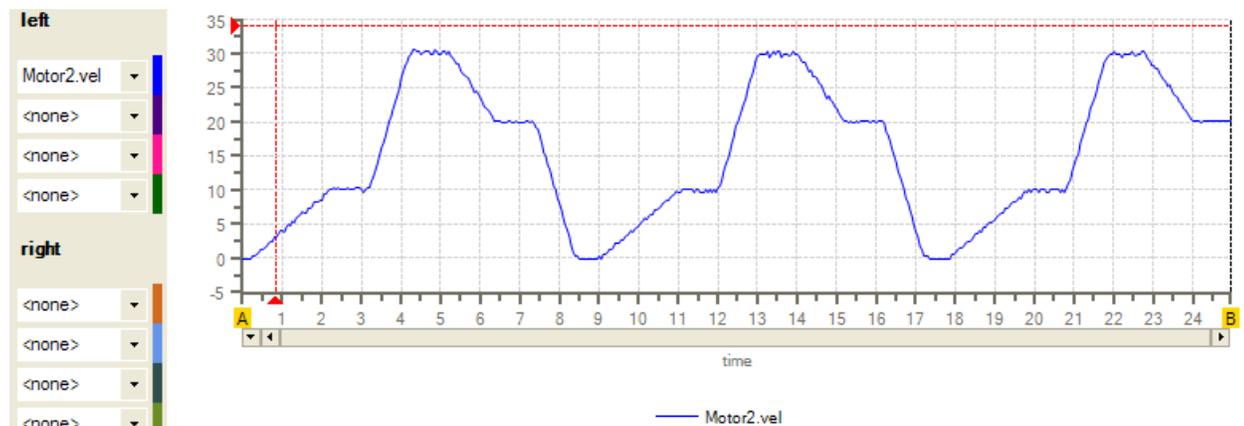
This command starts a relative segmented move – a “zero feedback position” occurs automatically upon executing this command.

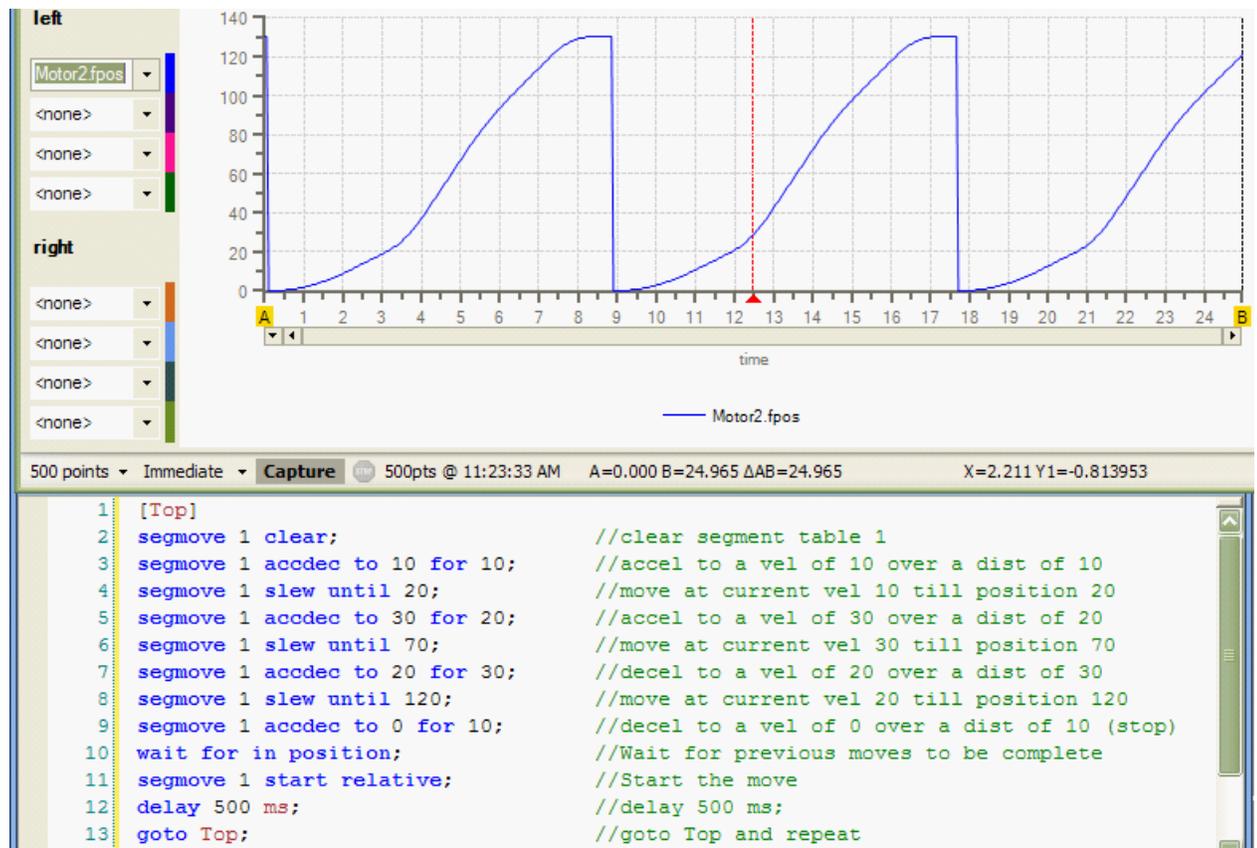
Example:

```
segmove 1 start relative;
```

### 5.6.3 Examples

The following pages include screen shots of move profiles and the code used to create them.

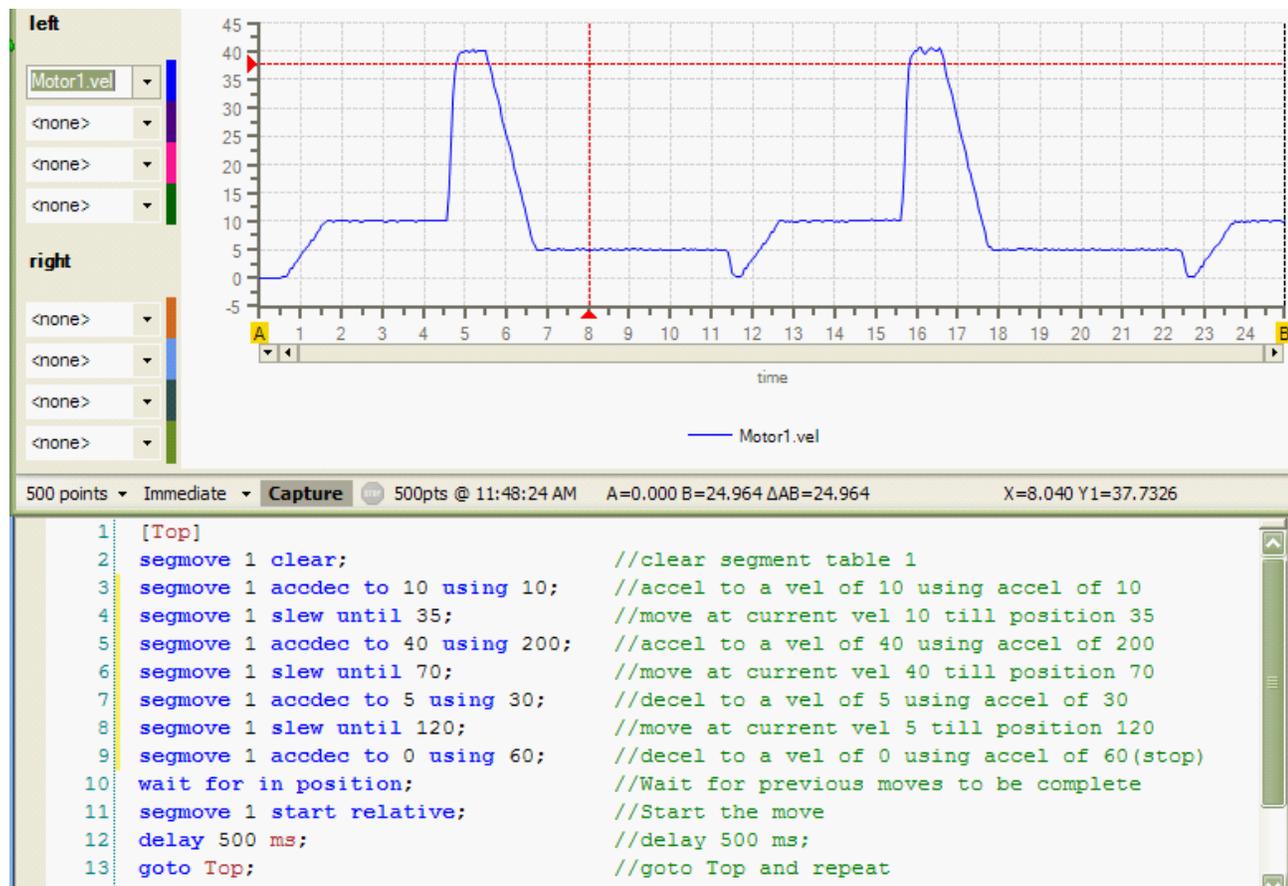




```

[Top]
segmove 1 clear; //clear segment table 1
segmove 1 accdec to 10 for 10; //accel to a vel of 10 over a dist of
10
segmove 1 slew until 20; //move at current vel 10 till position
20
segmove 1 accdec to 30 for 20; //accel to a vel of 30 over a dist of
20
segmove 1 slew until 70; //move at current vel 30 till position
70
segmove 1 accdec to 20 for 30; //decel to a vel of 20 over a dist of
30
segmove 1 slew until 120; //move at current vel 20 till position
120
segmove 1 accdec to 0 for 10; //decel to a vel of 0 over a dist of
10(stop)
wait for in position; //Wait for previous moves to be
complete
segmove 1 start relative; //Start the move
delay 500 ms; //delay 500 ms;
goto Top; //goto Top and repeat

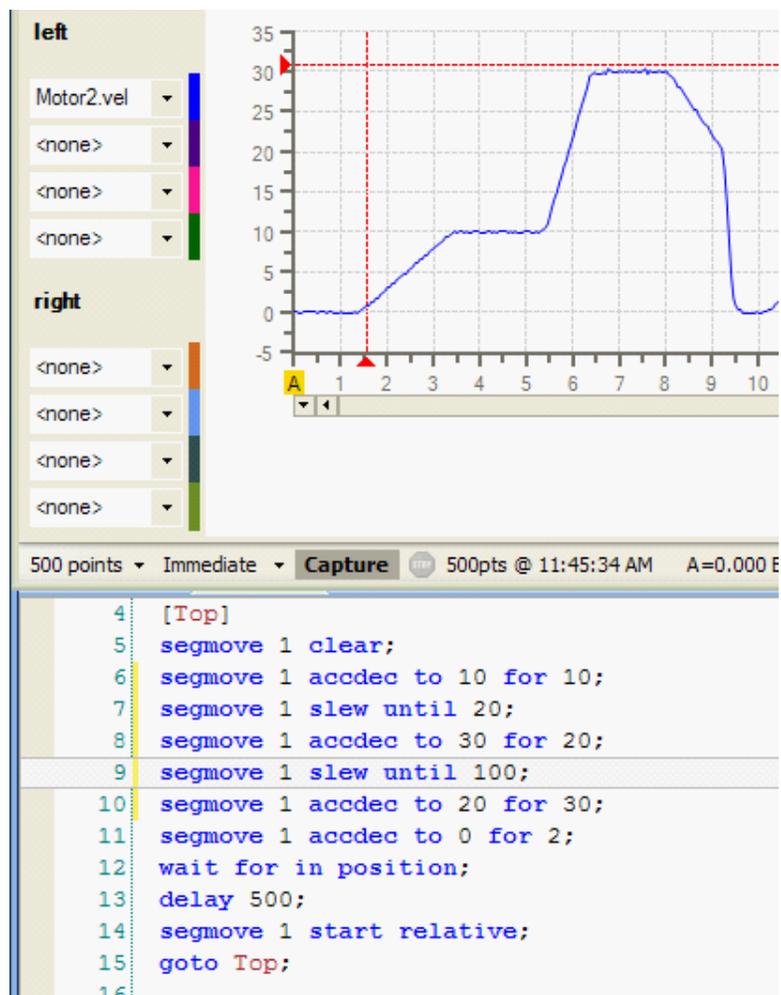
```



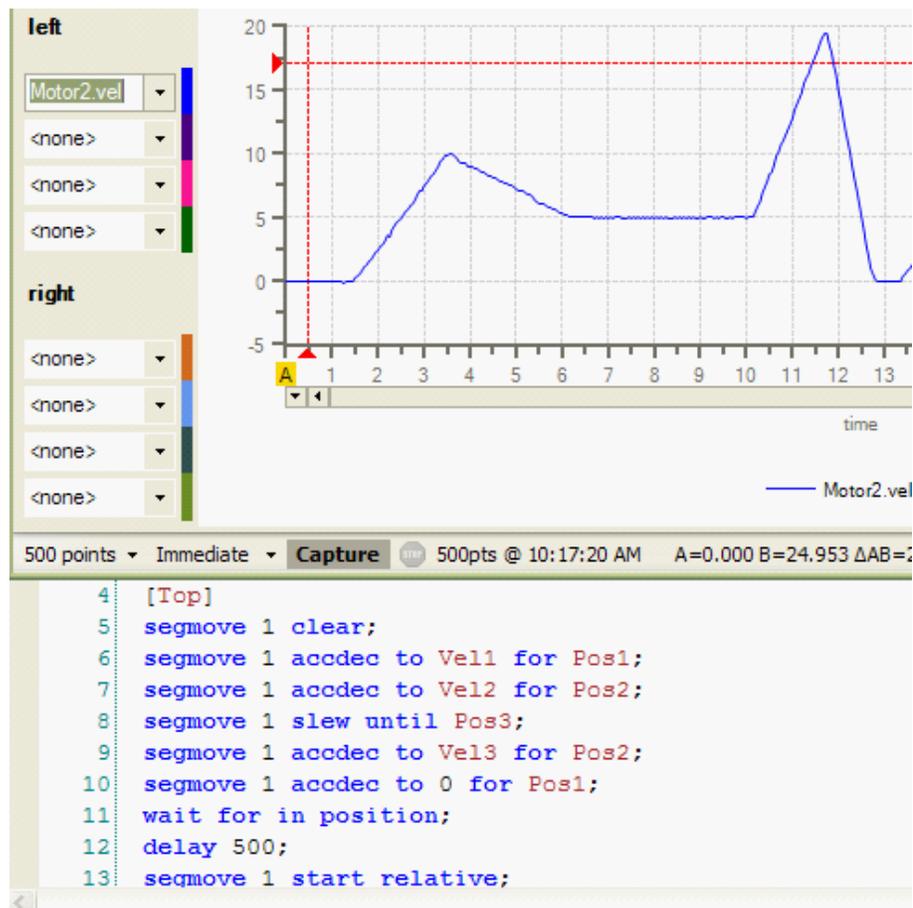
```

[Top]
segmove 1 clear; //clear segment table 1
segmove 1 accdec to 10 using 10; //accel to a vel of 10 using accel of
10
segmove 1 slew until 35; //move at current vel 10 till position
35
segmove 1 accdec to 40 using 200; //accel to a vel of 40 using accel of
200
segmove 1 slew until 70; //move at current vel 40 till position
70
segmove 1 accdec to 5 using 30; //decel to a vel of 5 using accel of 30
segmove 1 slew until 120; //move at current vel 5 till position
120
segmove 1 accdec to 0 using 60; //decel to a vel of 0 using accel of
60(stop)
wait for in position; //Wait for previous moves to be
complete
segmove 1 start relative; //Start the move
delay 500 ms; //delay 500 ms;
goto Top; //goto Top and repeat

```



```
[Top]
segmove 1 clear;
segmove 1 accdec to 10 for 10;
segmove 1 slew until 20;
segmove 1 accdec to 30 for 20;
segmove 1 slew until 100;
segmove 1 accdec to 20 for 30;
segmove 1 accdec to 0 for 2;
wait for in position;
delay 500;
segmove 1 start relative;
goto Top;
```



```

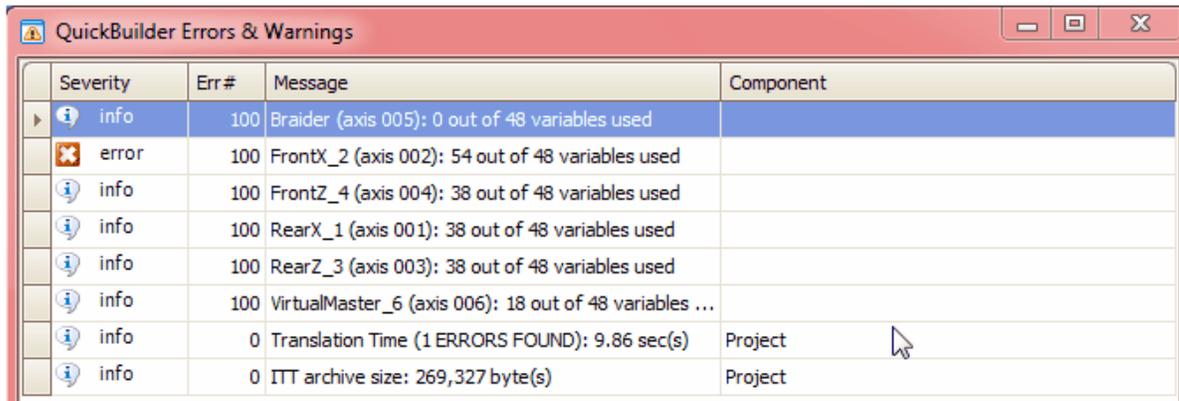
[Top]
segmove 1 clear;
segmove 1 accdec to Vel1 for Pos1;
segmove 1 accdec to Vel2 for Pos2;
segmove 1 slew until Pos3;
segmove 1 accdec to Vel1 for Pos2;
segmove 1 accdec to 0 for Pos1;
wait for in position;
delay 500;
segmove 1 start relative;

```

## 6 Chapter 6: Motion Variables

### 6.1 QuickMotion User-defined Variables

When entering code into an MSB, variables are automatically defined as they are typed in. A total of 48 user variables per axis are allowed. Each variable is automatically created as a double-precision floating point variable. When you translate a QuickBuilder program the number of variables used on each axis will be displayed, should too many be referenced an error will be flagged:



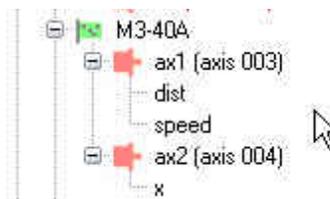
| Severity | Err# | Message  | Component |
|----------|------|--|-----------|
| info     | 100  | Braider (axis 005): 0 out of 48 variables used         |           |
| error    | 100  | FrontX_2 (axis 002): 54 out of 48 variables used       |           |
| info     | 100  | FrontZ_4 (axis 004): 38 out of 48 variables used       |           |
| info     | 100  | RearX_1 (axis 001): 38 out of 48 variables used        |           |
| info     | 100  | RearZ_3 (axis 003): 38 out of 48 variables used        |           |
| info     | 100  | VirtualMaster_6 (axis 006): 18 out of 48 variables ... |           |
| info     | 0    | Translation Time (1 ERRORS FOUND): 9.86 sec(s)         | Project   |
| info     | 0    | ITT archive size: 269,327 byte(s)                      | Project   |

Variables used in an MSB are automatically assigned to each axis that uses that particular MSB.

For example in the following example two MSB variables are used: *speed* and *dist*.

```
// move at assigned speed for assigned distance
[ top ]
move at speed for dist;
wait for in position;
delay 500;
goto top;
end;
```

In this sample project, this is the only MSB that QuickStep is calling for the axis named *ax1*, the *speed* and *dist* variables are automatically added to the *ax1* object at the time of translation in QuickBuilder. Note that they will not be shown in the resource tree under an axis object until the project is translated, because it is only at this point that QuickBuilder knows which axes are using which MSBs.



Because a single MSB can be used by more than one axis, the actual variable name has the axis name pre-pended to it so that it can be uniquely accessed by QuickStep (QS4). So in the above example, the variable *dist* used on

*ax1* has a name of *ax1.dist* that is used to access it from QuickStep. If that same MSB were to be used on *ax2* as well the *dist* variable *ax2.dist* would be used in QuickStep.

Note that axis prefixes are only used at the QuickStep level and not within MSBs. The MSB cannot directly access a variable from an MSB running on a different axis. If this information is needed, it can be obtained by first assigning the desired MSB variable to a QuickStep variable. This QuickStep variable can then be assigned to a variable in the other MSB. The methodology for reading and writing variables between QuickStep and an MSB is shown below.

QS4 Example code:

```
// QS4 Sample code showing how to update variables between
// QuickStep and MSBs

// set the MSB variable x for Axis1 DrillPosition
// where, DrillPosition is a QuickStep variable
Axis1.x = DrillPosition;

// set the MSB variable speed for Axis1 to 5
Axis1.Speed = 5;

// set the QuickStep variable AxOneTarget
// to the MSB variable Axis1.Target
AxOneTarget = Axis1.Target
```

Axis1 MSB Example code:

```
// MSB Sample code showing how to use updated variables
// between QuickStep and MSBs

Halfspd = Speed/2;

/* Make a trap move to the DrillPosition specified in the QS4 step at
half speed */
move at Halfspd to x;

wait for in position; // Wait for move to complete
pulse 1 for 1000; // Turn the drill output on for 1 sec

/* Move to Target at the speed specified above. */

move at Speed to Target;
```

## 6.2 QuickMotion Pre-defined Variables

In addition to user-defined variables, there are approximately 100 pre-defined variables for an axis in the QuickMotion language.

Many of these variables correspond to properties in the QS4 world.

