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2-Axis Servo Module

M/N 57C422B

Instruction Manual J-3642-7

Rockwell Automation

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The information in this manual is subject to change without notice.

WARNING

THIS UNIT AND ITS ASSOCIATED EQUIPMENT MUST BE INSTALLED, ADJUSTED AND MAINTAINED BY QUALIFIED PERSONNEL WHO ARE FAMILIAR WITH THE CONSTRUCTION AND OPERATION OF ALL EQUIPMENT IN THE SYSTEM AND THE POTENTIAL HAZARDS INVOLVED. FAILURE TO OBSERVE THESE PRECAUTIONS COULD RESULT IN BODILY INJURY

WARNING

INSERTING OR REMOVING THIS MODULE OR ITS CONNECTING CABLES MAY RESULT IN UNEXPECTED MACHINE MOTION. POWER TO THE MACHINE SHOULD BE TURNED OFF BEFORE INSERTING OR REMOVING THE MODULE OR ITS CONNECTING CABLES. FAILURE TO OBSERVE THESE PRECAUTIONS COULD RESULT IN BODILY INJURY.

CAUTION

THIS MODULE CONTAINS STATIC-SENSITIVE COMPONENTS. CARELESS HANDLING CAN CAUSE SEVERE DAMAGE.

DO NOT TOUCH THE CONNECTORS ON THE BACK OF THE MODULE. WHEN NOT IN USE, THE MODULE SHOULD BE STORED IN AN ANTI-STATIC BAG. THE PLASTIC COVER SHOULD NOT BE REMOVED. FAILURE TO OBSERVE THIS PRECAUTION COULD RESULT IN DAMAGE TO OR DESTRUCTION OF THE MATERIAL.

WARNING

RELIANCE STRONGLY RECOMMENDS THE USE OF AN EXTERNAL, HARDWIRED EMERGENCY STOP CIRCUIT THAT WILL DISABLE THE SYSTEM IN CASE OF IMPROPER OPERATION. UNCONTROLLED MACHINE OPERATION MAY RESULT IF THIS PROCEDURE IS NOT FOLLOWED. FAILURE TO OBSERVE THIS PRECAUTION COULD RESULT IN BODILY INJURY OR DAMAGE TO EQUIPMENT

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CHAPTER 1

INTRODUCTION

The 2-Axis Servo Module, in conjunction with external motor drive systems and electronic encoders, provides two axes of closed loop point-to-point position, velocity, and acceleration control. In addition, electronic gearing and electronic cam allow the module to replace mechanical gear trains and cams electronically for improved performance with no wear, no backlash, and faster setup times. Two or more modules can be connected together to provide synchronized control of multiple axes.

Typically, this module is used for velocity control, point-to-point positioning control, electronic line shaft applications, and electronic cams requiring position synchronization. See Appendix I for a software block diagram of the module.

This manual describes the functions and specifications of the module. It also includes a detailed overview of installation and servicing procedures, as well as examples of programming methods. See Appendix F for a list of enhancements to the current version of the module.

Related publications that may be of interest:

- J-3675 AutoMax ENHANCED BASIC LANGUAGE INSTRUCTION MANUAL
- J-3676 AutoMax CONTROL BLOCK LANGUAGE INSTRUCTION MANUAL
- J-3677 AutoMax LADDER LOGIC LANGUAGE INSTRUCTION MANUAL
- J-3684 RESOURCE AutoMax PROGRAMMING EXECUTIVE INSTRUCTION MANUAL VERSION 2.0
- J-3675 AutoMax PROGRAMMING EXECUTIVE INSTRUCTION MANUAL VERSION 3.0

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- IEEE-518 GUIDE FOR THE INSTALLATION OF ELECTRICAL EQUIPMENT TO MINIMIZE ELECTRICAL NOISE INPUTS TO CONTROLLERS FROM EXTERNAL SOURCES

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CHAPTER 2

MECHANICAL / ELECTRICAL DESCRIPTION

The following is a description of the faceplate LEDs, field termination connectors and electrical characteristics of the field connections.

2.1 Mechanical Description

The 2-Axis Servo module is a printed circuit board assembly that plugs into the backplane of the DCS 5000/AutoMax rack. It consists of the printed circuit board, a faceplate, and a protective enclosure. The faceplate contains tabs at the top and bottom to simplify removing the card from the rack. Assembly dimensions are listed in Appendix A.

The faceplate of the module contains a 37-pin D-shell connector socket and eight LED status indicators for each axis. It also contains three LEDs that can be controlled from the application software. Refer to figure 2.1.