The pre-defined variables are organized on the following pages into tables by function. The functional groups are:

- [Status Variables](#) – These are read-only variables that give information as to the status of a given axis, such as fault code, in position, over-travel reached, etc.
- [Control Variables](#) – These are a mix of read-only and read-write variables used to set general control conditions for the axis and how it interfaces with the drive. Some of these can only be adjusted before the axis is enabled.
- [Tuning Variables](#) – These variables are all read-write and they are used to adjust the control loop characteristics. These values can be adjusted while the axis is running either by using the tuning wizard in QuickBuilder, or by directly changing the value of the variable.
- [Feedback Variables](#) – These variables are a mix of read only and read-write that set the characteristics of the encoder feedback. This is where the counts per revolution and the user unit conversions are set.
- [IO and Register Variables](#) – These variables are used to read the status of the Axis I/O; change the status of outputs, and assign special functionality to an I/O point such as input to be used for positive over travel. Additionally general purpose global registers are available.
- [Tracking Variables](#) - This is a large set of variables used to set up electronic gearing and registration type applications. These variables greatly simplify these types of applications from a programming perspective, plus they dramatically improve performance.
- [Capture Variables](#) - These variables are used for registration/capture routines.
- [Diagnostic Variables](#) - These variables are useful in monitoring low level functionality internal to QuickMotion.
- [Quickstep Variables](#) - These variables are used when programming in Quickstep rather than QuickBuilder.
- [Fault Variables](#) - These variables are used to analyze axis fault conditions.
- [Setup Variables](#) - These variables are used to initialize and/or check certain parameters read during initialization and setup.
- [RFID Variables](#) - These variables are used with Turck RFID readers. Reference the EtherCAT Applications Guide.
- [Vector Variables](#) - These variables are used for vector moves during the implementation of 2D, 3D Linear Interpolation, and 2D Circular Interpolation (EtherCAT only).

| Status Variables  | Description   | Type              |
|---|---|-------------------|
| axisnum   | EtherCAT Only: Contains the axis number an MSB is running on, starting at 1.  | INT32, read-write |
| activeCAM_row   | Active cam row presently executing in cam table.  | INT32, read-only  |
| camRequest  | 1 requesting cam file from controller disk, 0 idle, else error code.  | INT32, read-only  |
| capStatus   | Capture status, bit 8 (axis 1), bit 9 (axis 2). 1 = active.   | INT16, read-only  |
| enabled   | Holds the state of <i>drive enable</i> . When used with EtherCAT this reflects the state of power on the drive (Voltage Enabled) and ready to run. Will be set after a 'drive enable' instruction if executes without error.  | BYTE8, read-only  |
| fault1<br>fault2 (not used)<br>fault3 (not used)<br>fault4 (not used) | Fault status words, reference <a href="#">Chapter 8</a> .   | BYTE8, read-only  |
| faulted   | Set to <i>true</i> when a fault has occurred.   | BYTE8, read-only  |
| inpos   | Holds the state of <i>in position</i> .<br><br><i>In Position</i> is <i>true</i> when the target generator is <i>inactive</i> and when the position error ( <i>perr</i> ) is within bounds set by <i>inposw</i> . When used with EtherCAT this reflects that the drive is "in position" that was commanded. | BYTE8, read-only  |
| overpos   | Set to <i>true</i> when target position ( <i>tpos</i> ) $\geq$ <i>poslim</i> or when the associated hardware positive overtravel limit is <i>active</i> .   | BYTE8, read-only  |
| overneg   | Set to <i>true</i> when target position ( <i>tpos</i> ) $\leq$ <i>neglim</i> or when the associated hardware negative overtravel limit is <i>active</i> .   | BYTE8, read-only  |
| overtrq   | Set to <i>true</i> when the commanded torque <i>trqc</i> has been clamped to the torque limit (either <i>tmax</i> or <i>tlim</i> ). Not used for EtherCAT.  | BYTE8, read-only  |
| pstate  | Current axis motion state (M3-40):<br><pre>enum PSTATE {   IDLE, // ready to run   RUNNING, // processing sub-steps   COMPLETE, // done running, awaiting IDLE   STOP, // stop   SLEWSTOP, // slewed stop   SLEWING, // slewing</pre>   | BYTE8, read-only  |

| Status Variables | Description   | Type |
|------------------|---|------|
|                  | <pre> PRESPLINE, // pre 'SPLINE' move PRECAM, // pre 'CAM' move CONT_CAM, // continue 'CAM' move that was stopped INSPLINE, // in 'SPLINE' move INCAM, // in 'CAM' move TABLESTOP, // stop table TRACKING, // geared PRETRACKING // initialization for TRACKING (geared) mode };  EtherCAT (IncentiveECAT and M3-41):  enum PSTATE {   IDLE, // ready to run   RUNNING, // processing sub-steps   COMPLETE, // done running, awaiting IDLE   STOP, // stop   SLEWSTOP, // slewed stop   SLEWING, // slewing   PRESPLINE, // pre 'SPLINE' move   PRECAM, // pre 'CAM' move   CONT_CAM, // continue 'CAM' move that was stopped   INSPLINE, // in 'SPLINE' move   INCAM, // in 'CAM' move   TABLESTOP, // stop table   TRACKING, // geared   PRETRACKING // initialization for TRACKING (geared) mode EXIT_TRACKING, ECAT_COMPLETE_PENDING, ECAT_PROFILE_POS_INIT, ECAT_PROFILE_POS_STARTING1, ECAT_PROFILE_POS_STARTING1A, ECAT_PROFILE_POS_STARTING2, // 20 ECAT_PROFILE_POS_RUNNING, ECAT_PROFILE_POS_WAIT_INPOS, ECAT_PROFILE_VEL_INIT, ECAT_PROFILE_VEL_WAIT_DELAY1, ECAT_PROFILE_VEL_WAIT_DELAY2, ECAT_PROFILE_VEL_WAIT_DELAY3, ECAT_PROFILE_VEL_WAIT, ECAT_PROFILE_TORQUE_INIT, ECAT_PROFILE_INIT_CSP, ECAT_PROFILE_INIT_INTERPOLATED, ECAT_PROFILE_WAIT_CSP1, ECAT_PROFILE_WAIT_CSP2, ECAT_MODE_WAIT_CSP, // 33 ECAT_MODE_WAIT_INTERPOLATED, ECAT_MODE_WAIT_PROFILE, // This just idles, awaiting // for the Profile request to be processed. ECAT_PROFILE_INIT_QSTOP, ECAT_PROFILE_WAIT_QSTOP1, </pre> |      |

| Status Variables | Description   | Type               |
|------------------|---|--------------------|
|                  | <pre> ECAT_PROFILE_WAIT_QSTOP2, ECAT_PROFILE_WAIT_QSTOP, ECAT_PROFILE_AT_VEL,           // 40 ECAT_PROFILE_AT_TORQUE, ECAT_HOMING_INIT, ECAT_HOMING_STARTING1, ECAT_HOMING_STARTING1A, ECAT_HOMING_STARTING2,       // 45 ECAT_HOMING_RUNNING, ECAT_HOMING_WAIT_INPOS_KOLLMORGEN, ECAT_HOMING_WAIT_INPOS, ECAT_HOMING_WAIT_INPOS_IAI, ECAT_PROFILE_POS_WAIT_ABORTING, // 50 ECAT_PROFILE_VEL_STOP, ECAT_PROFILE_VEL_STOPPING, ECAT_HOMING_ABORT_START, ECAT_HOMING_ABORT_WAIT,      // 54 ECAT_OFFLINE = -1, ECAT_USER_OFFLINE = -2 // User requested offline }; </pre> |                    |
| tracking_pstate  | <p>EtherCAT only, used mainly for vector moves on axis that is following main axis (Arc and linear interpolation). Same states as 'pstate'.</p> <p>Contains the current execution state of the drive during a 'move on a gear' operation. 'pstate' must be in TRACKING mode for this property to be valid.</p>  | INT32, read only   |
| time             | <p>A settable, accurate time counter (sec). This is a floating point variable with precision of the control loop period (800uS default, M3-40. 1mS, M3-41/IncentiveECAT). The value will increment by the control loop period value each interrupt cycle. time = time + period;</p>   | DOUBLE, read-write |
| touchProbeStatus | <p>EtherCAT Only:</p> <p>Maps directly to drive object 0x60b9.</p>  | INT32, read only   |
| zpulse*          | <p>Set to <i>true</i> when the Z-pulse has been seen.</p> <p>*Note: Currently this does not work properly and only detects the first Z-pulse. Workaround is to watch for a change in ztheta as an indication of Z-pulse. Not used on EtherCAT, only M3-40.</p>  | BYTE8, read-only   |

| Control Variables | Description   | Type                |
|-------------------|---|---------------------|
| acc               | Default acceleration rate for absolute and incremental motion. Scaled in user-units/sec/sec.  | FLOAT32, read-write |
| cmode             | <p>Control mode – controls the structure of the position/velocity loops.</p> <p>M3-40:</p> <p><i>Torque (0)</i> – Control loop outputs a torque command (velocity loop is active).</p> <p><i>Velocity (1)</i> – Control loop outputs a velocity command to the drive (velocity loop is inactive).</p> <p><i>Stepper (2)</i> – Control loop outputs step and direction pulses to the drive (velocity loop is inactive).</p> <p><i>Open loop (16)</i> – Or this with <i>Torque</i> mode for open loop, direct dac control. Write directly to trqc, -10 to 10 (float) representing volts.</p> <p>M3-41/IncentiveECAT:</p> <pre> \$CYCLIC_SYNC_POSITION_MODE 0 (default) \$PROFILE_VELOCITY_MODE      1 \$INTERPOLATED_MODE          3 \$PROFILE_POSITION_MODE      4 \$PROFILE_TORQUE_MODE         5 (not supported) \$CYCLIC_SYNC_TORQUE_MODE     6 (not supported) \$CYCLIC_SYNC_VELOCITY_MODE  7 (not supported) \$HOMING_MODE                 8 \$VELOCITY_MODE               9 </pre> <p>This variable cannot be changed while the axis is <i>enabled</i></p> | BYTE8, read-write   |
| dec               | Default deceleration rate for absolute and incremental motion. Scaled in user-units/sec/sec.  | FLOAT32, read-write |
| encoder_mode      | <p>EtherCAT Only:</p> <p>Enable Absolute Positioning mode by setting the encoder_mode axis property variable to a 1, prior to executing the ‘drive enable’ command. This will set the current position to that read from the drive, assuming battery backup, rather than 0. A value of 0 is for an incremental encoder. This variable can also be automatically set by using the axis property pull-down menu option: absolute.</p>   | INT32, read-write   |
| gtimebase         | A global timebase variable that affects both axes. This variable in conjunction with the per-axis <i>timebase</i> sets the  | FLOAT32, read-write |

| Control Variables | Description   | Type                |
|-------------------|---|---------------------|
|                   | <p>effective per-axis natural time base of the target generator.</p> <p>This parameter should only be set through a reference to the first axis in an MSB or from a QS4 program.</p> <p>Should not be used on M3-41/IncentiveECAT as it will increment the time between control loops used in calculations but not change the control loop period itself. Defaults to 1.0 since the control loop time is:</p> $\text{loop time} = \text{Tick Period} * \text{gtimebase};$ |                     |
| homing_speed1     | <p>EtherCAT only:<br/>Some homing modes require multiple speeds, with this one being the speed to the switch (object 0x6099.1).</p>   | FLOAT32, read-write |
| homing_speed2     | <p>EtherCAT only:<br/>Some homing modes require multiple speeds, with this one being the speed to the index (object 0x6099.2).</p>  | FLOAT32, read-write |
| inpos_t           | <p>EtherCAT only:<br/>Settling time for in position prior to notifying application in milliseconds. This value is written to the drive object 0x6068.0 if it is available.</p>  | INT32, read-write   |
| inpos_w           | <p>EtherCAT only:<br/>In Homing and Profile Position mode this is the in position window that is acceptable prior to acknowledging motor is in position. Object 6067.0 is written to if available. In CSP and other modes the per must be less than inpos_w in order for inpos to be set as 1.</p> <p>This variable maps to inposw which is available on M3-40 boards.</p>  | FLOAT32, read-write |
| invel_t           | <p>EtherCAT only:<br/>Time required, in milliseconds, to be at the target velocity, Profile Velocity mode. Maps to object 0x606E.0.</p>   | INT32, read-write   |
| invel_w           | <p>EtherCAT only:<br/>In Profile Velocity mode this is the window velocity is to be maintained in. <math>\text{inpos}_w \times \text{Target Velocity}</math>. Object 606D.0 is written to if available.</p>   | FLOAT32, read-write |
| jerk_a_req        | <p>Requested acceleration jerk (default 0), units/sec<sup>3</sup>. Jerk (S-curve generation) for absolute and incremental motion (scaled in user-units/sec/sec/sec). If set to zero (0.0), then S-curve generation is disabled. Set to -1 for automatic calculation based on move.</p>  | FLOAT32, read-write |
| jerk_d_req        | <p>Requested deceleration jerk (default 0), units/sec<sup>3</sup>. Jerk (S-curve generation) for absolute and incremental motion (scaled in user-units/sec/sec/sec). If set to zero (0.0), then S-curve generation is disabled. Set to -1 for automatic calculation based on move.</p>  | FLOAT32, read-write |
| jerk_a            | <p>Actual acceleration jerk used, units/sec<sup>3</sup>.</p>  | FLOAT32, read-only  |

| Control Variables | Description   | Type                |
|-------------------|---|---------------------|
| jerk_d            | Actual deceleration jerk used, units/sec <sup>3</sup> .   | FLOAT32, read-only  |
| newvel            | New velocity is used in conjunction with the 'new endposition' command to request a different velocity than is current. If 0 then is ignored.   | FLOAT32, read-write |
| sppr              | Steps/rev to output when in stepper mode (when <i>cmode</i> is <i>Stepper</i> ). Not used on M3-41/IncentiveECAT.   | INT3, read-write    |
| stoprate          | Rate at which to do a slewed stop (uu/sec/sec)  | FLOAT32, read-write |
| theta             | Motor angle. In EtherCAT this value is incremented by the position change (+/-) each control loop tick. UINT32.   | INT16, read-only    |
| time              | Incremented by loop period each interrupt.  | DOUBLE, read-write  |
| timebase          | Used to override the natural time base of the target generator. When set to 1.0 (the default value), the target generator's "time" is un-scaled. When set to a value between 0.0 and 1.0, the target generator's "time" is slowed-down, effectively generating lower velocities. When set to 0.0, motion stops.<br><br><i>Changing the timebase only effects commanded motions, it does not alter other commands such as delay. Do not change on EtherCAT systems, should stay as default of 1.0.</i> | FLOAT32, read-write |
| tlim              | M3-40:<br><br>Torque limit (Nm) – torque command limit.<br><br>EtherCAT:<br><br>Does not apply to most EtherCAT systems. Used on some drives in PROFILE TORQUE MODE and by IAI, reference the EtherCAT Applications Guide.  | FLOAT32, read-write |
| tmax              | M3-40:<br><br>Scale factor – maximum torque (Nm) that is generated at the motor when the control loop commands 10V to the drive.<br><br>This is set using the <i>property inspector</i> and cannot be changed in QM code. Consult the connected motor and drive specifications to properly set this value.<br><br>This property is valid when <i>cmode</i> is <i>Torque</i> .<br><br>EtherCAT:  | FLOAT32, read-write |

| Control Variables | Description  | Type                |
|-------------------|--|---------------------|
|                   | Used on most drives to limit the torque while in CSP mode. Reference the EtherCAT Applications Guide for specifics.  |                     |
| vmax              | <p>M3-40:</p> <p>Scale factor – velocity generated when the control loop commands 10V to the drive.</p> <p>Scaled in RPM (rotational) or linear-units/min (linear).</p> <p>This is set using the <i>property inspector</i> and cannot be changed in QM code. Consult the connected motor and drive specifications to properly set this value.</p> <p>This property is valid when <i>cmode</i> is <i>Velocity</i>.</p> <p>EtherCAT:</p> <p>Used to limit velocity in CSP mode to a maximum. Also to set the maximum velocity for Velocity and Position modes and homing speeds in Homing modes.</p> | FLOAT32, read-write |
| ztheta            | <p>M3-40:</p> <p>Motor angle of Z.</p> <p>EtherCAT:</p> <p>Not used.</p>   | INT16, read-only    |

| Tuning Variables | Description   | Type                |
|------------------|---|---------------------|
| _highBW          | Internal use only. Not used with EtherCAT.                            | BYTE8, read-write   |
| _inertia         | Internal use only (tuning inertia). Not used with EtherCAT.           | DOUBLE, read-write  |
| _wn              | Internal use only (tuning wn). Not used with EtherCAT.                | DOUBLE, read-write  |
| _zeta            | Internal use only (tuning zeta). Not used with EtherCAT.              | DOUBLE, read-write  |
| aff              | Velocity-loop acceleration feed-forward gain. Not used with EtherCAT. | FLOAT32, read-write |

| Tuning Variables | Description  | Type                |
|------------------|--|---------------------|
|                  | Scaled as Nm/(rev/sec)/sec or Nm/(linear-unit/sec)/sec of commanded velocity.  |                     |
| kd               | Velocity-loop derivative gain (D). Not used with EtherCAT.<br><br>Scaled as Nm-sec/(rev/sec) or Nm-sec/(linear-unit/sec) of velocity error.  | FLOAT32, read-write |
| kfilt            | A compensation value for the Kalman-filter used in the velocity estimator. Not used for EtherCAT.  | FLOAT32, read-write |
| kgain            | A compensation value for the Kalman-filter used in the velocity estimator. Not used for EtherCAT.  | FLOAT32, read-write |
| ki               | Velocity-loop integral gain (I). Not used with EtherCAT.<br><br>Scaled as Nm/(rev/sec)/sec or Nm/(linear-unit/sec)/sec of velocity error.  | FLOAT32, read-write |
| kv               | Velocity-loop proportional gain (P). Not used with EtherCAT<br><br>Scaled as Nm/(rev/sec) or Nm/(linear-unit/sec).   | FLOAT32, read-write |
| kvf              | Velocity-loop factor (0.0-1.0). Not used with EtherCAT.<br><br>When set to 1.0, the velocity loop is a classic PID structure. When set to 0.0, the velocity loop is a classic PDF structure. When set to a value in between, the velocity loop is a combination of both. | FLOAT32, read-write |
| nonvolatile      | Writing a 1 will cause tuning parameters to originate from nonvolatile serial flash instead of the defaults used in the property window when the program was first created. 0 clears this feature (one per axis). Not used for EtherCAT                                  | BYTE8, read-write   |
| pdead            | Position-loop dead-band (user-units). if perr <= pdead then perr = 0.  | FLOAT32, read-write |
| pff              | Position-loop velocity feed-forward gain (0.0 – 1.0). Not used on EtherCAT.  | FLOAT32, read-write |
| ppg              | Position-loop proportional gain. Not used with EtherCAT.<br><br>Scaled as 1000/min.  | FLOAT32, read-write |
| vff              | Velocity-loop velocity feed-forward gain.  | FLOAT32, read-write |

| Tuning Variables | Description   | Type |
|------------------|---|------|
|                  | <p>Scaled as Nm/(rev/sec) or Nm/(linear-unit/sec) of commanded velocity.</p> <p>EtherCAT:</p> <p>Used on some drives to set velocity feed forward value when initiating CSP mode. Not all drives support it, typically object 0x60B1.</p> |      |

| Feedback Variables | Description  | Type               |
|--------------------|--|--------------------|
| camming_invertend  | Inverts logic of invertmaster with regards to camming table start position and assumed direction traversing. By default 0, follow invertmaster, 1 to do opposite of invertmaster (!invertmaster).  | BYTE8, read-write  |
| encoderZ           | Z encoder input. Not used on EtherCAT  | INT64, read-only   |
| encoderZ3          | Combination of Axis 1 and Axis 2 Z inputs A/B. Not used on EtherCAT.   | INT64, read-only   |
| fpos               | The feedback position scaled in user-units.  | DOUBLE, read-only  |
| fposc              | The feedback position scaled in encoder counts.  | INT64, read-only   |
| gratio             | Present gear ratio.  | DOUBLE, read-only  |
| inposw             | <i>In Position</i> window. Controls when the axis is deemed <i>in position</i> . Scaled in user-units. Typically EtherCAT object 0x6067 when supported. Also used for EtherCAT settling to make sure perr is smaller than inposw when the drive has finished move. | DOUBLE, read-write |
| invertcmd          | <p>M3-40:</p> <p>Whether to invert the sign of the command output:<br/>           0 = no inversion<br/>           1 = invert<br/>           dac voltage = - dac voltage</p> <p>EtherCAT: Not used.</p>   | BYTE8, read-write  |
| invertfeed         | Whether to invert the way the feedback encoder counts:<br>0 = count normally<br>1 = count inverted   | BYTE8, read-write  |
| invertmaster       | Whether to invert the way the master encoder counts:<br>0 = count normally<br>1 = count inverted   | BYTE8, read-write  |

| Feedback Variables | Description  | Type                |
|--------------------|--|---------------------|
| mppr               | Master encoder counts per revolution (or per <i>linear unit</i> for linear feedback devices).  | INT32, read-write   |
| neglim             | Negative over-travel limit, scaled in user-units.<br><br>overneg = tpos <= axistc->neglim;   | DOUBLE, read-write  |
| perr               | The position error (scaled in user-units).   | DOUBLE, read-only   |
| perrlimit          | The limit before a <i>following-error</i> fault is generated. The variable is scaled in user-units.<br>0 = disable <i>following-error</i> fault check  | DOUBLE, read-write  |
| ppr                | Feedback encoder counts per revolution (or per <i>linear unit</i> for linear feedback devices).  | INT32, read-write   |
| poslim             | Positive over-travel limit, scaled in user-units.<br><br>overpos = tpos >= axistc->poslim;   | DOUBLE, read-write  |
| runv               | Calculated run velocity fed to PID algorithm. Used internally as next tick time velocity.  | FLOAT32, read-write |
| settling           | EtherCAT only:<br><br>Time in seconds to allow things to settle when commanding a new move while already in motion and will be changing directions.  | DOUBLE, read-write  |
| sign               | Nonzero for SCurve move, 1 for CCW, -1 for CW.<br><br>EtherCAT also uses it to show direction of all moves.  | BYTE8, read-only    |
| stepsout           | Stepper pulses output. Not used on EtherCAT.   | INT64, read-only    |
| substep            | Segmented move current step on. Trapezoidal is 0 to 2, S-Curve is 0 to 6. Used for diagnostics.  | BYTE8, read-only    |
| sfmod              | The secondary position modulus. Used to control when <i>sfposc</i> wraps around to 0.  | INT64, read-write   |
| sfpos              | Secondary feedback position (in revolutions).<br><br>$sfpos = sfposc * (1/ppr)$  | DOUBLE, read-only   |
| sfposc             | A secondary feedback position (scaled in counts).<br><br>A separately maintained feedback position similar to <i>fposc</i> with the exception that the position will “wrap” (modulo) at 0 and at <i>sfmod</i> (unless <i>sfmod</i> is set to 0).<br><br>$sfposc = fposc \% sfmod;$ | INT64, read-only    |

| Feedback Variables | Description  | Type   |
|--------------------|--|--|
| tpos               | The target position scaled in user-units.  | DOUBLE, read-only                              |
| tr                 | EtherCAT Only: Translation ratio. Result of uun/uud used by the program.   | DOUBLE, read-only                              |
| tposc              | The target position scaled in encoder counts.  | INT64, read-only                               |
| trqc               | M3-40:<br><br>The commanded torque value (Nm). Note that if in torque mode and cmode open loop bit set (bit 5) then this becomes DAC analog output -10 to 10V, floating point.<br><br>EtherCAT:<br><br>Used only on velocity drives as torque compensation. Presently not used by any drives, reserved for future use. | FLOAT32, read-only                             |
| uud                | User-units conversion factor ( <i>denominator</i> ).<br><br>Motion commands are divided by this value (after multiplying by uun) to scale user-units to revolutions (or <i>linear unit</i> or linear feedback devices).  | INT32, read-write                              |
| uun                | User-units conversion factor ( <i>numerator</i> ).<br><br>Motion commands are multiplied by this value (then divided by uud) to scale user-units to revolutions (or <i>linear unit</i> or linear feedback devices).  | INT32, read-write                              |
| units_ratio        | EtherCAT Only:<br><br>User-units conversion factor ( <i>uun/uud as a double</i> ).<br><br>If uun is set to 0 then units_ratio will be used for more precise ratio settings then uun/uud.   | DOUBLE, read-write                             |
| vcmd               | Commanded velocity (in rev/sec or linear-units/sec).<br><br>EtherCAT:<br><br>Used to set target velocity for drives and modes that require. Presently just MOTIONLINUX uses this variable, otherwise set to default of 1.0.  | M3-40 - read-only<br><br>EtherCAT - read-write |
| vel                | Feedback velocity (in rev/sec or linear-units/sec).  | FLOAT32, read-only                             |

| Feedback Variables | Description  | Type               |
|--------------------|--|--------------------|
| verr               | Velocity error (in rev/sec or linear-units/sec). Not used with EtherCAT.   | FLOAT32, read-only |
| zfpos              | Holds the last feedback position before it was modified by a “zero feedback position” or “zero following error” statement. Not used with EtherCAT. | DOUBLE, read-only  |
| ZPULSE_POS         | The next Z-pulse location in the positive direction; user-units. Not used with EtherCAT.   | DOUBLE, read-only  |
| ZPULSE_NEG         | The next Z-pulse location in the negative direction; user-units. Not used with EtherCAT.   | DOUBLE, read-only  |
| ztpos              | Holds the last target position before it was modified by a “zero feedback position” or “zero following error” statement. Not used with EtherCAT.   | DOUBLE, read-only  |

| IO and Register Variables | Description   | Type             |                    |      |      |      |      |      |      |      |      |      |      |      |                   |      |                   |      |                   |                   |
|---------------------------|---|------------------|--------------------|------|------|------|------|------|------|------|------|------|------|------|-------------------|------|-------------------|------|-------------------|-------------------|
| ctr0-ctr7                 | <p>Axis counters (64-bit). These variables count off-to-on transitions of the eight axis-related inputs (5 digital inputs, A, B and Z).</p> <table border="0"> <thead> <tr> <th>variable</th> <th>input (M3-40A/B/C)</th> </tr> </thead> <tbody> <tr> <td>ctr0</td> <td>din1</td> </tr> <tr> <td>ctr1</td> <td>din2</td> </tr> <tr> <td>ctr2</td> <td>din3</td> </tr> <tr> <td>ctr3</td> <td>din4</td> </tr> <tr> <td>ctr4</td> <td>din5</td> </tr> <tr> <td>ctr5</td> <td>A-encoder channel</td> </tr> <tr> <td>ctr6</td> <td>B-encoder channel</td> </tr> <tr> <td>ctr7</td> <td>Z-encoder channel</td> </tr> </tbody> </table> <p>EtherCAT: See EtherCAT Applications Guide.</p> | variable         | input (M3-40A/B/C) | ctr0 | din1 | ctr1 | din2 | ctr2 | din3 | ctr3 | din4 | ctr4 | din5 | ctr5 | A-encoder channel | ctr6 | B-encoder channel | ctr7 | Z-encoder channel | INT64, read-write |
| variable                  | input (M3-40A/B/C)  |                  |                    |      |      |      |      |      |      |      |      |      |      |      |                   |      |                   |      |                   |                   |
| ctr0                      | din1  |                  |                    |      |      |      |      |      |      |      |      |      |      |      |                   |      |                   |      |                   |                   |
| ctr1                      | din2  |                  |                    |      |      |      |      |      |      |      |      |      |      |      |                   |      |                   |      |                   |                   |
| ctr2                      | din3  |                  |                    |      |      |      |      |      |      |      |      |      |      |      |                   |      |                   |      |                   |                   |
| ctr3                      | din4  |                  |                    |      |      |      |      |      |      |      |      |      |      |      |                   |      |                   |      |                   |                   |
| ctr4                      | din5  |                  |                    |      |      |      |      |      |      |      |      |      |      |      |                   |      |                   |      |                   |                   |
| ctr5                      | A-encoder channel   |                  |                    |      |      |      |      |      |      |      |      |      |      |      |                   |      |                   |      |                   |                   |
| ctr6                      | B-encoder channel   |                  |                    |      |      |      |      |      |      |      |      |      |      |      |                   |      |                   |      |                   |                   |
| ctr7                      | Z-encoder channel   |                  |                    |      |      |      |      |      |      |      |      |      |      |      |                   |      |                   |      |                   |                   |
| din1 – din5               | The state of digital inputs 1 through 5.<br>EtherCAT: See EtherCAT Applications Guide.  | BYTE8, read-only |                    |      |      |      |      |      |      |      |      |      |      |      |                   |      |                   |      |                   |                   |
| din6 – din10              | The state of digital inputs 6 through 10.<br><i>Valid only when the module is in 1½ axis mode</i><br>EtherCAT: See EtherCAT Applications Guide.   | BYTE8, read-only |                    |      |      |      |      |      |      |      |      |      |      |      |                   |      |                   |      |                   |                   |
| dout1 – dout5             | The state of digital outputs 1 through 5.<br>EtherCAT: See EtherCAT Applications Guide.   | BYTE8, read-only |                    |      |      |      |      |      |      |      |      |      |      |      |                   |      |                   |      |                   |                   |
| dout6 – dout10            | The state of digital outputs 6 through 10.<br><i>Valid only when the module is in 1½ axis mode</i><br>EtherCAT: See EtherCAT Applications Guide.  | BYTE8, read-only |                    |      |      |      |      |      |      |      |      |      |      |      |                   |      |                   |      |                   |                   |

| IO and Register Variables    | Description  | Type               |
|------------------------------|--|--------------------|
| dins                         | <p>The state of digital inputs 1 through 5 (or 10 if in 1 ½ axis mode) as a single integer.</p> <p><i>Each input has its own binary value starting with 1 for din1, 2 for din2, 4 for din3, 8 for din4, etc. As an example, if din3 and din5 were both on, dins would equal 20.</i></p> <p>EtherCAT: See EtherCAT Applications Guide.</p>                              | INT32, read-only   |
| douts                        | <p>The state of digital outputs 1 through 5 (or 10 if in 1 ½ axis mode) as a single integer.</p> <p><i>Each output has its own binary value starting with 1 for dout1, 2 for dout2, 4 for dout3, 8 for dout4, etc. As an example, if dout3 and dout5 were both on, douts would equal 20.</i></p> <p>EtherCAT: See EtherCAT Applications Guide.</p>                     | INT32, read-only   |
| driveenable                  | <p>The digital output number to use for “drive enable.”</p> <p>Positive input number for true state=high<br/>           Negative number for true state=low<br/>           0 = use no output</p> <p><i>When an output is assigned for use as drive enable, all set/clear operations to that output are ignored.</i></p>   | BYTE8, read-write  |
| global_flag1 to global_flag5 | <p>EtherCAT only:<br/>           5 general use global flag registers directly accessible by all MSB's and QuickBuilder program.</p>  | DOUBLE, read-write |
| global_inputs                | <p>M3-41 Only:<br/>           Local I/O is present on the 5300 M3-41 EtherCAT module. This module has 6 inputs which is global to all MSBs. The MSB property ‘global_inputs’ is used to read the 6 inputs, with the first bit being the first input.</p>   | INT32, read-only   |
| global_outputs               | <p>M3-41 Only:<br/>           Local I/O is present on the 5300 M3-41 EtherCAT module. This module has 2 outputs which are global to all MSBs. The outputs are referenced as 9 and 10 when using the ‘setout’/‘clrout’ instructions. The MSB property ‘global_outputs’ can be used in addition to ‘setout’/‘clrout’ for read/write operations of the local outputs.</p> | INT32, read-write  |
| global_reg1 to global_reg32  | <p>EtherCAT only:<br/>           32 general use global registers directly accessible by all MSB's and QuickBuilder program.</p>  | DOUBLE, read-write |
| overposin                    | <p>The digital input number to use for positive over-travel.</p> <p>Positive input number for true state=high<br/>           Negative number for true state=low<br/>           0 = disable positive over-travel checking</p>   | BYTE8, read-write  |
| overnegin                    | <p>The digital input number to use for negative over-travel.</p> <p>Positive input number for true state=high<br/>           Negative number for true state=low</p>  | BYTE8, read-write  |

| IO and Register Variables | Description  | Type              |
|---------------------------|--|-------------------|
|                           | 0 = disable negative over-travel checking  |                   |
| running                   | The digital output number to use for “MSB active” (running).<br>0 = use no output<br><i>When an output is assigned for use as “MSB active” (running), all set/clear operations to that output are ignored.</i> | BYTE8, read-write |

| Tracking Variables | Description   | Type              |
|--------------------|---|-------------------|
| antibackup         | Whether or not to allow the slave to generate geared pulses in response to negative displacements of the master<br>0 = allow generated pulses in all cases<br>1 = accumulate negative displacements of the master and generate geared slave pulses when accumulated total > 0   | BYTE8, read-write |
| master_feedback    | <p>EtherCAT Only:</p> <p>Any axis can track another axis by simply dropping into tracking mode. To reference which axis to track, use the variable ‘master_feedback’, which by default is 1. Set this variable to the axis you wish to track, set whether to reference fpos or tpos of the master axis, and then drop into tracking mode.</p> <pre>// ***** TRACKING MODE ***** [SetTracking]   zero master counters;   master_feedback = 1; // Set we will track axis 1 // Set the feedback mode first so when enter tracking it is // referencing correct master. ‘set master feedback’ references // the other axis fposc or feedback position. // ‘set master target1’ references the other axis tpos position.   set master feedback;   set mode tracking; // Enter tracking mode</pre> <p>M3-41:</p> <p>Another option, only available on the M3-41 hardware module, is the provision for directly connecting up to 3 local quadrature encoders. These encoders can be used as master references by the EtherCAT axis. To reference these encoders, the master_feedback variable is set to 1001, 1002, or 1003, for each of the respective encoder inputs. Once master_feedback is referencing a local encoder, its present value will appear in ‘mpos’ and ‘mposc’ MSB variables. In addition, all local encoder counts can be accessed using the ‘ctr’ array, index 5 to 7 from an MSB, or ctr5, ctr6, and ctr7 from QuickBuilder.</p> <p>Master_feedback = 1001, ctr[5]/ctr5, P1 connector pins:</p> | INT32, read-write |

| Tracking Variables | Description   | Type              |
|--------------------|---|-------------------|
|                    | <p>P1-19 A0+<br/>P1-20 A0-<br/>P1-21 B0-<br/>P1-22 B0+</p> <p>Master_feedback = 1002, ctr[6]/ctr6, P1 connector pins:</p> <p>P1-23 A1+<br/>P1-24 A1-<br/>P1-25 B1-<br/>P1-26 B1+</p> <p>Master_feedback = 1003, ctr[7]/ctr7, P1 connector pins:</p> <p>P1-27 A2+<br/>P1-28 A2-<br/>P1-29 B2-<br/>P1-30 B2+</p>  |                   |
| mcinv              | <p>The bit-oriented variable controls when <i>mposc1-5</i> are cleared. Bit 0, the least-significant bit, controls <i>mposc1</i>. Bit 1, the next significant bit controls <i>mposc2</i>, etc.</p> <p>Bit 16 to bit 20 controls whether <i>mposc#</i> is cleared upon entering <i>tracking</i> mode. If set cleared.</p> <p>Bit 21 to bit 22 controls whether <i>tsc1/tsc2</i> is cleared upon entering <i>tracking</i> mode. If set cleared.</p> | INT32, read-write |
| mdelta1            | <p>Master position delta, counts</p> <p>This variable holds the displacement that occurred in the master encoder <i>between</i> position captures. Essentially this is the last value of <i>mposc1</i> before <i>mposc1</i> is cleared due to a position capture.</p> <p>Cleared upon entering <i>tracking</i> mode.</p>  | INT32, read-only  |
| mdelta2            | <p>Master position delta, counts</p> <p>This variable holds the displacement the occurred in the master encoder <i>between</i> position captures. Essentially this is the last value of <i>mposc2</i> before <i>mposc2</i> is cleared due to a position capture.</p> <p>Cleared upon entering <i>tracking</i> mode</p>  | INT32, read-only  |

| Tracking Variables | Description  | Type              |
|--------------------|--|-------------------|
| mdelta3            | <p>Master position delta, counts</p> <p>This variable holds the displacement the occurred in the master encoder <i>between</i> position captures. Essentially this is the last value of <i>mposc3</i> before <i>mposc3</i> is cleared due to a position capture.</p> <p>Cleared upon entering <i>tracking</i> mode</p>   | INT32, read-only  |
| mdelta4            | <p>Master position delta, counts</p> <p>This variable holds the displacement the occurred in the master encoder <i>between</i> position captures. Essentially this is the last value of <i>mposc4</i> before <i>mposc4</i> is cleared due to a position capture.</p> <p>Cleared upon entering <i>tracking</i> mode</p>   | INT32, read-only  |
| mdelta5            | <p>Master position delta, counts</p> <p>This variable holds the displacement the occurred in the master encoder <i>between</i> position captures. Essentially this is the last value of <i>mposc5</i> before <i>mposc5</i> is cleared due to a position capture.</p> <p>Cleared upon entering <i>tracking</i> mode</p>   | INT32, read-only  |
| mmc                | <p>Master position modulus (0=functionality disabled)</p> <p>This variable is used as a <i>modulus</i> for the variables <i>mposc1-5</i> and <i>tmodc</i>. Whenever updated, <i>mmc</i> is applied by formula:</p> $mposc1 = mposc1 \bmod mmc$ $mposc2 = mposc2 \bmod mmc$ $mposc3 = mposc3 \bmod mmc$ $mposc4 = mposc4 \bmod mmc$ $mposc5 = mposc5 \bmod mmc$ $tmodc = tmodc \bmod mmc$ | INT32, read-write |
| mposc              | <p>Master position, counts</p> <p>This variable is cleared when the mode is changed to <i>tracking</i>. This variable is unaffected by <i>mmc</i> or changes to <i>mposc1-5</i>.</p> <p>This counter rolls over at 65536 times the value of <i>mppr</i> when in <i>tracking</i> mode.</p>  | INT64, read-write |
| mposc1             | Master position, counts (modulo by <i>mmc</i> )  | INT32, read-only  |

| Tracking Variables      | Description   | Type              |
|-------------------------|---|-------------------|
|                         | <p>This variable is cleared when the mode is changed to <i>tracking</i>.</p> <p>This variable is cleared when input #1 makes an <i>off-to-on</i> transition unless the 0-bit in <i>mcinv</i> is set in which case this variable is cleared when the input makes an <i>on-to-off</i> transition. Bit 16 in <i>mcinv</i> set will disable clearing up on entering <i>tracking</i> mode.</p>   |                   |
| mposc2                  | <p>Master position, counts (modulo by <i>mmc</i>)</p> <p>This variable is cleared when the mode is changed to <i>tracking</i>.</p> <p>This variable is cleared when input #2 makes an <i>off-to-on</i> transition unless the 1-bit in <i>mcinv</i> is set in which case this variable is cleared when the input makes an <i>on-to-off</i> transition. Bit 17 in <i>mcinv</i> set will disable clearing up on entering <i>tracking</i> mode.</p> | INT32, read-only  |
| mposc3                  | <p>Master position, counts (modulo by <i>mmc</i>)</p> <p>This variable is cleared when the mode is changed to <i>tracking</i>.</p> <p>This variable is cleared when input #3 makes an <i>off-to-on</i> transition unless the 2-bit in <i>mcinv</i> is set in which case this variable is cleared when the input makes an <i>on-to-off</i> transition. Bit 18 in <i>mcinv</i> set will disable clearing up on entering <i>tracking</i> mode.</p> | INT32, read-only  |
| mposc4                  | <p>Master position, counts (modulo by <i>mmc</i>)</p> <p>This variable is cleared when the mode is changed to <i>tracking</i>.</p> <p>This variable is cleared when input #4 makes an <i>off-to-on</i> transition unless the 3-bit in <i>mcinv</i> is set in which case this variable is cleared when the input makes an <i>on-to-off</i> transition. Bit 19 in <i>mcinv</i> set will disable clearing up on entering <i>tracking</i> mode.</p> | INT32, read-only  |
| mposc5                  | <p>Master position, counts (modulo by <i>mmc</i>)</p> <p>This variable is cleared when the mode is changed to <i>tracking</i>.</p> <p>This variable is cleared when input #5 makes an <i>off-to-on</i> transition unless the 4-bit in <i>mcinv</i> is set in which case this variable is cleared when the input makes an <i>on-to-off</i> transition. Bit 20 in <i>mcinv</i> set will disable clearing up on entering <i>tracking</i> mode.</p> | INTE32, read-only |
| move_master_counts      | Move master counts target if not forever.   | INT32, read-only  |
| move_master_rate_target | Move master rate target setting (virtual master).   | INT32, read-only  |
| move_master_ramp        | Move master ramp setting (virtual master)   | INT32, read-only  |

| Tracking Variables | Description   | Type              |
|--------------------|---|-------------------|
| move_master_rate   | Move master rate setting (virtual master)   | INT32, read-only  |
| mpgai              | Master position during <i>gear...at...in</i> , counts<br><br>This variable holds the number of consumed master position counts during the last <i>gear...at...in</i> statement  | INT32, read-only  |
| mpgfi              | Master position during <i>gear...for...in</i> , counts<br><br>This variable holds the number of consumed master position counts during the last <i>gear...for...in</i> statement  | INT32, read-only  |
| sdc                | Slave decrement counter<br><br>This counter decrements for every output slave count whereas <i>tsc1</i> and <i>tsc2</i> increment.  | INT32, read-write |
| spgai              | Slave position during <i>gear...at...in</i> , counts<br><br>This variable holds the number of consumed slave position counts during the last <i>gear...at...in</i> statement.   | INT32, read-only  |
| spgfi              | Slave position during <i>gear...for...in</i> , counts<br><br>This variable holds the number of consumed slave position counts during the last <i>gear...for...in</i> statement.   | INT32, read-only  |
| smodc              | Slave position counter.<br><br>This variable is cleared when the mode is changed to <i>tracking</i> .   | INT32, read-only  |
| smod               | Slave position modulus<br><br>This variable is used as a <i>modulus</i> for the variable <i>smodc</i> . Whenever <i>smodc</i> is updated, <i>smod</i> is applied by formula:<br><br>$smodc = smodc \bmod smod$  | INT32, read-write |
| smark              | Slave modulo marker position, counts<br><br>When an input transitions in conjunction with the bits specified in <i>smarkrise</i> and <i>smarkfall</i> , this variable is computed by formula:<br><br>$smark = sphase - smodc$                             | INT32, read-only  |
| smarkrise          | This bit-oriented variable controls when <i>smark</i> is calculated. When the input corresponding to a set bit in <i>smarkrise</i> makes an off-to-on transition, <i>smark</i> is calculated. Bit 0, the least significant bit, represents input #1, etc. | INT32, read-write |

| Tracking Variables | Description  | Type              |
|--------------------|--|-------------------|
| smarkfall          | This bit-oriented variable controls when <i>smark</i> is calculated. When the input corresponding to a set bit in <i>smarkfall</i> makes an on-to-off transition, <i>smark</i> is calculated.<br>Bit 0, the least significant bit, represents input #1, etc. | INT32, read-write |
| sphase             | Slave marker position phase, counts<br><br>Used to offset <i>smark</i> .   | INT32, read-only  |
| tmc1               | Temporary master position counter 1<br><br>This variable is auxiliary, settable counter that tracks master position.<br><br>These variables can be zeroed atomically by <i>zero master counters</i> . Cleared when changing mode to TRACKING.                | INT32, read-write |
| tmc2               | Temporary master position counter 2<br><br>This variable is auxiliary, settable counter that tracks master position.<br><br>These variables can be zeroed atomically by <i>zero master counters</i> . Cleared when changing mode to TRACKING.                | INT32, read-write |
| tmodc              | Temporary master position counter mod mmc. User cleared only.  | INT32, read-write |
| tsc1               | Temporary slave position, counter 1<br><br>This variable is auxiliary, settable counter that tracks slave position.  | INT32, read-write |
| tsc1rise           | This bit-oriented variable controls when <i>tsc1</i> is cleared. When the input corresponding to a set bit in <i>tsc1rise</i> makes an off-to-on transition, <i>tsc1</i> is cleared.<br>Bit 0, the least significant bit, represents input #1, etc.          | INT32, read-write |
| tsc1fall           | This bit-oriented variable controls when <i>tsc1</i> is cleared. When the input corresponding to a set bit in <i>tsc1fall</i> makes an on-to-off transition, <i>tsc1</i> is cleared.<br>Bit 0, the least significant bit, represents input #1, etc.          | INT32, read-write |
| tsc2               | Temporary slave position, counter 2<br><br>This variable is auxiliary, settable counter that tracks slave position.  | INT32, read-write |
| tsc2rise           | This bit-oriented variable controls when <i>tsc2</i> is cleared. When the input corresponding to a set bit in <i>tsc2rise</i> makes an off-to-on transition, <i>tsc2</i> is cleared.<br>Bit 0, the least significant bit, represents input #1, etc.          | INT32, read-write |

| Tracking Variables | Description  | Type              |
|--------------------|--|-------------------|
| tsc2fall           | This bit-oriented variable controls when <i>tsc2</i> is cleared. When the input corresponding to a set bit in <i>tsc2fall</i> makes an on-to-off transition, <i>tsc2</i> is cleared.<br>Bit 0, the least significant bit, represents input #1, etc.  | INT32, read-write |
| tracking_pstate    | EtherCAT Only: See Status Variables.   | INT32, read_only  |
| tracking_sign      | EtherCAT Only: If the axis is tracking this variable is set to 1 or -1 depending on the direction of rotation.   | INT32, read_only  |
| tracking_status    | EtherCAT Only: If an axis is tracking this variable represents the current state of motion:<br><br><pre>enum QS2STATE {     NOT_INITIALIZED,     STOPPED_READY,     WAIT_START,     ACCELERATING,     AT_MAX_SPEED,     DECEL_TO_NEW_MAX_SPEED,     DECEL_TO_STOP,     SOFT_STOP,     REG_MOVE,     HOME,     NOT_USED1,     FOLLOWING,     NOT_USED2,     COMMAND_ACCEPTED };</pre> | BYTE8, read-only  |
| tracking_tpos      | EtherCAT Only: If an axis is tracking then this is the target position scaled in user-units.   | DOUBLE, read-only |
| tracking_tposc     | EtherCAT Only: If an axis is tracking then this is the target position scaled in encoder counts.   | INT64, read-only  |
| vmdelta            | Virtual master delta counts.   | INT32, read-only  |

| Capture Variables | Description  | Type              |
|-------------------|--|-------------------|
| capArmed          | Capture armed, non zero. If capture is armed and this variable is cleared any capture will be ignored (equivalent to disabling capture). | BYTE8, read-write |
| capEdge           | Edge to monitor for capture as set by the 'set capture' instruction.<br>2 – any edge, 1 – rising edge, 0 – falling edge.                 | INT16, read-only  |
| capGate           | Capture input used to gate the trigger input, if -1 then always gated.   | INT16, read-write |

|               |   |                   |
|---------------|---|-------------------|
| capGateState  | Gate active as on or off, 0 if waiting for gate to be high, 1 if waiting for gate to be low.  | INT16, read-only  |
| capInput      | Capture input to be used as a trigger.  | INT16, read-only  |
| capLimit      | Capture limit value   | INT64, read_write |
| capLimitflag  | Set if capture limit occurred   | BYTE8, read-only  |
| capMod        | EtherCAT only:<br>Defaults to 1 and applies a modulus to the captured value.  | INT32, read-write |
| capOffset     | Amount to move after a capture occurs, $fposc + capOffset = \text{new end position}$ . If 0 then move continues as was originally instructed.   | INT64, read-write |
| cappos        | Capture position in user units. $capposc * 1/ppr$ .   | DOUBLE, read-only |
| capposc       | Capture position in counts. This will be $fposc + \text{encoder offset}$ if not in Tracking mode. If Tracking then $sposc + \text{encoder offset}$ . Latched when defined capture input goes active.  | INT64, read-only  |
| capStatus     | Capture status, bit 8 (axis 1), bit 9 (axis 2). 1 = active.   | INT16, read-only  |
| capTriggered  | Capture occurred flag, non zero. $capposc/cappos$ contains the latched position when occurred.  | BYTE8, read-write |
| capWait       | If 1, an MSB is waiting on a 'wait capture' instruction, else 0.  | BYTE8, read-only  |
| capwaitBranch | Capture MSB offset branch value.  | INT16, read-only  |
| capwinEnd     | End of capture range as set by the 'set capwin' instruction. If same as capwinStart then no window is active.   | INT64, read-write |
| capwinStart   | Start of capture range as set by the 'set capwin' instruction. If same as capwinEnd then no window is active.   | INT64, read-write |
| capwinType    | Capture window type (0-17):<br><b>fposc</b> (0) feedback position<br><b>mposc1 - mposc5</b> (1-6) master position counters #1 through #5<br><b>mposc</b> (7) master position counter<br><b>smodc</b> (8) slave position (modulo)<br><b>smark</b> (9) slave marked position<br><b>tmc1 tmc2</b> (10/11) temporary master counters #1 & #2<br><b>tsc1 tsc2</b> (12/13) temporary slave counters #1 & #2<br><b>sdc</b> (14) slave decrement counter<br><b>fposc1</b> (15) feedback position of axis 1 ( $fposcA$ )<br><b>fposc2</b> (16) feedback position of axis 2 ( $fposcB$ )<br><b>tmodc</b> (17) temporary master counter mod mmc<br><b>sfposc</b> (18) secondary feedback position of axis<br><br>EtherCAT: Reference EtherCAT Application Guide. | INT16, read-only  |
| msource       | Master source setting:<br>0x01 – feedback1<br>0x02 – feedback2  | BYTE8, read-only  |

|  |  |
|--|--|
| <p>0x03 - feedbackz<br/> 0x04 - target1<br/> 0x05 - target2<br/> 0x06 - common<br/> 0x07 - virtual<br/> Bit OR of above:<br/> 0x80 - global</p> <p>EtherCAT: Reference EtherCAT Application Guide.</p> |  |
|--|--|

| Diagnostic Variables | Description   | Type               |
|----------------------|---|--------------------|
| activeBG_MSBs        | Number of active background MSB's running on axis.                              | BYTE8, read-only   |
| activeFG_MSBs        | Number of active foreground MSB's running on axis.                              | BYTE8, read-only   |
| debugTable           | Cam table to view, from 0 to 5  | INT32, read-write  |
| debugTableRows       | Number of rows presently in the selected cam table, debugTable.                 | INT32, read-only   |
| debugTableRow        | Current row number to view in the selected cam table, debugTable.               | INT32, read-write  |
| debugTableX          | X value for selected debugTableRow.   | FLOAT32, read-only |
| debugTableY          | Y value for selected debugTableRow.   | FLOAT32, read-only |
| last_ALStatusCode    | EtherCAT Only:<br><br>Last AL Status code read from drive.                      | INT32, read-write  |
| last_errorCode       | EtherCAT Only:<br><br>Last error code read from drive, typically object 0x603F. | INT32, read-write  |
| last_errorRegister   | EtherCAT Only:<br><br>Last error register from drive, typically 0x1001.         | INT32, read-write  |
| last_errorType       | EtherCAT Only:<br><br>Used internally by M3-41/IncentiveECAT.                   | INT32, read-write  |
| lastOverall          | Last full loop time of all axis in uS.<br><br>EtherCAT: Not used.               | FLOAT32, read-only |
| loopperiod           | Periodic motion loop interrupt time in uS.                                      | FLOAT32, read-only |
| looprate             | Number of motion loop interrupts/second.  | FLOAT32, read-only |

|              |  |                    |
|--------------|--|--------------------|
| minLoopTime  | Minimum actual individual axis loop execution time (uS) reached.<br>EtherCAT: Not used.  | FLOAT32, read-only |
| maxLoopTime  | Maximum actual individual axis loop execution time (uS) reached.<br>EtherCAT: Not used.  | FLOAT32, read-only |
| minOverall   | Minimum actual axis loop execution time (uS) reached for all axis.<br>EtherCAT: Not used.  | FLOAT32, read-only |
| maxOverall   | Maximum actual axis loop execution time (uS) reached for all axis.<br>EtherCAT: Not used.  | FLOAT32, read-only |
| overflowFlag | Motion loop overflow flag, set to 1 if loop time exceeded while in the loop (800uS default, reference 'set loopperiod')<br>EtherCAT: Not used. | INT32, read-only   |
| scanning     | EtherCAT Only:<br><br>Variable set according to EtherCAT scan state. 0 = not scanning, 1= initializing, 2 = operational and scanning.          | INT32, read-only   |
| wStatus      | EtherCAT Only:<br><br>Status Word read from the drive, object 0x6041.  | INT16, read-only   |
| wControlWord | EtherCAT Only:<br><br>Control Word used to issue commands to the drive, object 0x6040.   | INT16, read-only   |

| Setup Variables  | Description  | Type              |
|------------------|--|-------------------|
| axisptr          | EtherCAT Only:<br>Properties such as fpos, tpos, etc., are local to an axis and not shared with other axis MSBs. This limitation can be overridden by using the 'axisptr' property of an MSB. This property controls what axis the MSB will retrieve its property value on a read and write operation. It is typically set to the value of 'axisnum', which is the axis number of that axis executing the MSB. Setting this axis number to any other value will override what axis the property is retrieved from. | INT32, read-write |
| dim_factor_num   | EtherCAT Only:<br>Reserved for later use with velocity drives.   | INT32, read-write |
| dim_factor_denom | EtherCAT Only:<br>Reserved for later use with velocity drives.   | INT32, read-write |
| dwSlaveID        | EtherCAT Only:<br>Slave ID for this axis.  | INT32, read-only  |
| eCAT_driveType   | EtherCAT Only:<br><br>The type of drive and axis number that an MSB is executing can be referenced programmatically via the 'eCAT_driveType' and   | INT32, read-only  |

| Setup Variables              | Description   | Type                |   |                 |   |                              |   |                    |   |                     |   |                 |   |             |   |                 |   |                        |    |                       |    |                        |    |                       |    |                    |    |                    |    |                          |    |                          |    |  |
|------------------------------|---|---------------------|---|-----------------|---|------------------------------|---|--------------------|---|---------------------|---|-----------------|---|-------------|---|-----------------|---|------------------------|----|-----------------------|----|------------------------|----|-----------------------|----|--------------------|----|--------------------|----|--------------------------|----|--------------------------|----|--|
|                              | <p>'axisnum' property variables. 'axisnum' contains the axis number, where 1 is the first. 'eCAT_driveType' is defined as follows:</p> <table border="0"> <tr><td>\$DRIVE_COPLEY</td><td>2</td></tr> <tr><td>\$DRIVE_YASKAWA</td><td>3</td></tr> <tr><td>\$DRIVE_ELMO (not supported)</td><td>4</td></tr> <tr><td>\$DRIVE_KOLLMORGEN</td><td>5</td></tr> <tr><td>\$DRIVE_SANYO_DENKI</td><td>6</td></tr> <tr><td>\$DRIVE_EMERSON</td><td>7</td></tr> <tr><td>\$DRIVE_AMC</td><td>8</td></tr> <tr><td>\$DRIVE_VIRTUAL</td><td>9</td></tr> <tr><td>\$DRIVE_IAI_ACON_MODE3</td><td>11</td></tr> <tr><td>\$DRIVE_ABB_MICROFLEX</td><td>12</td></tr> <tr><td>\$DRIVE_ABB_MITSUBISHI</td><td>13</td></tr> <tr><td>\$DRIVE_ABB_PANASONIC</td><td>14</td></tr> <tr><td>\$DRIVE_ABB_LINMOT</td><td>15</td></tr> <tr><td>\$DRIVE_MOTIONLINX</td><td>17</td></tr> <tr><td>\$DRIVE_WAGO_ENCODER_631</td><td>18</td></tr> <tr><td>\$DRIVE_WAGO_ENCODER_637</td><td>19</td></tr> </table> | \$DRIVE_COPLEY      | 2 | \$DRIVE_YASKAWA | 3 | \$DRIVE_ELMO (not supported) | 4 | \$DRIVE_KOLLMORGEN | 5 | \$DRIVE_SANYO_DENKI | 6 | \$DRIVE_EMERSON | 7 | \$DRIVE_AMC | 8 | \$DRIVE_VIRTUAL | 9 | \$DRIVE_IAI_ACON_MODE3 | 11 | \$DRIVE_ABB_MICROFLEX | 12 | \$DRIVE_ABB_MITSUBISHI | 13 | \$DRIVE_ABB_PANASONIC | 14 | \$DRIVE_ABB_LINMOT | 15 | \$DRIVE_MOTIONLINX | 17 | \$DRIVE_WAGO_ENCODER_631 | 18 | \$DRIVE_WAGO_ENCODER_637 | 19 |  |
| \$DRIVE_COPLEY               | 2   |                     |   |                 |   |                              |   |                    |   |                     |   |                 |   |             |   |                 |   |                        |    |                       |    |                        |    |                       |    |                    |    |                    |    |                          |    |                          |    |  |
| \$DRIVE_YASKAWA              | 3   |                     |   |                 |   |                              |   |                    |   |                     |   |                 |   |             |   |                 |   |                        |    |                       |    |                        |    |                       |    |                    |    |                    |    |                          |    |                          |    |  |
| \$DRIVE_ELMO (not supported) | 4   |                     |   |                 |   |                              |   |                    |   |                     |   |                 |   |             |   |                 |   |                        |    |                       |    |                        |    |                       |    |                    |    |                    |    |                          |    |                          |    |  |
| \$DRIVE_KOLLMORGEN           | 5   |                     |   |                 |   |                              |   |                    |   |                     |   |                 |   |             |   |                 |   |                        |    |                       |    |                        |    |                       |    |                    |    |                    |    |                          |    |                          |    |  |
| \$DRIVE_SANYO_DENKI          | 6   |                     |   |                 |   |                              |   |                    |   |                     |   |                 |   |             |   |                 |   |                        |    |                       |    |                        |    |                       |    |                    |    |                    |    |                          |    |                          |    |  |
| \$DRIVE_EMERSON              | 7   |                     |   |                 |   |                              |   |                    |   |                     |   |                 |   |             |   |                 |   |                        |    |                       |    |                        |    |                       |    |                    |    |                    |    |                          |    |                          |    |  |
| \$DRIVE_AMC                  | 8   |                     |   |                 |   |                              |   |                    |   |                     |   |                 |   |             |   |                 |   |                        |    |                       |    |                        |    |                       |    |                    |    |                    |    |                          |    |                          |    |  |
| \$DRIVE_VIRTUAL              | 9   |                     |   |                 |   |                              |   |                    |   |                     |   |                 |   |             |   |                 |   |                        |    |                       |    |                        |    |                       |    |                    |    |                    |    |                          |    |                          |    |  |
| \$DRIVE_IAI_ACON_MODE3       | 11  |                     |   |                 |   |                              |   |                    |   |                     |   |                 |   |             |   |                 |   |                        |    |                       |    |                        |    |                       |    |                    |    |                    |    |                          |    |                          |    |  |
| \$DRIVE_ABB_MICROFLEX        | 12  |                     |   |                 |   |                              |   |                    |   |                     |   |                 |   |             |   |                 |   |                        |    |                       |    |                        |    |                       |    |                    |    |                    |    |                          |    |                          |    |  |
| \$DRIVE_ABB_MITSUBISHI       | 13  |                     |   |                 |   |                              |   |                    |   |                     |   |                 |   |             |   |                 |   |                        |    |                       |    |                        |    |                       |    |                    |    |                    |    |                          |    |                          |    |  |
| \$DRIVE_ABB_PANASONIC        | 14  |                     |   |                 |   |                              |   |                    |   |                     |   |                 |   |             |   |                 |   |                        |    |                       |    |                        |    |                       |    |                    |    |                    |    |                          |    |                          |    |  |
| \$DRIVE_ABB_LINMOT           | 15  |                     |   |                 |   |                              |   |                    |   |                     |   |                 |   |             |   |                 |   |                        |    |                       |    |                        |    |                       |    |                    |    |                    |    |                          |    |                          |    |  |
| \$DRIVE_MOTIONLINX           | 17  |                     |   |                 |   |                              |   |                    |   |                     |   |                 |   |             |   |                 |   |                        |    |                       |    |                        |    |                       |    |                    |    |                    |    |                          |    |                          |    |  |
| \$DRIVE_WAGO_ENCODER_631     | 18  |                     |   |                 |   |                              |   |                    |   |                     |   |                 |   |             |   |                 |   |                        |    |                       |    |                        |    |                       |    |                    |    |                    |    |                          |    |                          |    |  |
| \$DRIVE_WAGO_ENCODER_637     | 19  |                     |   |                 |   |                              |   |                    |   |                     |   |                 |   |             |   |                 |   |                        |    |                       |    |                        |    |                       |    |                    |    |                    |    |                          |    |                          |    |  |
| eCAT_manufID                 | EtherCAT Only:<br>EtherCAT ESI manufacturer ID.   | INT32, read-only    |   |                 |   |                              |   |                    |   |                     |   |                 |   |             |   |                 |   |                        |    |                       |    |                        |    |                       |    |                    |    |                    |    |                          |    |                          |    |  |
| eCAT_productCode             | EtherCAT Only:<br>EtherCAT ESI product code.  | INT32, read-only    |   |                 |   |                              |   |                    |   |                     |   |                 |   |             |   |                 |   |                        |    |                       |    |                        |    |                       |    |                    |    |                    |    |                          |    |                          |    |  |
| qs_decel_time                | EtherCAT Only:<br>Reserved for future VFD quick stop deceleration time.   | INT32, read-write   |   |                 |   |                              |   |                    |   |                     |   |                 |   |             |   |                 |   |                        |    |                       |    |                        |    |                       |    |                    |    |                    |    |                          |    |                          |    |  |
| vel_accel_time               | EtherCAT Only:<br>Reserved for future VFD velocity acceleration time.   | INT32, read-write   |   |                 |   |                              |   |                    |   |                     |   |                 |   |             |   |                 |   |                        |    |                       |    |                        |    |                       |    |                    |    |                    |    |                          |    |                          |    |  |
| vel_decel_time               | EtherCAT Only: Reserved for future VFD velocity deceleration time.  | INT32, read-write   |   |                 |   |                              |   |                    |   |                     |   |                 |   |             |   |                 |   |                        |    |                       |    |                        |    |                       |    |                    |    |                    |    |                          |    |                          |    |  |
| vmin                         | EtherCAT Only:<br>Reserved for future VFD velocity minimum.   | FLOAT32, read-write |   |                 |   |                              |   |                    |   |                     |   |                 |   |             |   |                 |   |                        |    |                       |    |                        |    |                       |    |                    |    |                    |    |                          |    |                          |    |  |

| RFID Variables     | Description (EtherCAT Only)  | Type              |   |           |   |                |   |  |
|--------------------|--|-------------------|---|-----------|---|----------------|---|--|
| RFID_channel       | Selects the RFID channel to be operated on by the properties that follow. Entries of 1 to RFID_totalChannels are the valid selections, with 0 disabling access. All properties should be initialized to their proper values before setting the RFID_channel to a non-zero value. | INT32, read-write |   |           |   |                |   |  |
| RFID_totalChannels | Represents the total number of RFID channels available in the system.  | INT32, read-only  |   |           |   |                |   |  |
| RFID_state         | Represents the current state of the RFID interface logic state machine as it executes any requests issued by the RFID_control property variable. Possible values are as follows:   | INT32, read-write |   |           |   |                |   |  |
|                    | <table border="0"> <tr><td>RFID_OFF</td><td>0</td></tr> <tr><td>RFID_IDLE</td><td>1</td></tr> <tr><td>RFID_READING_1</td><td>2</td></tr> </table>  | RFID_OFF          | 0 | RFID_IDLE | 1 | RFID_READING_1 | 2 |  |
| RFID_OFF           | 0  |                   |   |           |   |                |   |  |
| RFID_IDLE          | 1  |                   |   |           |   |                |   |  |
| RFID_READING_1     | 2  |                   |   |           |   |                |   |  |

| RFID Variables   | Description (EtherCAT Only)   | Type              |
|------------------|---|-------------------|
|                  | RFID_READING_2            3<br>RFID_READING_WAIT_DONE 4<br>RFID_WRITING_1            10<br>RFID_WRITING_2            11<br>RFID_WRITING_3            12<br>RFID_WRITING_4            13<br>RFID_WRITE_DONE            15<br>RFID_WRITE_WAITTAG        20<br>RFID_READ_WAITTAG         21<br>RFID_WAITNOTAG            22<br>RFID_ERROR                 30   |                   |
| RFID_error       | Turck specific error where bits 7 to 0 represent the category and bits 15 to 8 are the description. Any time the RFID_error property is non-zero an error is present. To clear the error the RFID reader must be reset using the RFID_control property RESET bit. See EtherCAT Applications Guide for error codes..   | INT32, read-only  |
| RFID_address     | This address is forwarded to the RFID reader to determine where in its memory block to begin accessing data for read and write operations. A value of 0 is the first address. RFID_address is auto-incremented after any read or write by the amount in RFID_bytesTransferred therefore set it back to the desired start location after each read or write. | INT32, read-write |
| RFID_index       | The index is used to select which RFID_data_readl/RFID_data_readh or RFID_data_writel/RFID_data_wriته array item is to be operated on. Where 0 is the first item, up to 31 (32 array items for 256 bytes total possible).<br><br><pre>int RFID_data_readl[32]; int RFID_data_readh[32]; int RFID_data_writel[32]; int RFID_data_wriته[32];</pre>            | INT32, read-write |
| RFID_data_readl  | The first 32 bit integer or 4 bytes of data transferred from the RFID tag. This property is an array of 32 deep, indexed by the RFID_index property.<br><br><pre>int RFID_data_readl[32];</pre>   | INT32, read-write |
| RFID_data_readh  | Read/write, the second 32 bit integer or 4 bytes of data transferred from the RFID tag. This property is an array of 32 deep, indexed by the RFID_index property in parallel to RFID_data_readl.<br><br><pre>int RFID_data_readh[32];</pre>   | INT32, read-write |
| RFID_data_writel | Read/write, the first 32 bit integer or 4 bytes of data transferred to the RFID tag. This property is an array of 32 deep, indexed  | INT32, read-write |

| RFID Variables     | Description (EtherCAT Only)  | Type              |
|--------------------|--|-------------------|
|                    | <p>by the RFID_index property.</p> <pre>int RFID_data_writel[32];</pre>  |                   |
| RFID_data_wrieh    | <p>The second 32 bit integer or 4 bytes of data transferred to the RFID tag. This property is an array of 32 deep, indexed by the RFID_index property in parallel to RFID_data_writel.</p> <pre>int RFID_data_wrieh[32];</pre>   | INT32, read-write |
| RFID_status        | <p>32 bit integer with only the first 8 bits reflecting the status as returned by the Turck RFID reader.</p> <ul style="list-style-type: none"> <li>• Done – (Bit 7) Slice is ready to receive command. This bit will be off until previous command bit is turned off.</li> <li>• Busy – (Bit 6) Slice is currently processing command. This is normally on when transceiver is waiting for a tag to be presented.</li> <li>• Error – (Bit 5) Slice has encountered an error during last command. Refer to Error_Cat and Error_Desc for details. This bit is not always set so check RFID_error for nonzero.</li> <li>• Trans_Conn – (Bit 4) Transceiver is correctly connected and communicating with the slice.</li> <li>• Trans_On – (Bit 3) Transceiver has been turned on by slice.</li> <li>• TP – (Bit 2) Tag present; Tag is present in transceiver field. LED on transceiver will blink rapidly.</li> <li>• TFR – (Bit 1) Tag Fully Read; Tag has been present in transceiver field long enough so that entire tag memory has been stored in buffer. This bit does not need to be on to indicate a command has been completed.</li> </ul> | INT32, read-only  |
| RFID_control       | <p>32 bit integer which is used to request RFID transactions to occur, read and writing different aspects of the tag and transceiver. Some of the bits are defined by Turck but have been enhanced by CTC for additional features.</p>   | INT32, read-write |
| RFID_controlActive | <p>Represents the value actually being transferred to the Turck RFID controller at any moment. During operation bits are set/cleared automatically by the M3-41 module, especially when transferring multiple blocks of data. Useful for diagnostic purposes.</p>  | INT32, read-only  |
| RFID_count         | <p>Represents the value actually being transferred to the Turck RFID controller as the needed byte count. This property is automatically set based upon the RFID_bytesTotal required. Useful for diagnostic purposes.</p>  | INT32, read-only  |
| RFID_bytesTotal    | <p>This property must be set to the total number of bytes to be transferred to/from the RFID reader. If to the reader RFID_data_writel/h array is used, if from the reader RFID_data_readl/h is used. For a single transfer this is typically set to 8. This property is also used in conjunction with the 'host read' and 'host write' commands when transfers are done</p>   | INT32, read-write |

| RFID Variables        | Description (EtherCAT Only)   | Type              |
|-----------------------|---|-------------------|
|                       | with the RFID_data_readl and RFID_data_writel properties. These properties can be used to transfer strings to/from Quickbuilder variants.   |                   |
| RFID_bytesTransferred | This property represents the number of bytes that have been transferred during a read/write RFID operation as well as 'host read' and 'host write'. If a 'host read' is used to read a QuickBuilder variant string this property will represent the length of the string after the access.                            | INT32, read-write |
| RFID_tagIDl           | This property is automatically set when a TAG ID read operation is performed. This property represents the lower 4 bytes.   | INT32, read-write |
| RFID_tagIDh           | This property is automatically set when a TAG ID read operation is performed. This property represents the upper 4 bytes.   | INT32, read-write |
| RFID_lasttagIDl       | This property is automatically set when a TAG ID read operation is performed and a unique id is found, different than that previously read. This property represents the lower 4 bytes. The RFID_lasttagIDl/h is checked against the latest tag id read to ensure no duplicates are found, if that option is enabled. | INT32, read-write |
| RFID_lasttagIDh       | This property is automatically set when a TAG ID read operation is performed and a unique id is found, different than that previously read. This property represents the upper 4 bytes. The RFID_lasttagIDl/h is checked against the latest tag id read to ensure no duplicates are found, if that option is enabled. | INT32, read-write |

| Vector Variables | Description (EtherCAT Only)  | Type               |
|------------------|--|--------------------|
| accX             | Calculated acceleration along the X axis of the last vector move.  | DOUBLE, read-only  |
| accY             | Calculated acceleration along the Y axis of the last vector move.  | DOUBLE, read-only  |
| accZ             | Calculated acceleration along the Z axis of the last vector move.  | DOUBLE, read-only  |
| accVector        | Circular Interpolation:<br>Acceleration in radians/second <sup>2</sup> that is being used for the calculated profile.  | DOUBLE, read-only  |
| angle            | Circular Interpolation:<br>Initialized to 0 and records the calculated angle as it sweeps.<br><br>2D and 3D Linear Interpolation:<br>Calculated angle of the last vector move.                                 | FLOAT32, read-only |
| angleStart       | Circular Interpolation:<br>The angle at which motion should start where 0 is vertical on the Y axis, minus angle moves left, and positive angle moves right. The 'angleSweep' variable is added to this angle. | DOUBLE, read-write |

| Vector Variables | Description (EtherCAT Only)   | Type               |
|------------------|---|--------------------|
| angleSweep       | Circular Interpolation:<br>The desired amount of angular motion that is to occur relative to the radius center point. A positive angleSweep rotates clockwise, negative, counter clockwise.   | DOUBLE, read-write |
| axisY            | The axis number, from 1 to N, which will be the Y axis, commanded from the X axis. The Y axis must be set for either 2D or 3D interpolation to occur.   | INT32, read-write  |
| axisZ            | 3D Linear Interpolation:<br>The axis number, from 1 to N, which will be the Z axis, commanded from the X axis.  | INT32, read-write  |
| decVector        | Circular Interpolation:<br>Deceleration in radians/second <sup>2</sup> that is being used for the calculated profile.   | DOUBLE, read-only  |
| decX             | Calculated deceleration along the X axis of the last vector move.   | DOUBLE, read-only  |
| decY             | Calculated deceleration along the Y axis of the last vector move.   | DOUBLE, read-only  |
| decZ             | Calculated deceleration along the Z axis of the last vector move.   | DOUBLE, read-only  |
| magnitude        | 2D and 3D Linear Interpolation:<br>Calculated size of the last vector move.   | DOUBLE, read-only  |
| radius           | Circular Interpolation:<br>The radius in user units of the arc to be drawn. A negative radius flips the arc.  | DOUBLE, read-write |
| vectorY          | Circular Interpolation:<br>The calculated center of the arc for the Y axis will be stored here for diagnostic reference, in machine units. Make sure you update vectorY after a circular move if the next move is linear interpolation.<br><br>3D Linear Interpolation:<br>The desired Y position on an X/Y/Z grid in user units, based upon revolutions. Note that this value is overwritten after a circular interpolated move for diagnostic purposes.<br><br>2D Linear Interpolation:<br>The desired Y position on an X/Y grid in user units, based upon revolutions. | DOUBLE, read-write |
| vectorZ          | Circular Interpolation:<br>The calculated center of the arc for the X axis will be stored here for diagnostic reference, in machine units.<br><br>3D Linear Interpolation:<br>The desired Z position on an X/Y/Z grid in user units, based upon revolutions. Note that this value is overwritten after a circular interpolated move for diagnostic purposes.  | DOUBLE, read-write |

| Vector Variables | Description (EtherCAT Only)  | Type              |
|------------------|--|-------------------|
| velVector        | Circular Interpolation:<br>Velocity in radians/second that is being used for the calculated profile. | DOUBLE, read-only |
| velX             | Calculated velocity along the X axis of the last vector move.  | DOUBLE, read-only |
| velY             | Calculated velocity along the Y axis of the last vector move.  | DOUBLE, read-only |
| velZ             | Calculated velocity along the Z axis of the last vector move.  | DOUBLE, read-only |

### 6.3 Host Register Access

The Host Read/Write commands are used to directly access all the main controller's registers, including variant storage. These registers consist of, but are not limited to:

- Analog I/O
- Digital I/O
- Data tables
- Volatile and non-volatile Variant scalar, vector and tables
- Generic integer registers
- Non-volatile register
- Communications

Reference the Quickstep Register Guide for a summary of available registers:

[http://www.ctc-control.com/customer/techinfo/docs/5300\\_951/951-530006.pdf](http://www.ctc-control.com/customer/techinfo/docs/5300_951/951-530006.pdf)

Summary:

[host read variable, register {, row, column}](#)

[host write variable, register {, row, column}](#)

| Host Read  |  | <input checked="" type="checkbox"/> Positioning | <input checked="" type="checkbox"/> Slewing | <input checked="" type="checkbox"/> Tracking | <input checked="" type="checkbox"/> BG MSB<br><input checked="" type="checkbox"/> FG MSB |
|--|--|---|---|--|--|
| <i>syntax</i>  |  |   |   |  |  |
| <code>host read variable, register {, row, column }</code> |  |   |   |  |  |
| <i>parameters</i>  |  |   |   |  |  |
| <i>variable</i>  | Local user variable or axis property to have 'register' stored to it.  |   |   |  |  |
| <i>register</i>  | Main controller QuickBuilder register as defined in the Model 5300 Quick Reference Register Guide. May be constant or variable access. |   |   |  |  |
| <i>row</i>   | Optional row used only for variant register table access. May be constant or variable access.  |   |   |  |  |
| <i>column</i>  | Optional column used only for variant register table access. May be constant or variable access.                                       |   |   |  |  |

This statement pauses execution of the MSB while the contents of a QuickBuilder register is retrieved from the main processor. The register value is then stored into the local 'variable' or axis 'property'. The data type will automatically be converted to that of the local storage. Both integer based registers and variant vectors and tables are supported. When reading a variant, one cell at a time in the table (if any) is read. If no row or column is specified, 0 is assumed.

```
// Read the controller tick timer referencing a variable
// and store to 'userVar'
reg = 13002;
host read userVar, reg;
// Read the controller tick timer using constant register
// number and store to 'userVar'
host read userVar, 13002;
```

| Host Write  |  | <input checked="" type="checkbox"/> Positioning | <input checked="" type="checkbox"/> Slewing | <input checked="" type="checkbox"/> Tracking | <input checked="" type="checkbox"/> BG MSB<br><input checked="" type="checkbox"/> FG MSB |
|---|--|---|---|--|--|
| <i>syntax</i>   |  |   |   |  |  |
| <b>host write</b> <i>variable</i> , <i>register</i> {, <i>row</i> , <i>column</i> } |  |   |   |  |  |
| <i>parameters</i>   |  |   |   |  |  |
| <i>variable</i>   | Local user variable or axis property to store to controller 'register'.  |   |   |  |  |
| <i>register</i>   | Main controller QuickBuilder register as defined in the Model 5300 Quick Reference Register Guide. May be constant or variable access. |   |   |  |  |
| <i>row</i>  | Optional row used only for variant register table access. May be constant or variable access.  |   |   |  |  |
| <i>column</i>   | Optional column used only for variant register table access. May be constant or variable access.                                       |   |   |  |  |

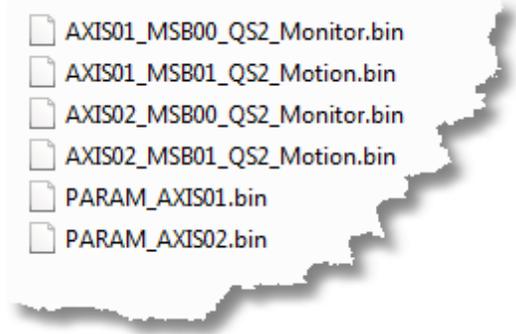
This statement pauses execution of the MSB while the contents of a local 'variable' or axis 'property' is written to a QuickBuilder register on the main processor. The data type will automatically be converted to that of the QuickBuilder register, thus double will be converted to integer, etc. Both integer based registers and variant vectors and tables are supported. When writing a variant, one cell at a time in the table (if any) is written. If no row or column is specified, 0 is assumed.

```
// Clear the controller tick timer, register 13002,
// referencing the contents of 'userVar'.
userVar = 0;
reg = 13002;
host write userVar, reg;
// Clear the controller tick timer, register 13002,
// using a constant value.
host write 0, 13002;
```

## 7 Chapter 7: Quickstep Support

QuickMotion has been designed for high integration with the QuickBuilder language and include such features as program interaction and user units. A legacy product, Quickstep, uses a register interface for motion control. This interface is not as tightly coupled but there is a large existing code base thus an MSB emulation mode has been created which allows the M3-40 module to appear as a 2219 motion control card, used on the 2700 series controllers, or 5140, within the 5100/5200 controller family.

Register emulation is always available from a read only perspective. In order to fully support the emulation mode a special MSB has been created and must be loaded. This MSB is the output of a QuickBuilder project where initial parameters and any minor MSB customization can be made. To simplify initial use a fully compiled project is available that can be loaded into a 5300 controller for Quickstep program support, QS2MSB. This project is available from the download portion of CTCs' web site. In the example provided, 2 axis, are supported. To support more axis simply add the card to the QuickBuilder project as well as 'start axis' references, or if QuickBuilder is not available, you may simply copy and rename the files with the appropriate axis names. Note the files which are available after compiling QS2MSB, within the controller sub-directory:



These files consist of the binary output, generated by QuickBuilder, for MSB's (AXIS??\_MSB??\_msbname.bin) and their respective configuration parameters (PARAM\_AXIS???.bin). They must be placed in the controller '/\_system/Programs/Motion' subdirectory. Upon power up or reset the M3-40A module will automatically look in this directory and if the files are present then an auto-boot sequence will begin. Namely, the files will be loaded into the M3-40 card and automatically executed. If a servo has been tuned and parameters saved to the card, the PARAM file settings will be ignored and only the MSB binary file will be loaded.

Once loaded and running most legacy Quickstep motion applications will run, unchanged.

**⚠** Note that the emulation will appear similar to a 2700, 2219 module. Any extended features available within the 5100/5200 controller 5140 module are not currently supported. The Register interface is fully available on all motion products. If only Registers are desired the above .bin files do not have to be loaded. The .bin files are used to simulate full Quickstep motion instructions thus if MSB's are used in a normal QuickBuilder program, they are not needed.

## 7.1 Registers

Most of the motion registers supported by the 2700/5100/5200 controller are available within the 5300/Incentive environment, regardless of whether the emulation mode is run or not. If emulation is not running then write operations are not supported. These registers consist of:

| Motion Registers Grouped by function then axis |   |            |             |            |                      |   |                   |   |                                    |   |              |   |               |   |                               |   |                      |   |           |   |                                       |   |      |    |                      |         |                  |
|--|---|------------|-------------|------------|----------------------|---|-------------------|---|------------------------------------|---|--------------|---|---------------|---|-------------------------------|---|----------------------|---|-----------|---|---------------------------------------|---|------|----|----------------------|---------|------------------|
|  | The 5300 firmware is designed to access up to 16 axes. For the 14XXX register values below substitute the axis number for 'ax' to get the correct register. <b>Axis #1 = 1</b> ; For example the position of axis #1 is stored in register 14001.   |            |             |            |                      |   |                   |   |                                    |   |              |   |               |   |                               |   |                      |   |           |   |                                       |   |      |    |                      |         |                  |
| 140ax  | <b>Position</b> (counts), R only [QuickBuilder reference = fposc]   |            |             |            |                      |   |                   |   |                                    |   |              |   |               |   |                               |   |                      |   |           |   |                                       |   |      |    |                      |         |                  |
| 141ax  | <b>Error</b> (counts), R only [QuickBuilder reference = perr * ppr * (uun/uud)]   |            |             |            |                      |   |                   |   |                                    |   |              |   |               |   |                               |   |                      |   |           |   |                                       |   |      |    |                      |         |                  |
| 142ax  | <b>Velocity</b> (counts / sec), R only [QuickBuilder reference = vel * ppr * (uun/uud)]   |            |             |            |                      |   |                   |   |                                    |   |              |   |               |   |                               |   |                      |   |           |   |                                       |   |      |    |                      |         |                  |
| 143ax  | <p><b>Status</b>, R only:</p> <table border="1"> <thead> <tr> <th>Status</th> <th>Description</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>Axis not initialized</td> </tr> <tr> <td>1</td> <td>Stopped and ready</td> </tr> <tr> <td>2</td> <td>Motion imminent: waiting for start</td> </tr> <tr> <td>3</td> <td>Accelerating</td> </tr> <tr> <td>4</td> <td>At max speed.</td> </tr> <tr> <td>5</td> <td>Decelerating to new max speed</td> </tr> <tr> <td>6</td> <td>Decelerating to stop</td> </tr> <tr> <td>7</td> <td>Soft stop</td> </tr> <tr> <td>8</td> <td>Registration move (armed, not moving)</td> </tr> <tr> <td>9</td> <td>Home</td> </tr> <tr> <td>10</td> <td>Following (not used)</td> </tr> <tr> <td>128-255</td> <td>Error (not used)</td> </tr> </tbody> </table> | Status     | Description | 0          | Axis not initialized | 1 | Stopped and ready | 2 | Motion imminent: waiting for start | 3 | Accelerating | 4 | At max speed. | 5 | Decelerating to new max speed | 6 | Decelerating to stop | 7 | Soft stop | 8 | Registration move (armed, not moving) | 9 | Home | 10 | Following (not used) | 128-255 | Error (not used) |
| Status   | Description   |            |             |            |                      |   |                   |   |                                    |   |              |   |               |   |                               |   |                      |   |           |   |                                       |   |      |    |                      |         |                  |
| 0  | Axis not initialized  |            |             |            |                      |   |                   |   |                                    |   |              |   |               |   |                               |   |                      |   |           |   |                                       |   |      |    |                      |         |                  |
| 1  | Stopped and ready   |            |             |            |                      |   |                   |   |                                    |   |              |   |               |   |                               |   |                      |   |           |   |                                       |   |      |    |                      |         |                  |
| 2  | Motion imminent: waiting for start  |            |             |            |                      |   |                   |   |                                    |   |              |   |               |   |                               |   |                      |   |           |   |                                       |   |      |    |                      |         |                  |
| 3  | Accelerating  |            |             |            |                      |   |                   |   |                                    |   |              |   |               |   |                               |   |                      |   |           |   |                                       |   |      |    |                      |         |                  |
| 4  | At max speed.   |            |             |            |                      |   |                   |   |                                    |   |              |   |               |   |                               |   |                      |   |           |   |                                       |   |      |    |                      |         |                  |
| 5  | Decelerating to new max speed   |            |             |            |                      |   |                   |   |                                    |   |              |   |               |   |                               |   |                      |   |           |   |                                       |   |      |    |                      |         |                  |
| 6  | Decelerating to stop  |            |             |            |                      |   |                   |   |                                    |   |              |   |               |   |                               |   |                      |   |           |   |                                       |   |      |    |                      |         |                  |
| 7  | Soft stop   |            |             |            |                      |   |                   |   |                                    |   |              |   |               |   |                               |   |                      |   |           |   |                                       |   |      |    |                      |         |                  |
| 8  | Registration move (armed, not moving)   |            |             |            |                      |   |                   |   |                                    |   |              |   |               |   |                               |   |                      |   |           |   |                                       |   |      |    |                      |         |                  |
| 9  | Home  |            |             |            |                      |   |                   |   |                                    |   |              |   |               |   |                               |   |                      |   |           |   |                                       |   |      |    |                      |         |                  |
| 10   | Following (not used)  |            |             |            |                      |   |                   |   |                                    |   |              |   |               |   |                               |   |                      |   |           |   |                                       |   |      |    |                      |         |                  |
| 128-255  | Error (not used)  |            |             |            |                      |   |                   |   |                                    |   |              |   |               |   |                               |   |                      |   |           |   |                                       |   |      |    |                      |         |                  |
| 144ax  | <b>Integral Error</b> (count-seconds), R only ( <b>not supported</b> )  |            |             |            |                      |   |                   |   |                                    |   |              |   |               |   |                               |   |                      |   |           |   |                                       |   |      |    |                      |         |                  |
| 145ax  | <b>Velocity Feedforward</b> [QuickBuilder reference =QS2_VAR_NEW_VEL_FEEDFORWARD]   |            |             |            |                      |   |                   |   |                                    |   |              |   |               |   |                               |   |                      |   |           |   |                                       |   |      |    |                      |         |                  |
| 146ax  | <b>Deceleration</b> (counts/sec <sup>2</sup> ) [QuickBuilder reference = QS2_NEW_DECELERATION]  |            |             |            |                      |   |                   |   |                                    |   |              |   |               |   |                               |   |                      |   |           |   |                                       |   |      |    |                      |         |                  |
| 147ax  | <p><b>Dedicated Inputs</b>, R only:</p> <p><b>This is a bit map of the input signals</b></p> <table border="1"> <thead> <tr> <th>Bit Number</th> <th>Description</th> <th>Bit Number</th> <th>Description</th> </tr> </thead> <tbody> <tr> <td> </td> <td> </td> <td> </td> <td> </td> </tr> </tbody> </table>  | Bit Number | Description | Bit Number | Description          |   |                   |   |                                    |   |              |   |               |   |                               |   |                      |   |           |   |                                       |   |      |    |                      |         |                  |
| Bit Number                                     | Description   | Bit Number | Description |            |                      |   |                   |   |                                    |   |              |   |               |   |                               |   |                      |   |           |   |                                       |   |      |    |                      |         |                  |
|  |   |            |             |            |                      |   |                   |   |                                    |   |              |   |               |   |                               |   |                      |   |           |   |                                       |   |      |    |                      |         |                  |

|                |   |                |                                  |          |         |          |      |          |         |          |       |          |                                  |          |      |          |          |
|----------------|---|----------------|----------------------------------|----------|---------|----------|------|----------|---------|----------|-------|----------|----------------------------------|----------|------|----------|----------|
|                | <table border="1"> <tr> <td><b>0 (lsb)</b></td> <td>Reg. (<b>not supported</b>)</td> <td><b>4</b></td> <td>Rev EOT</td> </tr> <tr> <td><b>1</b></td> <td>Home</td> <td><b>5</b></td> <td>Fwd EOT</td> </tr> <tr> <td><b>2</b></td> <td>Start</td> <td><b>6</b></td> <td>Z/Index (<b>not supported</b>)</td> </tr> <tr> <td><b>3</b></td> <td>Kill</td> <td><b>7</b></td> <td>Not Used</td> </tr> </table> | <b>0 (lsb)</b> | Reg. ( <b>not supported</b> )    | <b>4</b> | Rev EOT | <b>1</b> | Home | <b>5</b> | Fwd EOT | <b>2</b> | Start | <b>6</b> | Z/Index ( <b>not supported</b> ) | <b>3</b> | Kill | <b>7</b> | Not Used |
| <b>0 (lsb)</b> | Reg. ( <b>not supported</b> )   | <b>4</b>       | Rev EOT                          |          |         |          |      |          |         |          |       |          |                                  |          |      |          |          |
| <b>1</b>       | Home  | <b>5</b>       | Fwd EOT                          |          |         |          |      |          |         |          |       |          |                                  |          |      |          |          |
| <b>2</b>       | Start   | <b>6</b>       | Z/Index ( <b>not supported</b> ) |          |         |          |      |          |         |          |       |          |                                  |          |      |          |          |
| <b>3</b>       | Kill  | <b>7</b>       | Not Used                         |          |         |          |      |          |         |          |       |          |                                  |          |      |          |          |
| 148ax          | <b>Acceleration Feedforward</b> [QuickBuilder reference = QS2_VAR_NEW_ACC_FEEDFORWARD]  |                |                                  |          |         |          |      |          |         |          |       |          |                                  |          |      |          |          |
| 149ax          | <b>Analog Output, RW</b> - 32,767 = -10.000V; 32,767 = 10.000V, [QuickBuilder reference = rint(dac_mv * 3.2767)]  |                |                                  |          |         |          |      |          |         |          |       |          |                                  |          |      |          |          |

### Motion Registers Grouped by axis then function

|          | For the 15xxx, 16xxx, 17xxx register values below substitute the axis number for ' <b>bx</b> ' to get the correct register. Axis <b>#1 = 0</b> ; For example the position of axis #1 is stored in register 15000.  |                |                                       |       |             |          |                      |          |                      |          |                   |          |                      |          |                                    |          |                                       |          |              |          |      |          |              |           |                      |          |                               |                |                  |
|----------|--|----------------|---------------------------------------|-------|-------------|----------|----------------------|----------|----------------------|----------|-------------------|----------|----------------------|----------|------------------------------------|----------|---------------------------------------|----------|--------------|----------|------|----------|--------------|-----------|----------------------|----------|-------------------------------|----------------|------------------|
| 15bx0    | <b>Position</b> (counts), R only [QuickBuilder reference = fposc]  |                |                                       |       |             |          |                      |          |                      |          |                   |          |                      |          |                                    |          |                                       |          |              |          |      |          |              |           |                      |          |                               |                |                  |
| 15bx1    | <b>Error</b> (counts), R only [QuickBuilder reference = perr * ppr * (uun/uud)]  |                |                                       |       |             |          |                      |          |                      |          |                   |          |                      |          |                                    |          |                                       |          |              |          |      |          |              |           |                      |          |                               |                |                  |
| 15bx2    | <b>Velocity</b> (counts / sec), R only [QuickBuilder reference = vel * ppr * (uun/uud)]  |                |                                       |       |             |          |                      |          |                      |          |                   |          |                      |          |                                    |          |                                       |          |              |          |      |          |              |           |                      |          |                               |                |                  |
| 15bx3    | <p><b>Status</b>, R only:</p> <table border="1"> <thead> <tr> <th>Value</th> <th>Description</th> <th>Value</th> <th>Description</th> </tr> </thead> <tbody> <tr> <td><b>0</b></td> <td>Axis not initialized</td> <td><b>6</b></td> <td>Decelerating to stop</td> </tr> <tr> <td><b>1</b></td> <td>Stopped and ready</td> <td><b>7</b></td> <td>Soft stop (not used)</td> </tr> <tr> <td><b>2</b></td> <td>Motion imminent: waiting for start</td> <td><b>8</b></td> <td>Registration move (armed, not moving)</td> </tr> <tr> <td><b>3</b></td> <td>Accelerating</td> <td><b>9</b></td> <td>Home</td> </tr> <tr> <td><b>4</b></td> <td>At MAX speed</td> <td><b>10</b></td> <td>Following (not used)</td> </tr> <tr> <td><b>5</b></td> <td>Decelerating to new MAX speed</td> <td><b>128-255</b></td> <td>Error (not used)</td> </tr> </tbody> </table> | Value          | Description                           | Value | Description | <b>0</b> | Axis not initialized | <b>6</b> | Decelerating to stop | <b>1</b> | Stopped and ready | <b>7</b> | Soft stop (not used) | <b>2</b> | Motion imminent: waiting for start | <b>8</b> | Registration move (armed, not moving) | <b>3</b> | Accelerating | <b>9</b> | Home | <b>4</b> | At MAX speed | <b>10</b> | Following (not used) | <b>5</b> | Decelerating to new MAX speed | <b>128-255</b> | Error (not used) |
| Value    | Description  | Value          | Description                           |       |             |          |                      |          |                      |          |                   |          |                      |          |                                    |          |                                       |          |              |          |      |          |              |           |                      |          |                               |                |                  |
| <b>0</b> | Axis not initialized   | <b>6</b>       | Decelerating to stop                  |       |             |          |                      |          |                      |          |                   |          |                      |          |                                    |          |                                       |          |              |          |      |          |              |           |                      |          |                               |                |                  |
| <b>1</b> | Stopped and ready  | <b>7</b>       | Soft stop (not used)                  |       |             |          |                      |          |                      |          |                   |          |                      |          |                                    |          |                                       |          |              |          |      |          |              |           |                      |          |                               |                |                  |
| <b>2</b> | Motion imminent: waiting for start   | <b>8</b>       | Registration move (armed, not moving) |       |             |          |                      |          |                      |          |                   |          |                      |          |                                    |          |                                       |          |              |          |      |          |              |           |                      |          |                               |                |                  |
| <b>3</b> | Accelerating   | <b>9</b>       | Home                                  |       |             |          |                      |          |                      |          |                   |          |                      |          |                                    |          |                                       |          |              |          |      |          |              |           |                      |          |                               |                |                  |
| <b>4</b> | At MAX speed   | <b>10</b>      | Following (not used)                  |       |             |          |                      |          |                      |          |                   |          |                      |          |                                    |          |                                       |          |              |          |      |          |              |           |                      |          |                               |                |                  |
| <b>5</b> | Decelerating to new MAX speed  | <b>128-255</b> | Error (not used)                      |       |             |          |                      |          |                      |          |                   |          |                      |          |                                    |          |                                       |          |              |          |      |          |              |           |                      |          |                               |                |                  |
| 15bx4    | <b>Integral Error</b> (count-seconds), R only ( <b>not supported</b> )   |                |                                       |       |             |          |                      |          |                      |          |                   |          |                      |          |                                    |          |                                       |          |              |          |      |          |              |           |                      |          |                               |                |                  |

| 15bx5          | <b>Velocity Feedforward, also used to specify the Output in Direct mode</b> [QuickBuilder reference = QS2_VAR_NEW_VEL_FEEDFORWARD], output in direct mode not supported, use Analog Output instead (15bx9).   |            |                         |            |             |                |                      |          |         |          |      |          |         |          |       |          |                         |          |      |          |          |
|----------------|---|------------|-------------------------|------------|-------------|----------------|----------------------|----------|---------|----------|------|----------|---------|----------|-------|----------|-------------------------|----------|------|----------|----------|
| 15bx6          | <b>Deceleration</b> (counts/sec <sup>2</sup> ), R only [QuickBuilder reference = QS2_NEW_DECELERATION]  |            |                         |            |             |                |                      |          |         |          |      |          |         |          |       |          |                         |          |      |          |          |
| 15bx7          | <p><b>Dedicated Inputs, R only:</b></p> <p><b>This is a bit map of the input signals</b></p> <table border="1"> <thead> <tr> <th>Bit Number</th> <th>Description</th> <th>Bit Number</th> <th>Description</th> </tr> </thead> <tbody> <tr> <td><b>0 (lsb)</b></td> <td>Reg. (not supported)</td> <td><b>4</b></td> <td>Rev EOT</td> </tr> <tr> <td><b>1</b></td> <td>Home</td> <td><b>5</b></td> <td>Fwd EOT</td> </tr> <tr> <td><b>2</b></td> <td>Start</td> <td><b>6</b></td> <td>Z/Index (not supported)</td> </tr> <tr> <td><b>3</b></td> <td>Kill</td> <td><b>7</b></td> <td>Not Used</td> </tr> </tbody> </table> | Bit Number | Description             | Bit Number | Description | <b>0 (lsb)</b> | Reg. (not supported) | <b>4</b> | Rev EOT | <b>1</b> | Home | <b>5</b> | Fwd EOT | <b>2</b> | Start | <b>6</b> | Z/Index (not supported) | <b>3</b> | Kill | <b>7</b> | Not Used |
| Bit Number     | Description   | Bit Number | Description             |            |             |                |                      |          |         |          |      |          |         |          |       |          |                         |          |      |          |          |
| <b>0 (lsb)</b> | Reg. (not supported)  | <b>4</b>   | Rev EOT                 |            |             |                |                      |          |         |          |      |          |         |          |       |          |                         |          |      |          |          |
| <b>1</b>       | Home  | <b>5</b>   | Fwd EOT                 |            |             |                |                      |          |         |          |      |          |         |          |       |          |                         |          |      |          |          |
| <b>2</b>       | Start   | <b>6</b>   | Z/Index (not supported) |            |             |                |                      |          |         |          |      |          |         |          |       |          |                         |          |      |          |          |
| <b>3</b>       | Kill  | <b>7</b>   | Not Used                |            |             |                |                      |          |         |          |      |          |         |          |       |          |                         |          |      |          |          |
| 15bx8          | <b>Acceleration Feedforward</b> [QuickBuilder reference = QS2_VAR_NEW_ACC_FEEDFORWARD]  |            |                         |            |             |                |                      |          |         |          |      |          |         |          |       |          |                         |          |      |          |          |
| 15bx9          | <b>Analog Output, RW</b> -32,767 = -10.000V; 32,767 = 10.000V [QuickBuilder reference = rint(dac_mv * 3.2767)]. On 2219 this is read only and Velocity Feedforward is written to for Analog Output.   |            |                         |            |             |                |                      |          |         |          |      |          |         |          |       |          |                         |          |      |          |          |
| 16bx0          | <b>Reg. Start, RW</b> – Position at which the registration will be enabled [QuickBuilder reference = QS2_CAP_WINSTART]  |            |                         |            |             |                |                      |          |         |          |      |          |         |          |       |          |                         |          |      |          |          |
| 16bx1          | <b>Reg. Window, RW</b> – The range that the registration will be enabled [QuickBuilder reference = QS2_CAP_WINEND_REL]  |            |                         |            |             |                |                      |          |         |          |      |          |         |          |       |          |                         |          |      |          |          |
| 16bx2          | <b>Reg. Position, R only</b> – The position at which the registration was detected, when Reg status is 1 [QuickBuilder reference = cappoc]  |            |                         |            |             |                |                      |          |         |          |      |          |         |          |       |          |                         |          |      |          |          |
| 16bx3          | <b>Reg. Offset, RW</b> – The distance to be moved after the registration input [QuickBuilder reference = QS2_CAP_WINOFFSET]   |            |                         |            |             |                |                      |          |         |          |      |          |         |          |       |          |                         |          |      |          |          |
| 16bx4          | <b>Reg. Status, RW</b> – 0 = Armed (write 0 to arm), 1 = Detected, can only set to 0 [QuickBuilder reference = QS2_REG_STATUS]  |            |                         |            |             |                |                      |          |         |          |      |          |         |          |       |          |                         |          |      |          |          |
| 16bx5          | <b>Numerator, RW</b> – For following the master axis [QuickBuilder reference = QS2_VAR_MTN]   |            |                         |            |             |                |                      |          |         |          |      |          |         |          |       |          |                         |          |      |          |          |
| 16bx6          | <b>Denominator, RW</b> – For following the master axis [QuickBuilder reference = QS2_VAR_MTD]   |            |                         |            |             |                |                      |          |         |          |      |          |         |          |       |          |                         |          |      |          |          |
| 16bx7          | <b>Leader Position, R only</b> – Only valid when following a master axis (not supported)  |            |                         |            |             |                |                      |          |         |          |      |          |         |          |       |          |                         |          |      |          |          |
| 16bx8          | <b>Leader Velocity, R only</b> – Only valid when following a master axis (not supported)  |            |                         |            |             |                |                      |          |         |          |      |          |         |          |       |          |                         |          |      |          |          |
| 16bx9          | Reserved  |            |                         |            |             |                |                      |          |         |          |      |          |         |          |       |          |                         |          |      |          |          |
| 17bx0          | <b>Firmware Revision, R only</b>  |            |                         |            |             |                |                      |          |         |          |      |          |         |          |       |          |                         |          |      |          |          |
| 17bx1          | <b>Filter &amp; Mode, RW:</b>   |            |                         |            |             |                |                      |          |         |          |      |          |         |          |       |          |                         |          |      |          |          |

|  | <p>In Direct mode the Feedforward Velocity gain specifies the output value (0 to 32767) with a value of 32767 = 10V (sign depends on the Filter type).<br/>                 [QuickBuilder reference = QS2_FILTER_MODE]</p> <table border="1"> <thead> <tr> <th>Description</th> <th>Value</th> </tr> </thead> <tbody> <tr> <td><b>Lower 3 bits (0x07) Filter type</b></td> <td>0 or 3 = PID<br/>                     1 = + Direct (CW)      2 = - Direct (CCW)<br/>                     4 = PAVff      5 = PAV<br/>                     6 = Stepper      7 = Initialize Encoder Resolution</td> </tr> <tr> <td><b>Bits 4 &amp; 5 Accel/Decel Type</b></td> <td>0 = Linear      1 = S Curve<br/>                     2 = Parabolic      3 = Inverse-Parabolic</td> </tr> <tr> <td><b>Bit 7 (0x80)</b></td> <td>0=Trajectory Following<br/>                     1 (value 128) = Encoder Following</td> </tr> </tbody> </table> <p>Note: Initialize Encoder Resolution, filter type 7 is only a temporary mode that can be applied anytime there is no motion. It is recommended this be done prior to initial motion. This can be used to override the default ppr, mppr, and sppr. Upon writing this value the following registers will be initialized as follows, thus set accordingly prior to execution:</p> <p>ppr = QS2_VAR_NEW_VEL_FEEDFORWARD<br/>                 mppr = QS2_VAR_NEW_ACC_FEEDFORWARD<br/>                 sppr = QS2_NEW_DECELERATION</p> <p>After changing the above variables set them back to their previous values and set the Filter Mode to the proper mode for motion desired.</p> | Description | Value                   | <b>Lower 3 bits (0x07) Filter type</b> | 0 or 3 = PID<br>1 = + Direct (CW)      2 = - Direct (CCW)<br>4 = PAVff      5 = PAV<br>6 = Stepper      7 = Initialize Encoder Resolution | <b>Bits 4 &amp; 5 Accel/Decel Type</b> | 0 = Linear      1 = S Curve<br>2 = Parabolic      3 = Inverse-Parabolic | <b>Bit 7 (0x80)</b> | 0=Trajectory Following<br>1 (value 128) = Encoder Following |          |      |          |         |          |       |          |                         |          |      |          |          |
|--|---|-------------|-------------------------|--|---|--|---|---------------------|---|----------|------|----------|---------|----------|-------|----------|-------------------------|----------|------|----------|----------|
| Description                            | Value   |             |                         |  |   |  |   |                     |   |          |      |          |         |          |       |          |                         |          |      |          |          |
| <b>Lower 3 bits (0x07) Filter type</b> | 0 or 3 = PID<br>1 = + Direct (CW)      2 = - Direct (CCW)<br>4 = PAVff      5 = PAV<br>6 = Stepper      7 = Initialize Encoder Resolution   |             |                         |  |   |  |   |                     |   |          |      |          |         |          |       |          |                         |          |      |          |          |
| <b>Bits 4 &amp; 5 Accel/Decel Type</b> | 0 = Linear      1 = S Curve<br>2 = Parabolic      3 = Inverse-Parabolic   |             |                         |  |   |  |   |                     |   |          |      |          |         |          |       |          |                         |          |      |          |          |
| <b>Bit 7 (0x80)</b>                    | 0=Trajectory Following<br>1 (value 128) = Encoder Following   |             |                         |  |   |  |   |                     |   |          |      |          |         |          |       |          |                         |          |      |          |          |
| <p>17bx2</p>                           | <p><b>Input Polarity, RW:</b></p> <p>This is a bit map that controls the active level of the input signals,. When the bit is 0 then the input is active when it is On; if the bit is 0 then the input is active Off.</p> <table border="1"> <thead> <tr> <th>Bit Number</th> <th>Description</th> <th>Bit Number</th> <th>Description</th> </tr> </thead> <tbody> <tr> <td><b>0 (lsb)</b></td> <td>Reg. (not supported)</td> <td><b>4</b></td> <td>Rev EOT</td> </tr> <tr> <td><b>1</b></td> <td>Home</td> <td><b>5</b></td> <td>Fwd EOT</td> </tr> <tr> <td><b>2</b></td> <td>Start</td> <td><b>6</b></td> <td>Z/Index (not supported)</td> </tr> <tr> <td><b>3</b></td> <td>Kill</td> <td><b>7</b></td> <td>Not Used</td> </tr> </tbody> </table>  | Bit Number  | Description             | Bit Number                             | Description   | <b>0 (lsb)</b>                         | Reg. (not supported)  | <b>4</b>            | Rev EOT   | <b>1</b> | Home | <b>5</b> | Fwd EOT | <b>2</b> | Start | <b>6</b> | Z/Index (not supported) | <b>3</b> | Kill | <b>7</b> | Not Used |
| Bit Number                             | Description   | Bit Number  | Description             |  |   |  |   |                     |   |          |      |          |         |          |       |          |                         |          |      |          |          |
| <b>0 (lsb)</b>                         | Reg. (not supported)  | <b>4</b>    | Rev EOT                 |  |   |  |   |                     |   |          |      |          |         |          |       |          |                         |          |      |          |          |
| <b>1</b>                               | Home  | <b>5</b>    | Fwd EOT                 |  |   |  |   |                     |   |          |      |          |         |          |       |          |                         |          |      |          |          |
| <b>2</b>                               | Start   | <b>6</b>    | Z/Index (not supported) |  |   |  |   |                     |   |          |      |          |         |          |       |          |                         |          |      |          |          |
| <b>3</b>                               | Kill  | <b>7</b>    | Not Used                |  |   |  |   |                     |   |          |      |          |         |          |       |          |                         |          |      |          |          |
| <p>17bx3</p>                           | <p><b>Home Direction, RW</b> [QuickBuilder reference = QS2_HOME]</p> <table border="1"> <thead> <tr> <th>Direction</th> <th>Description</th> </tr> </thead> <tbody> <tr> <td><b>CCW</b></td> <td>0 or -1 = Home &amp; Index<br/>                     -2 = Home Only<br/>                     -3 = Index Only (not supported)</td> </tr> </tbody> </table>  | Direction   | Description             | <b>CCW</b>                             | 0 or -1 = Home & Index<br>-2 = Home Only<br>-3 = Index Only (not supported)   |  |   |                     |   |          |      |          |         |          |       |          |                         |          |      |          |          |
| Direction                              | Description   |             |                         |  |   |  |   |                     |   |          |      |          |         |          |       |          |                         |          |      |          |          |
| <b>CCW</b>                             | 0 or -1 = Home & Index<br>-2 = Home Only<br>-3 = Index Only (not supported)   |             |                         |  |   |  |   |                     |   |          |      |          |         |          |       |          |                         |          |      |          |          |

|           |  |           |   |
|-----------|--|-----------|---|
|           | <table border="1"> <tr> <td style="text-align: center;"><b>CW</b></td> <td>           1 = Home &amp; Index<br/>           2 = Home Only<br/>           3 = Index Only (not supported)         </td> </tr> </table> | <b>CW</b> | 1 = Home & Index<br>2 = Home Only<br>3 = Index Only (not supported) |
| <b>CW</b> | 1 = Home & Index<br>2 = Home Only<br>3 = Index Only (not supported)  |           |   |
| 17bx4     | <b>Options</b> , R only (not supported)  |           |   |
| 17bx5     | <b>Reserved</b>  |           |   |
| 17bx6     | <b>Maximum Following Error, RW</b> default = 30000 [QuickBuilder reference = perlimit * ppr]   |           |   |
| 17bx7     | <b>Speed Limit, RW</b> – overrides maximum velocity, default = 4194303 steps/sec (not supported)   |           |   |
| 17bx8     | <b>Maximum Position, RW</b> – Used as a Software EOT when it is larger than the Minimum Position (not supported)   |           |   |
| 17bx9     | <b>Minimum Position, RW</b> – Used as a Software EOT when it is smaller than the Maximum Position (not supported)  |           |   |

## 7.2 Quickstep Variables

| Quickstep Variables          | Description   | Type       |
|------------------------------|---|------------|
| QS2_Status                   | Axis status as defined by register 143xx.   | read-write |
| QS2_Cmd                      | Command to be processed by the MSB, emulates 2700 2219 module.  | read-write |
| QS2_Overrides                | Override commands that can be processed by the MSB during motion without a fault.                     | read-write |
| QS2_Holding                  | Holding command to be processed by the MSB.   | read-write |
| QS2_Params                   | Parameter command to be processed by the MSB. Written once any 'VAR_NEW' variables are updated.       | read-write |
| QS2_VAR_NEW_ACCELERATION     | X value for selected debugTableRow.   | read-write |
| QS2_VAR_NEW_MAX_SPEED        | Y value for selected debugTableRow.   | read-write |
| QS2_VAR_NEW_PROPORTIONAL     | Requested new kd, processed by MSB as required. This is also written to by the QS2 profile statement. | read-write |
| QS2_VAR_NEW_INTEGRAL         | Requested new ki, processed by MSB as required. This is also written to by the QS2 profile statement. | read-write |
| QS2_VAR_NEW_DIFFERENTIAL     | Requested new kd, processed by MSB as required. This is also written to by the QS2 profile statement. | read-write |
| QS2_VAR_NEW_VEL_FEEDFORWARD  | Processed by MSB application.   | read-write |
| QS2_VAR_NEW_HOLDING_MODE     | Processed by MSB application.   | read-write |
| QS2_VAR_NEW_DECELERATION     | Processed by MSB application.   | read-write |
| QS2_VAR_NEW_FORCE_POSITION   | Processed by MSB application.   | read-write |
| QS2_VAR_NEW_FORCE_CUMULATIVE | Processed by MSB application. Not currently used.   | read-write |
| QS2_CAP_WINSTART             | Processed by MSB application.   | read-write |
| QS2_CAP_WINEND_REL           | Processed by MSB application.   | read-write |

| Quickstep Variables         | Description   | Type       |
|-----------------------------|---|------------|
| QS2_CAP_WINOFFSET           | Processed by MSB application.   | read-write |
| QS2_VAR_NEW_ACC_FEEDFORWARD | Processed by MSB application.   | read-write |
| QS2_HOME                    | Processed by MSB application.   | read-write |
| QS2_VAR_MTN                 | Processed by MSB application.   | read-write |
| QS2_VAR_MTD                 | Processed by MSB application.   | read-write |
| QS2_LAST_CMD                | Last QS2_Cmd processed.   | read-write |
| QS2_CMD_CNT                 | Number of QS2_Cmd's processed.  | read-write |
| QS2_OVERRIDE_CNT            | Number of override commands processed.  | read-write |
| QS2_HOLDING_CNT             | Number of holding commands processed.   | read-write |
| QS2_PARAM_CNT               | Number of parameter commands processed.   | read-write |
| QS2_MSB_STATE               | General scratch storage used by the MSB to write program execution state information. | read-write |
| QS2_FILTER_MODE             | Reference register 17bx1 for mode settings.   | read-write |
| QS2_TMP1                    | General scratch storage used by the MSB as needed (integer).                          | read-write |
| QS2_TMP2                    | General scratch storage used by the MSB as needed (integer).                          | read-write |
| QS2_TMP3                    | General scratch storage used by the MSB as needed (integer).                          | read-write |
| QS2_TMP4                    | General scratch storage used by the MSB as needed (integer)                           | read-write |
| QS2_REG_STATUS              | Registration status, write a 0 to arm, else read a 1 if detected.                     | read-write |
|                             |   |            |



### 7.3 Input Mapping (M3-40 Only)

M3-40A inputs are monitored by the QS2MSB MSB program and when executing the DIN inputs are monitored similar to a 2219. The inputs are mapped as:

- DIN1 - START
- DIN2 - REGISTRATION INPUT
- DIN3 - FWD LIMIT
- DIN4 - REV LIMIT
- DIN5 - HOME

## 8 Chapter 8: Fault Codes & MSB Debugging

Should an error occur several registers contain information which can be helpful in detecting what caused the problem. These registers exist for each axis:

| Fault Variables   | Description  | Type      |
|---|--|-----------|
| fault1<br>fault2 (not used)<br>fault3 (not used)<br>fault4 (not used) | Fault status words, reference Chapter 8.   | read-only |
| faulted   | 0 = no fault, 1 = faulted.   | read-only |
| faultFunction   | Code 0 to N which represents internal function where fault occurred.<br>Thus far defines as:<br>FGTick - 1<br>runMSB - 2<br>processMSB - 3<br>process_motion_command - 4<br>DP_MGRTask_Axis1 - 5<br>DP_MGRTask_Axis2 - 6<br>processVFC - 7 | read-only |
| faultMSB  | The MSB number from 0 to 31 which has faulted.   | read-only |
| faultMSBLine  | The line number as referenced to source code MSB where the fault occurred. Note that the source must be in sync with what is executing for this to be correct.   | read-only |
| faultMSBOffset  | Absolute byte offset into MSB binary opcode where was executing when fault occurred. Internal use.   | read-only |
| faultOpcode   | MSB opcode that was being executed when fault occurred. Internal use.  | read-only |
|   |  |           |

## 8.1 Fault Codes

⚠ Note that firmware prior to V1.40 (M3-40A) use outdated fault codes. Changes were made to enhance diagnostic abilities.

| Fault Codes       | Description                                    | Code Value |
|-------------------|--|------------|
| MF_NO_ERROR       | No error.                                      | 0          |
| MF_GENERICFAULT   | Generic Motion Fault.                          | 1          |
| MF_INVALIDTIME    | Negative or Zero 'time' specified in MOVE.     | 2          |
| MF_INVALIDVEL     | Negative or Zero 'velocity' specified in MOVE. | 3          |
| MF_INVALIDACC     | Negative or Zero 'acc' specified in MOVE.      | 4          |
| MF_INVALIDDEC     | Negative or Zero 'dec' specified in MOVE.      | 5          |
| MF_INVALIDRATE    | Negative or Zero 'rate' specified in MOVE.     | 6          |
| MF_ONLYINBG       | QM command only allowed in BG MSB.             | 7          |
| MF_MOTIONACTIVE   | MOVE attempted while MOVE in progress.         | 8          |
| MF_UNIMPLEMENTED  | MOVE attempted while MOVE in progress.         | 9          |
| MF_WRONGMODE      | In wrong mode (positioning/tracking/slewing.   | 10         |
| MF_FGMSBLIMIT     | FG MSB limit reached.                          | 11         |
| MF_NOTINSLEW      | Not in SLEW mode.                              | 12         |
| MF_FOLLOWERR      | Following error limit reached.                 | 13         |
| MF_BADINPUTNO     | Invalid input number specified.                | 14         |
| MF_NOTENABLED     | Not enabled.                                   | 15         |
| MF_BADARGUMENT1   | Bad argument 1/parameter.                      | 16         |
| MF_INVALID_TBL_OP | Invalid 'table' operation.                     | 17         |

| Fault Codes       | Description                            | Code Value |
|-------------------|--|------------|
| MF_NOTINTRACK     | Not in 'tracking' mode.                | 18         |
| MF_CANTCONSUME    | Illegal state for 'consume'.           | 19         |
| MF_SESGMOVE_ERROR | 'Segmented Move' error.                | 20         |
| MF_SESGMOVE_SIZE  | 'Segment size' error, too many.        | 21         |
| MF_NOCAMFILE      | Requested CAM file not found.          | 22         |
| MF_REMOTE_READ    | Read of controller register failed.    | 23         |
| MF_REMOTE_WRITE   | Write of controller register failed.   | 24         |
| MF_NOMSBFILE      | MSB file does not exist on flash disk. | 25         |
| MF_BADARGUMENT2   | Bad argument2/parameter.               | 26         |
| MF_BADARGUMENT3   | Bad argument3/parameter.               | 27         |
| MF_BADARGUMENT4   | Bad argument4/parameter.               | 28         |
|                   |  |            |

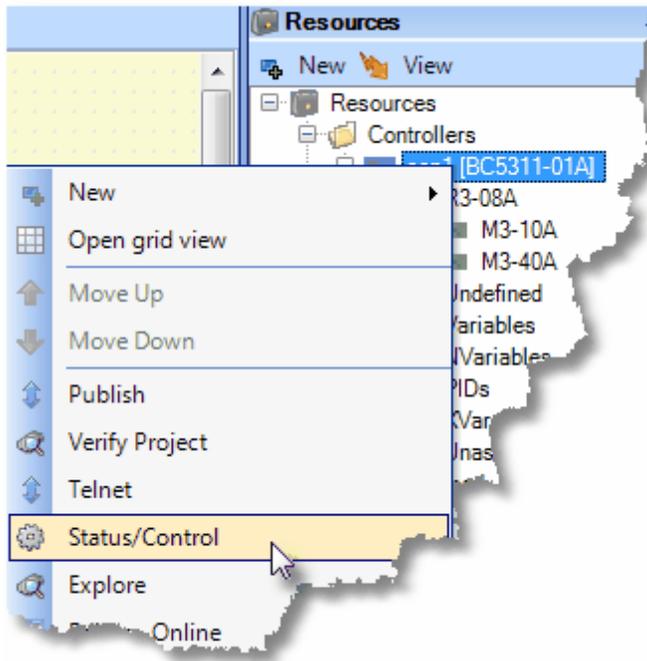
| Additional EtherCAT Only Fault Codes | Description   | Code Value |
|--------------------------------------|---|------------|
| MF_SDO_READ                          | EtherCAT SDO read failed. Either network error or object not supported by device.                   | 29         |
| MF_SDO_WRITE                         | EtherCAT SDO write Failed. Either network error or object not supported by device.                  | 30         |
| MF_DRIVE_ERR_MSG                     | Generic drive error message.  | 31         |
| MF_ECOT_OFFLINE                      | EtherCAT is offline   | 32         |
| MF_DCSYNC                            | Execution of DCSync instruction failed. Drive may be offline or not support objects.                | 33         |
| MF_INVALID_ECOT_MODE                 | Attempted to set a mode (cmode) the drive does not support. Typically CSP mode is used generically. | 34         |

| Additional EtherCAT Only Fault Codes | Description   | Code Value |
|--------------------------------------|---|------------|
| MF_STACK_ERROR                       | MSB instruction execution error, attempted to pop a variable off the stack and it was not there?  | 35         |
| MF_READONLY                          | Trying to write to a read only variable.  | 36         |
| MF_INVALID_TBL_OP_Y                  | Attempted to address more tables than available on Y axis.  | 37         |
| MF_INVALID_TBL_OP_Z                  | Attempted to address more tables than available on Z axis.  | 38         |
| MF_INVALID_TRACKING                  | Attempted an invalid instruction while in tracking mode. Typically beginning slew.  | 39         |
| MF_TIMEOUT                           | IncentiveECAT API:<br><br>Error occurring while waiting for in-position and have a timeout occur.   | 40         |
| MF_ERROR_NO_SERVO                    | IncentiveECAT API:<br><br>Error occurring while attempting to read or write to an axis that does not exist.   | 41         |
| MF_ABORT_REQUESTED                   | IncentiveECAT API:<br><br>Error occurring while executing an API command and the user application requested an ABORT occur, restarting the network. | 42         |
| MF_ERROR_OO_RANGE                    | Incentive ECAT API:<br><br>Error occurring while attempting to online/offline an invalid axis #.  | 43         |
| MF_ERROR_INIT_CONFIG                 | Incentive ECAT API:<br><br>Attempting to online an offline axis and it failed while initializing the configuration.                                 | 44         |
| MF_ERROR_NO_INIT                     | Incentive ECAT API:<br><br>Attempting to online an offline axis and it failed while trying to place it in the EtherCAT INIT state.                  | 45         |
| MF_ERROR_NO_PREOP                    | Incentive ECAT API:<br><br>Attempting to online an offline axis and it failed while trying to place it in the EtherCAT PRE-OP state.                | 46         |
| MF_ERROR_NO_SAFEOP                   | Incentive ECAT API:   | 47         |

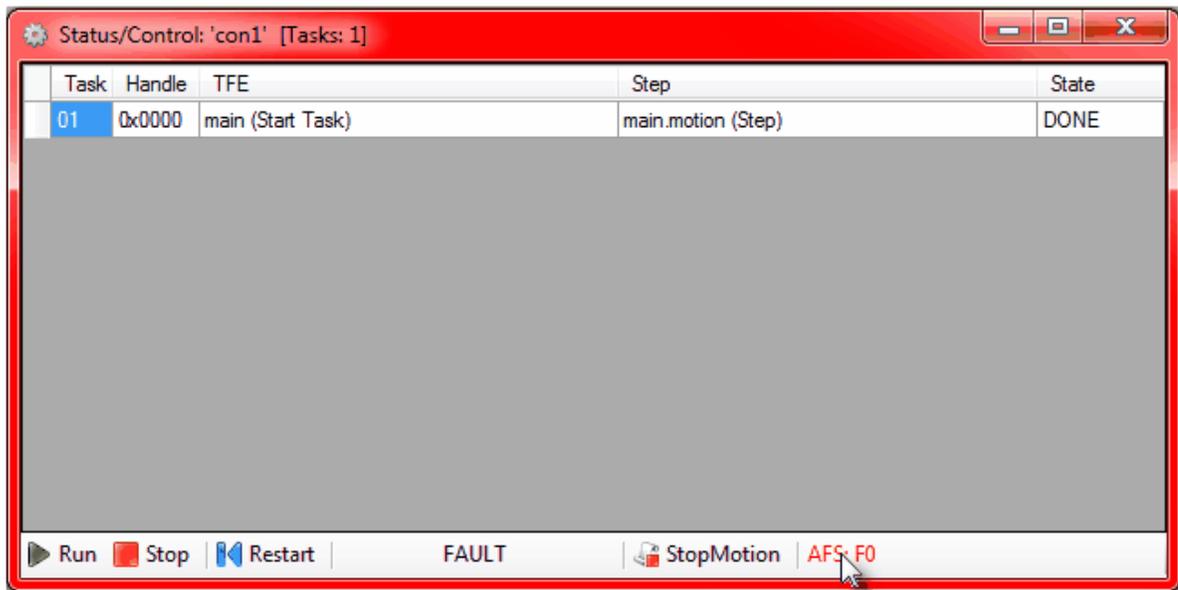
| Additional EtherCAT Only Fault Codes | Description   | Code Value |
|--------------------------------------|---|------------|
|                                      | Attempting to online an offline axis and it failed while trying to place it in the EtherCAT SAFEOP state.   |            |
| MF_ERROR_NO_OPERATIONAL              | Incentive ECAT API:<br><br>Attempting to online an offline axis and it failed while trying to place it in the EtherCAT OPERATIONAL state.   | 48         |
| MF_ERROR_INIT_PDO                    | Incentive ECAT API:<br><br>Attempting to online an offline axis and it failed while trying to initialize the PDO mapping.   | 49         |
| MF_ERROR_REMAP_CONFIG                | Incentive ECAT API:<br><br>Attempting to online an offline axis and it failed while trying to remap the configuration.  | 50         |
| MF_ERROR_DC_RESTORE                  | Incentive ECAT API:<br><br>Attempting to online an offline axis and it failed while trying to restore propagation delay.  | 51         |
| MF_ERROR_DC_SYNC01                   | Incentive ECAT API:<br><br>Attempting to online an offline axis and it failed while trying to setup DC Sync (some drives require DC Sync operational before the drive is fully in the OPERATIONAL state). | 52         |
| MF_ERROR_ILLEGAL_VAL                 | Incentive ECAT API:<br><br>Attempting to online an offline axis and it is no longer available in the drive table.   | 53         |
| MF_ERROR_NOT_ONLINE                  | Incentive ECAT API:<br><br>Attempting to online an offline axis and it is no longer available. Probably still offline.  | 54         |

## 8.2 MSB Status/Control Monitor Fault Processing

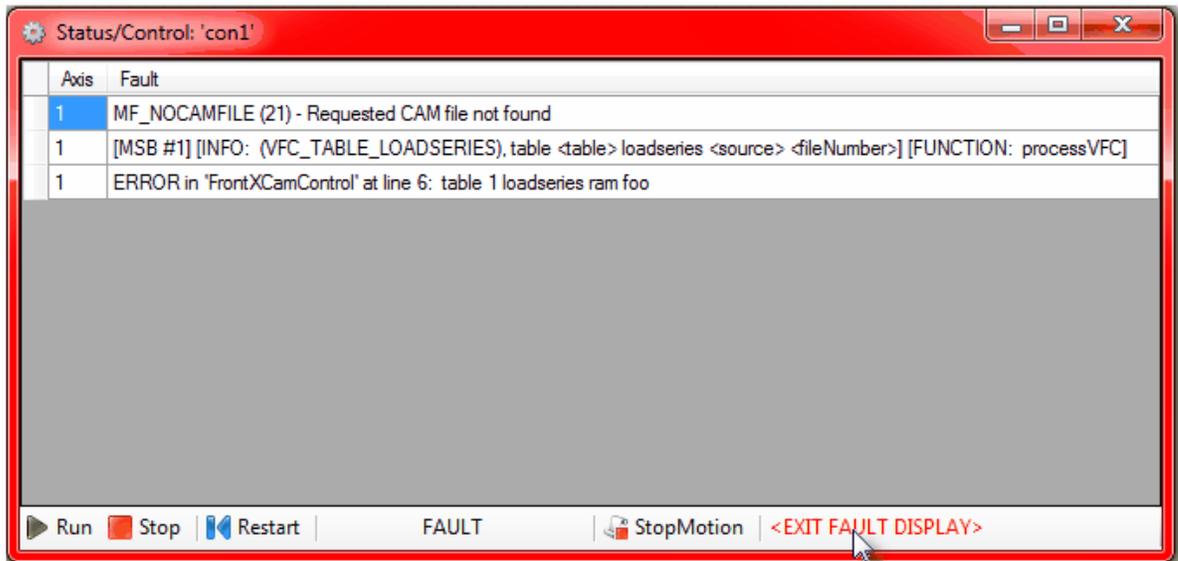
There are a number of features within QuickBuilder to enable the debugging of QuickMotion MSB's. This can be either during normal operation or should a fault occur. A fault is indicate by a flashing FLT LED on the controller CPU. To observe a QuickMotion fault the Status/Control monitor can be viewed:



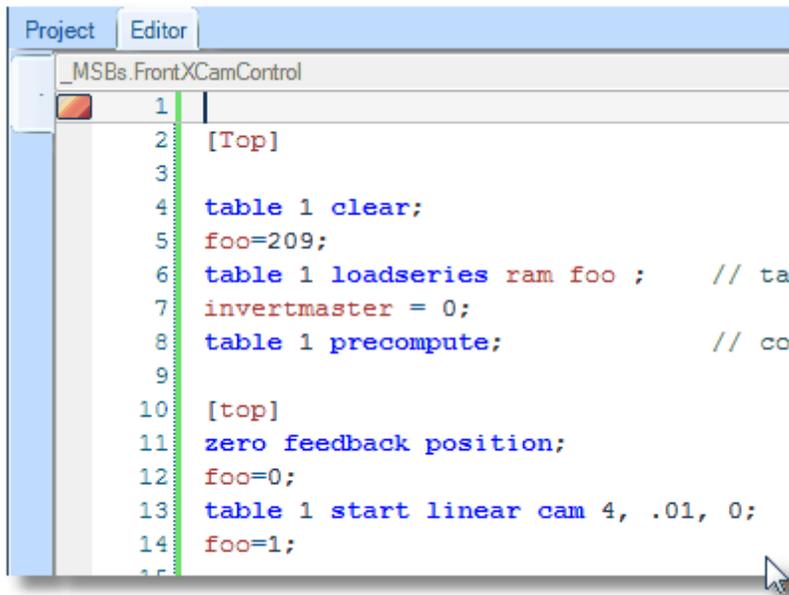
Once the Status/Control window appears observe and click the AFS text. Note that each character represents an axis, with the first on the far left. In the example below a 0 means the axis is OK, F that there is a fault. Below shows a fault on axis 1 since it is 'F'.



Once clicked detailed information about the fault will be shown, if available:



Note that the error occurred at line 6 of the source code of the FrontXCamControl MSB. In referencing that MSB we can see the line listed, 'table 1 loadseries ram foo' as being the problem. In this case there was no camtable209 file present within the controller flash disk.:



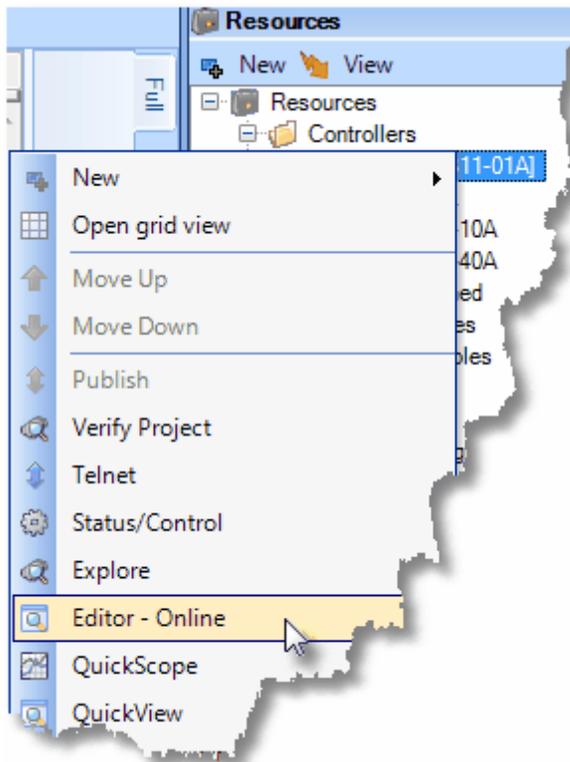
```

Project Editor
_MSBs.FrontXCamControl
1
2 [Top]
3
4 table 1 clear;
5 foo=209;
6 table 1 loadseries ram foo ; // ta
7 invertmaster = 0;
8 table 1 precompute; // co
9
10 [top]
11 zero feedback position;
12 foo=0;
13 table 1 start linear cam 4, .01, 0;
14 foo=1;
15

```

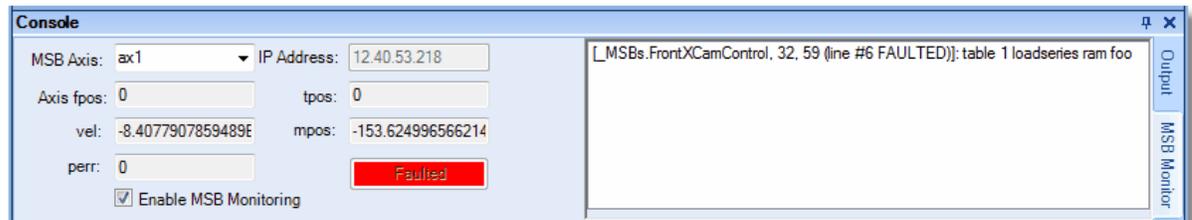
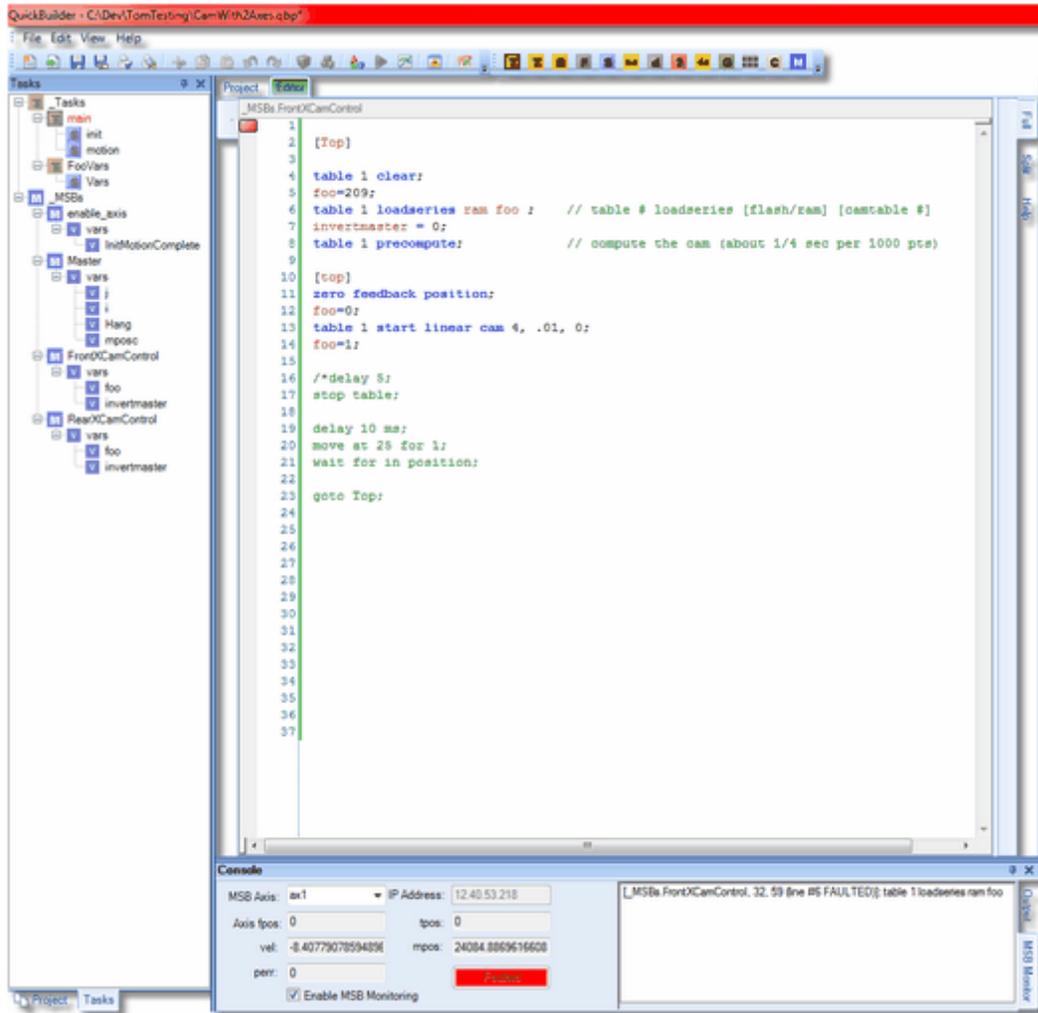
### 8.3 MSB Monitor

QuickBuilder offers a MSB Monitor when online in the Editor mode.



This monitor periodically (about every second) refreshes axis information for display. Current fpos, mpos, vel, tpos and perr are available as well as the instruction and state of MSB's that are executing. A pull down combo box lists all available axis, that selected is what will be automatically refreshed.

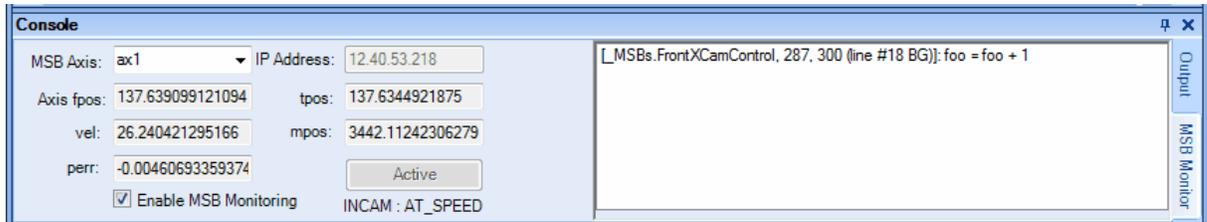
If the axis is faulted, using the example from the 'MSB Status/Control Monitor Fault Processing' section, the following will appear:



⚠ Note that the 'Enable MSB Monitoring' check box must be checked for monitoring to be active. Also the Editor tab should be green to indicate online debug mode.

⚠ Double clicking on the MSB line appearing in the list box will automatically make that code and line current in the Editor.

In situations where a fault had not occurred multiple MSB's would appear executing, as well as their line number and axis motion status:



## 9 Appendix: Sample Code

**⚠WARNING:** The following examples are offered for training purposes only and are not intended to perform any actual real-world application or function.

```
// ----- Pause Motion MSB -----

/* This MSB will pause motion by moving the timebase to 0
and then back to 1 based on switch 3 position.
Note: that changes to the timebase variable only impact
the actual motion commands other MSB commands such as
delay are not altered. */

[top]
    wait for rise of 3;           // wait for rising edge of input3
    timebase=0;                 // set the motion timebase to zero
    wait for fall of 3;         // wait for falling edge of input3
    timebase=1;                 // put timebase back to 100%
    goto top;                   // repeat

end;

// ----- Jog MSB -----

/* This MSB performs a simple jogging routine
The variable JogSpeed is passed to this MSB to set
the jog velocity. If switch 1 is on a positive Jog
is activated, if switch 5 is on a negative Jog is activated;
if neither 1 or 5 are on zero speed is commanded, and the
motor stops. */

JogSpeed=1;                     // set a default jog speed

slew begin;                     // witch to slewing mode

[loop]
    // check the switches
    if !din1 && !din5 then speed=0;
    if din1 then speed = JogSpeed;
    if din5 then speed = -JogSpeed;

    slew at speed in 0.5;       // slew to speed in .5 sec
    delay 510;                 // wait 510 ms until at speed

    if !din2 goto loop;        // as long as input 2 is off loop

    slew end;                 // return to position mode

end;
```

```
// ----- Home via Z MSB -----

// add a move to switch code here if needed

foundz = 0;
// set zdir to 1 to search in the positive dir
// set zdir to -1 to search in the negative dir
zdir = -1;

// check if we know where the Z-pulse is
if zpulse goto knownz;

// dont know where z is, so...
// move positive for +/- 2 revs looking for it
zero feedback position;
move in 0.25 for zdir*2;

[searchloop]
// a z while moving?
// check the zpulse variable (1 if a z pulse has been seen)
if zpulse goto foundmid;
// done?
if !inpos goto searchloop;
// no z, stop and quit
stop;
end;

// found a z mid move, so stop
[foundmid]
new endposition relative 0 using 10000;
wait for in position;

// move to z
[knownz]

// find the Z that is closest
if zdir > 0 goto posz;

[negz]
move in 0.125 to ZPULSE_NEG;
goto exit;

[posz]
move in 0.125 to ZPULSE_POS;
goto exit;

[exit]
wait for in position;
zero feedback position;
```

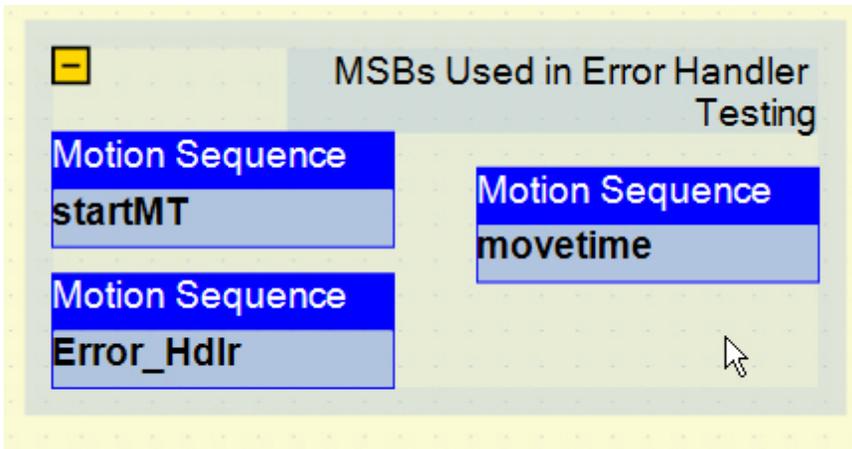
```

foundz = 1;
end;

// ----- Error Handler Example -----

```

The following MSBs illustrate how an error handler can be used on a motion axis. The code for each is given below with a brief explanation.



**startMT MSB:** This MSB starts the asynchronous event handler. In this case Error\_Hdlr will automatically be called whenever there is a hardfault.

```

on hardfault start Error_Hdlr;           //start an asynchronous event to
                                        //monitor for a hardfault error
start movetime FG;                       //now go do some motion

```

**Error\_Hdlr:** This MSB contains the error handler code. The comment at the end gives a listing of valid error codes

```

// Error handler example MSB

// Check for a fault
if fault1 == 0 goto genfault; //Generic Motion Fault
if fault1 == 1 goto invtime;  //Negative or Zero 'time' specified in MOVE
if fault1 == 2 goto invvel;   //Negative or Zero 'velocity' specified in
MOVE
                                        //(etc)continue on to trap
all errors if you want

goto unknown;                          // If you get here there's no
known fault code

[genfault]                               //routine for general fault goes
here
//(put code here)

```

```

[invtime]
// Invalid Time Fault: Trigger this error by setting move time to 0 in the
movetime MSB
    setout 5;                //turn on output to signal error
    delay 5000;              // wait 5 sec
    clrout 5;                // turn off output 5
    delay 1000;              // wait 1 sec
    reset;                   // reset all faults

    delay 1000;              // wait 1 sec
    start movetime FG;       //re-start the MSB. Hint if you don't change
                             the movetime
    //you'll end up right back here in six seconds.

[invvel]

    //(code)

[unknown]

    //(code)

end;

movetime MSB: This MSB contains a simple motion routine used to trigger a
hardfault

zero feedback position;

xm=1;                //default mode setting

// Do a repeating forward and back move
[top]

    time=0;                //reset timer
    move in time2 for dist mode xm; //move forward
    wait for in position;

    move in time2 for -dist mode xm; //move back
    wait for in position;
    movetime=time;        //update movetime

goto top;

```

## 10 Appendix: Command Hyperlinks

Statements:

[Utility](#)  
[Set](#)  
[Program Flow](#)  
[Common bits and variables](#)  
[I/O](#)  
[Simple Motion](#)  
[Gearing](#)  
[Position and Capture](#)  
[Loading Tables](#)  
[Spline/CAM](#)  
[Virtual Master](#)  
[Segmented Moves](#)  
[Host Register](#)

Utility Statements:

[stop { slewed using rate }](#)  
[drive enable](#)  
[drive disable](#)  
[delay time ms](#)  
[variable = expression](#)  
[zero feedback position](#)  
[zero target position](#)  
[zero following error](#)  
[reset](#)  
[if condition then variable = expression](#)  
[wait until condition](#)

Set Statements:

[set common bit number state](#)  
[set common var number value](#)  
[set looperiod value](#)  
[set mode positioning](#)  
[set mode tracking](#)  
[set timeout ticks](#)  
[set target position value](#)  
[set feedback position value](#)  
[set target position counts vcounts](#)  
[set feedback position counts vcounts](#)  
[set simulated feedback on/off](#)  
[offset position value](#)  
[offset position counts vcounts](#)  
[set master mode { using global }](#)

## Program Flow Statements:

[label]  
start MSB mode  
end { and start MSB mode }  
abort MSB  
goto label  
if condition goto label  
on asynchevent asynchhandler

## Common bits and variables Statements:

set common bit number state  
wait common bit number state  
set common var number value  
wait common var number range

## I/O Statements:

setout outputlist  
clrout outputlist  
pulse output for n  
pls output using reference definitions  
pls output state  
wait for transition of input { or condition }  
generate output output rate freq  
generate n steps on pair  
variable = ctr[n]  
ctr[n] = expression  
ctr[n] = offset  
generate alternate mode

## Simple Motion Statements:

move to position { using acc, dec }  
move at maxvelocity to position { using acc, dec }  
move trap to position using rate  
move in time to position {mode n }  
move for displacement { using acc, dec }  
move at maxvelocity for displacement { using acc, dec }  
move trap for displacement using rate  
move in time for displacement {mode n }  
wait for in position  
new endposition position using rate  
new endposition relative displacement using rate  
slew begin  
slew at velocity in time

slew for displacement

slew end

#### Gearing Statements:

gear at numerator : denominator

gear at numerator : denominator in counts

gear at numerator : denominator in counts after accounts

gear for slavecounts in mastercounts

gear for slavecounts in mastercounts after accounts

offset slave by slavecounts in time

wait master counts

wait slave counts

wait source within start , end

wait source outside start , end

zero masslv counters

#### Position and Capture Statements:

set capture transition of input input { gate input gateinput gatestate }

set capwin range start, end using reference { arm }

wait capture { if limit of limit goto limitlabel }

#### Loading Tables Statements:

table n clear

table n addpair xexpression , yexpression

table n addseries pairs

table n copy from rowOffset1 to table m rowOffset2 numRows

table n loadoffset rowOffsetFile, numPairs,rowOffsetTable

table n loadseries source fileNumber

#### Spline/CAM Statements:

table n continue

table n precompute

table n start imethod tscale , rpscale , repeatcount

table n start imethod cam mpscale , spscale , repeatcount

stop table

#### Virtual Master Statements:

move master at rate for limit { using ramp }

#### Segmented Move Statements:

segmove table clear

segmove table accdec to vel using rate  
segmove table accdec to vel for displacement  
segmove table slew until position  
segmove table stop at position using rate  
segmove table start relative

Host Register Statements:

host read variable, register {, row, column}  
host write variable, register {, row, column}

# Index

## - A -

axis module 23, 24  
 axis object: 23, 25  
 axis properties:  
   acc/dec 32  
   cmode 32, 107  
   driveenable 32  
   imposw 32  
   neglim/poslim 32  
   overnegin/overposin 32  
   perlimit 32  
   ppr 32  
   tmax 32, 107  
   uun/uud 32  
   vmax 32, 107  
 axis setup: 31  
   operating modes 37  
   positioning 37  
   slewing 37  
   tracking 37

## - C -

camming and data table commands:  
   loading tables 84  
   manipulating master position 95  
   manipulating tables 88  
   reading and writing data to/from tables 92  
   using data from Excel spreadsheets 94  
 camming and data tables: 81  
 command outputs 8  
 common bits 51  
 common variables 51

## - D -

document:  
   general info (QuickMotion Reference) 5  
   version number (QuickMotion Reference) 5

## - E -

encoders 8

## - F -

Fault Codes:

Codes, EtherCAT 151, 152, 153  
 Codes, General 150, 151  
 MF\_ABORT\_REQUESTED 152  
 MF\_BADARGUMENT1 150  
 MF\_BADARGUMENT2 151  
 MF\_BADARGUMENT3 151  
 MF\_BADARGUMENT4 151  
 MF\_BADINPUTNO 150  
 MF\_CANTCONSUME 151  
 MF\_DCSYNC 151  
 MF\_DRIVE\_ERR\_MSG 151  
 MF\_ECAT\_OFFLINE 151  
 MF\_ERROR\_DC\_RESTORE 153  
 MF\_ERROR\_DC\_SYNC01 153  
 MF\_ERROR\_ILLEGAL\_VAL 153  
 MF\_ERROR\_INIT\_CONFIG 152  
 MF\_ERROR\_INIT\_PDO 153  
 MF\_ERROR\_NO\_INIT 152  
 MF\_ERROR\_NO\_OPERATIONAL 153  
 MF\_ERROR\_NO\_PREOP 152  
 MF\_ERROR\_NO\_SAFEOP 152  
 MF\_ERROR\_NO\_SERVO 152  
 MF\_ERROR\_NOT\_ONLINE 153  
 MF\_ERROR\_OO\_RANGE 152  
 MF\_ERROR\_REMAP\_CONFIG 153  
 MF\_FGMSBLIMIT 150  
 MF\_FOLLOWERR 150  
 MF\_GENERICFAULT 150  
 MF\_INVALID\_ECAT\_MODE 151  
 MF\_INVALID\_TBL\_OP 150  
 MF\_INVALID\_TBL\_OP\_Y 152  
 MF\_INVALID\_TBL\_OP\_Z 152  
 MF\_INVALID\_TRACKING 152  
 MF\_INVALIDACC 150  
 MF\_INVALIDDEC 150  
 MF\_INVALIDRATE 150  
 MF\_INVALIDTIME 150  
 MF\_INVALIDVEL 150  
 MF\_MOTIONACTIVE 150

## Fault Codes:

|                   |     |
|-------------------|-----|
| MF_NO_ERROR       | 150 |
| MF_NOCAMFILE      | 151 |
| MF_NOMSBFILE      | 151 |
| MF_NOTENABLED     | 150 |
| MF_NOTINSLEW      | 150 |
| MF_NOTINTRACK     | 151 |
| MF_ONLYINBG       | 150 |
| MF_READONLY       | 152 |
| MF_REMOTE_READ    | 151 |
| MF_REMOTE_WRITE   | 151 |
| MF_SDO_READ       | 151 |
| MF_SDO_WRITE      | 151 |
| MF_SESGMOVE_ERROR | 151 |
| MF_SESGMOVE_SIZE  | 151 |
| MF_STACK_ERROR    | 152 |
| MF_TIMEOUT        | 152 |
| MF_UNIMPLEMENTED  | 150 |
| MF_WRONGMODE      | 150 |

**- I -**

icons used in this manual 7

interpolation, for splines and CAM tables:

|           |    |
|-----------|----|
| cubic     | 81 |
| linear    | 81 |
| quadratic | 81 |

**- K -**

knots 81

**- M -**

M3-40A servo module: 7, 10, 12, 24

|             |    |
|-------------|----|
| LED mapping | 15 |
| pinouts     | 15 |

M3-40B stepper module:

|             |    |
|-------------|----|
| LED mapping | 16 |
| pinouts     | 16 |

M3-40C stepper module:

|             |    |
|-------------|----|
| LED mapping | 17 |
| pinouts     | 17 |

M3-40D servo module 7

MF\_ERROR\_DC\_RESTORE 150

Model 5300 controller 10, 19, 28

motion control programming: 39, 44, 54, 62, 72, 76

and QuickStep 37

operators 38

motion control:

getting started 31

statements 27

tuning 33, 34, 35

tuning wizard 33, 34, 35

motion sequence blocks (MSBs): 10, 22, 23, 37

and QuickStep 105

background MSBs 26, 27

foreground MSBs 26, 27

sample code 159

variables 105, 107

**- P -**

positioning mode 37

programmable limit switch (PLS) 12

**- Q -**

QS4 (QuickStep4): 19, 21, 105

hardware compatibility 7

motion control statements 27

start statement 27

stop statement 27

QuickBuilder 19, 20

QuickMotion 19

QuickMotion commands:

abort 45

asynchronous event handling 46

clrout 54

counter = expression, offset 59

counter read, write, offset 59

delay 40

drive disable 40

drive enable 40

end 45

gear at (ratio) 72

gear at (ratio, counts) 72

gear for (slavecounts, mastercounts) 73

generate alternate mode (alternate/standard pins)  
60

generate output rate (pulse) 57

generate steps on (step/direction) 58

goto 45

host read 137

## QuickMotion commands:

host write 138  
 if/goto 46  
 if/then 42  
 move at (maxvelocity) for (displacement; trapezoidal) 65  
 move at (maxvelocity) to (position; trapezoidal) 63  
 move for (displacement; triangular) 65  
 move in (time) for (displacement; trapezoidal) 66  
 move in (time) to (position; trapezoidal) 64  
 move master at 95  
 move to (position; triangular) 62  
 move trap for (displacement; trapezoidal) 66  
 move trap to (position; trapezoidal) 63  
 new endposition (position or displacement) 67  
 offset position 49  
 offset slave (position) 73  
 on 46  
 pls (output) on/off 56  
 pls (output) using 55  
 pulse (output) for 55  
 reset 42  
 segmove <n> accdec...rate 98  
 segmove <table> accdec...disp 99  
 segmove <table> clear 98  
 segmove <table> slew 99  
 segmove <table> start relative 100  
 segmove <table> stop 99  
 set capture (registration input) 76  
 set capwin range (start, end) 76  
 set common bit 52  
 set common var 53  
 set feedback position 49  
 set looperperiod 48  
 set master source 50  
 set mode positioning 48  
 set mode tracking 49  
 set simulated feedback 49  
 set target position 49  
 set timeout 40  
 setout 54  
 slew begin 69  
 slew end 70  
 slew for (displacement) 70  
 start 44  
 statement 44

stop 39  
 stop table 91  
 table <n> addpair 84  
 table <n> addseries 85  
 table <n> clear 84  
 table <n> continue 88  
 table <n> copy 85  
 table <n> loadoffset 86  
 table <n> loadseries 86  
 table <n> precompute 88  
 table <n> start <imethod> <tscale>... 89  
 table <n> start <imethod> cam... 90  
 variable assignment (to expression) 41  
 wait capture (registration input) 77  
 wait common bit 53  
 wait for (transition) of (input) 57  
 wait for common var 53  
 wait for in position 67  
 wait master (counts) 73  
 wait outside (position range) 74  
 wait slave (counts) 73  
 wait until 43  
 wait within (position range) 74  
 zero (master/slave) counters 74  
 zero feedback position 41  
 zero following error 41  
 zero target position 41

## QuickMotion programming:

gearing statements 72  
 I/O statements 54  
 operators 38  
 position capture and queue statements 76  
 program flow statements 44  
 simple motion statements 62  
 utility statements 39

## QuickMotion variables:

\_highBW 114  
 \_inertia 114  
 \_wn 114  
 \_zeta 114  
 acc 111  
 accVector 134  
 accX 134  
 accY 134  
 accZ 134  
 activeBG\_MSBs 129  
 activeCAM\_row 108  
 activeFG\_MSBs 129

## QuickMotion variables:

|                    |              |
|--------------------|--------------|
| aff                | 114          |
| angle              | 134          |
| angleStart         | 134          |
| angleSweep         | 135          |
| antibackup         | 121          |
| axisnum            | 108          |
| axisptr            | 130          |
| axisY              | 135          |
| axisZ              | 135          |
| camming_invertend  | 116          |
| camRequest         | 108          |
| capArmed           | 127          |
| capEdge            | 127          |
| capGate            | 127          |
| capGateState       | 128          |
| capInput           | 128          |
| capLimit           | 128          |
| capLimitflag       | 128          |
| capMod             | 128          |
| capOffset          | 128          |
| cappos             | 128          |
| capposc            | 128          |
| capStatus          | 128          |
| capTriggered       | 128          |
| capWait            | 128          |
| capwaitBranch      | 128          |
| capwinEnd          | 128          |
| capwinStart        | 128          |
| capwinType         | 128          |
| cmode              | 111          |
| ctr#               | 119          |
| debugTable         | 93, 129, 149 |
| debugTableRow      | 93, 129, 149 |
| debugTableRows     | 93, 129, 149 |
| debugTableX        | 93, 129, 149 |
| debugTableY        | 93, 129, 149 |
| dec                | 111          |
| decVector          | 135          |
| decX               | 135          |
| decY               | 135          |
| decZ               | 135          |
| dim_factor_denom   | 130          |
| dim_factor_num     | 130          |
| din#               | 119          |
| dins               | 120          |
| dout#              | 119          |
| douts              | 120          |
| driveenable        | 120          |
| dwSlaveID          | 130          |
| eCAT_driveType     | 130          |
| eCAT_manufID       | 131          |
| eCAT_productCode   | 131          |
| enabled            | 108          |
| encoder_mode       | 111          |
| encoderZ           | 116          |
| encoderZ3          | 116          |
| fault#             | 108, 149     |
| faulted            | 108, 149     |
| fpos               | 116          |
| fposc              | 116          |
| global_flag#       | 120          |
| global_inputs      | 120          |
| global_outputs     | 120          |
| global_reg#        | 120          |
| gratio             | 116          |
| gtimebase          | 111          |
| homing_speed1      | 112          |
| homing_speed2      | 112          |
| inpos              | 108          |
| inpos_t            | 112          |
| inpos_w            | 112          |
| inposw             | 116          |
| invel_t            | 112          |
| invel_w            | 112          |
| invertcmd          | 116          |
| invertfeed         | 116          |
| invertmaster       | 116          |
| jerk_a             | 112          |
| jerk_a_req         | 112          |
| jerk_d             | 113          |
| jerk_d_req         | 112          |
| kd                 | 115          |
| kfilt              | 115          |
| kgain              | 115          |
| ki                 | 115          |
| 115                |              |
| kvf                | 115          |
| last_ALStatusCode  | 129          |
| last_errorCode     | 129          |
| last_errorRegister | 129          |
| last_errorType     | 129          |
| lastOverall        | 129          |
| looperiod          | 129          |
| looprate           | 129          |
| magnitude          | 135          |

## QuickMotion variables:

|                         |     |                              |     |
|-------------------------|-----|------------------------------|-----|
| master_feedback         | 121 | QS2_OVERRIDE_CNT             | 146 |
| maxLoopTime             | 130 | QS2_Overrides                | 145 |
| maxOverall              | 130 | QS2_PARAM_CNT                | 146 |
| mcinv                   | 122 | QS2_Params                   | 145 |
| mdelta#                 | 122 | QS2_REG_STATUS               | 146 |
| minLoopTime             | 130 | QS2_Status                   | 145 |
| minOverall              | 130 | QS2_TMP1                     | 146 |
| mmc                     | 123 | QS2_TMP2                     | 146 |
| move_master_counts      | 124 | QS2_TMP3                     | 146 |
| move_master_ramp        | 124 | QS2_TMP4                     | 146 |
| move_master_rate        | 125 | QS2_VAR_MTD                  | 146 |
| move_master_rate_target | 124 | QS2_VAR_MTN                  | 146 |
| mpgai                   | 125 | QS2_VAR_NEW_ACC_FEEDFORWARD  | 146 |
| mpgfi                   | 125 | QS2_VAR_NEW_ACCELERATION     | 145 |
| mposc                   | 123 | QS2_VAR_NEW_DECELERATION     | 145 |
| mposc#                  | 123 | QS2_VAR_NEW_DIFFERENTIAL     | 145 |
| mppr                    | 117 | QS2_VAR_NEW_FORCE_CUMULATIVE | 145 |
| msource                 | 128 | QS2_VAR_NEW_FORCE_POSITION   | 145 |
| neglim                  | 117 | QS2_VAR_NEW_HOLDING_MODE     | 145 |
| newvel                  | 113 | QS2_VAR_NEW_INTEGRAL         | 145 |
| nonvolatile             | 115 | QS2_VAR_NEW_MAX_SPEED        | 145 |
| overflowFlag            | 130 | QS2_VAR_NEW_PROPORTIONAL     | 145 |
| overneg                 | 108 | QS2_VAR_NEW_VEL_FEEDFORWARD  | 145 |
| overnegin               | 120 | radius                       | 135 |
| overpos                 | 108 | RFID_address                 | 132 |
| overposin               | 120 | RFID_bytesTotal              | 133 |
| overtrq                 | 108 | RFID_bytesTransferred        | 134 |
| pdead                   | 115 | RFID_channel                 | 131 |
| perr                    | 117 | RFID_control                 | 133 |
| perrlimit               | 117 | RFID_controlActive           | 133 |
| pff                     | 115 | RFID_count                   | 133 |
| poslim                  | 117 | RFID_data_readh              | 132 |
| ppg                     | 115 | RFID_data_readl              | 132 |
| ppr                     | 117 | RFID_data_wrieh              | 133 |
| pstate                  | 108 | RFID_data_writel             | 132 |
| qs_decel_time           | 131 | RFID_error                   | 132 |
| QS2_CAP_WINEND_REL      | 145 | RFID_index                   | 132 |
| QS2_CAP_WINOFFSET       | 146 | RFID_lasttagIDh              | 134 |
| QS2_CAP_WINSTART        | 145 | RFID_lasttagIDl              | 134 |
| QS2_Cmd                 | 145 | RFID_state                   | 131 |
| QS2_CMD_CNT             | 146 | RFID_status                  | 133 |
| QS2_FILTER_MODE         | 146 | RFID_tagIDh                  | 134 |
| QS2_Holding             | 145 | RFID_tagIDl                  | 134 |
| QS2_HOLDING_CNT         | 146 | RFID_totalChannels           | 131 |
| QS2_HOME                | 146 | running                      | 121 |
| QS2_LAST_CMD            | 146 | runv                         | 117 |
| QS2_MSB_STATE           | 146 | scanning                     | 130 |
|                         |     | sdv                          | 125 |

## QuickMotion variables:

|                  |          |
|------------------|----------|
| settling         | 117      |
| sfmod            | 117      |
| sfpos            | 117      |
| sfposc           | 117      |
| sign             | 117      |
| smark            | 125      |
| smarkfall        | 126      |
| smarkrise        | 125      |
| smod             | 125      |
| smodc            | 125      |
| spgai            | 125      |
| spgfi            | 125      |
| sphase           | 126      |
| sppr             | 113      |
| stepsout         | 117      |
| stoprate         | 113      |
| substep          | 117      |
| theta            | 113      |
| time             | 110, 113 |
| timebase         | 113      |
| tlim             | 113      |
| tmax             | 113      |
| tmc1             | 126      |
| tmc2             | 126      |
| tmodc            | 126      |
| touchProbeStatus | 110      |
| tpos             | 118      |
| tposc            | 118      |
| tr               | 118      |
| tracking_pstate  | 110      |
| tracking_sign    | 127      |
| tracking_status  | 127      |
| tracking_tpos    | 127      |
| tracking_tposc   | 127      |
| trqc             | 118      |
| tsc1             | 126      |
| tsc1fall         | 126      |
| tsc1rise         | 126      |
| tsc2             | 126      |
| tsc2fall         | 127      |
| tsc2rise         | 126      |
| units_ratio      | 118      |
| uud              | 118      |
| uun              | 118      |
| vcmd             | 118      |
| vectorY          | 135      |
| vectorZ          | 135      |
| vel              | 118      |
| vel_accel_time   | 131      |
| vel_decel_time   | 131      |
| velVector        | 136      |
| velX             | 136      |
| velY             | 136      |
| velZ             | 136      |
| verr             | 119      |
| vff              | 115      |
| vmax             | 114      |
| vmdelta          | 127      |
| vmin             | 131      |
| wControlWord     | 130      |
| wStatus          | 130      |
| zfpes            | 119      |
| zpulse           | 110      |
| ZPULSE_NEG       | 119      |
| ZPULSE_POS       | 119      |
| ztheta           | 114      |
| ztpes            | 119      |

**- R -**

|                        |    |
|------------------------|----|
| registration inputs    | 15 |
| Resource Manager (RM): | 10 |

**- S -**

|                             |    |
|-----------------------------|----|
| servo drives                | 8  |
| servo motors                | 8  |
| servo operating modes:      |    |
| positioning                 | 37 |
| slewing                     | 37 |
| tracking                    | 37 |
| slew at (velocity, time)    | 69 |
| slewing mode                | 37 |
| splines                     | 81 |
| stepper drives              | 9  |
| stepper motors              | 9  |
| symbols used in this manual | 7  |

**- T -**

|               |    |
|---------------|----|
| tracking mode | 37 |
|---------------|----|

---

## - V -

### Variables, Pre-defined:

|                           |                                      |
|---------------------------|--------------------------------------|
| Capture Variables         | 127                                  |
| Control Variables         | 111, 112, 113, 114                   |
| Diagnostic Variables      | 93, 129                              |
| Fault Variables           | 149                                  |
| Feedback Variables        | 116, 117, 118, 119                   |
| IO and Register Variables | 119, 120, 121                        |
| Quickstep Variables       | 145, 146                             |
| RFID Variables            | 131, 132, 133, 134                   |
| Setup Variables           | 130, 131                             |
| Status Variables          | 108, 109, 110                        |
| Tracking Variables        | 121, 122, 123, 124, 125,<br>126, 127 |
| Tuning Variables          | 114, 115, 116                        |
| Vector Variables          | 134, 135, 136                        |