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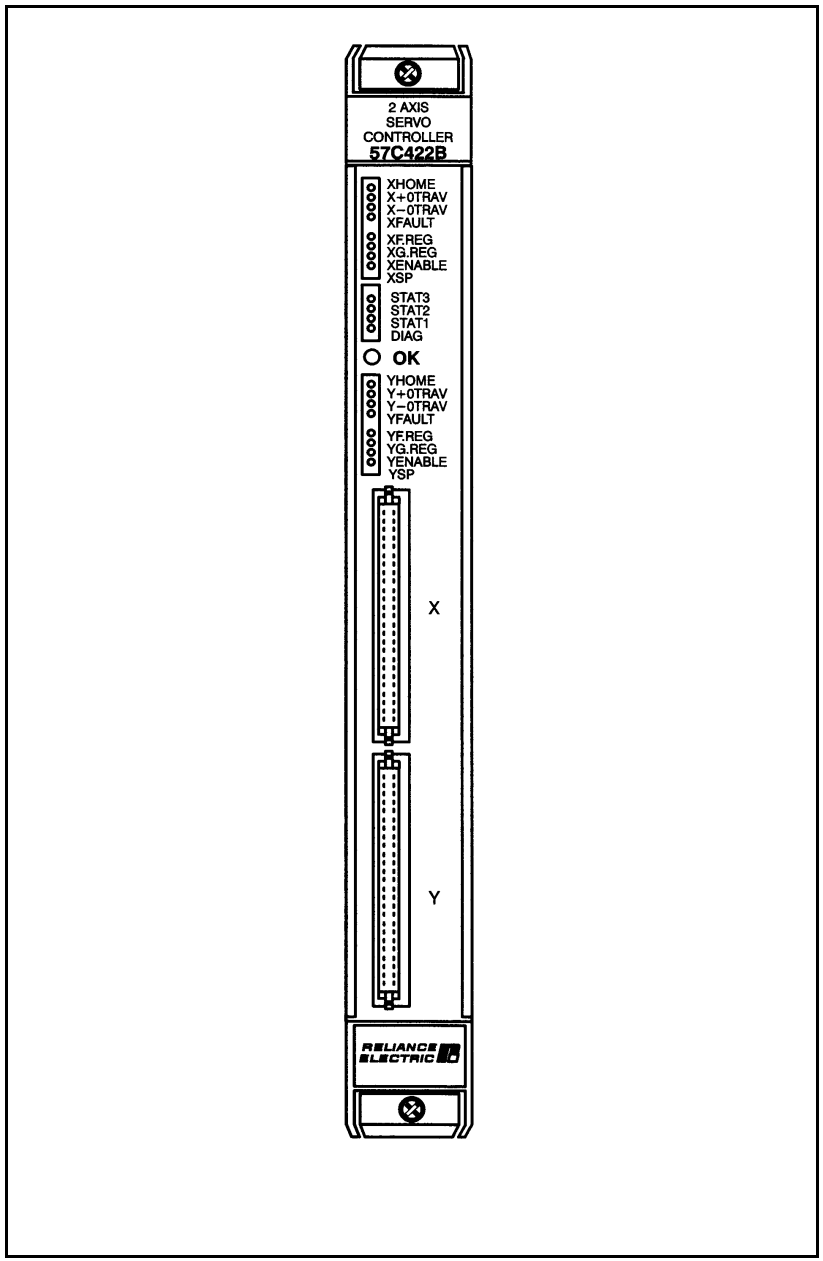


Figure 2.1 – Module Faceplate

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Signals are brought into the module via a multi-conductor cable (M/N 57C377). One end of this cable attaches to the faceplate connector, while the other end of the cable attaches to a terminal board for easy wiring.

On the back of the module are two edge connectors that attach to the system backplane.

2.2 Electrical Description

The module contains an 80186 microprocessor, local RAM, and EPROM for the axis software. It also contains a dual port memory organized as 4k x 16 for transferring data to/from the module and the application software. Refer to the block diagram in Appendix B.

This module also contains a watchdog timer that is used to detect a processor failure. The processor is required to keep resetting the watchdog before it expires. If the watchdog expires, the processor will be halted, the green LED on the faceplate of the module will be turned off, and dual port memory will be locked so that the module can no longer be accessed by application software.

M/N 57C422A and later versions of the module support level-sensitive hardware interrupts. Interrupts are used to trigger execution of some part of an application task and are implemented using BASIC language hardware EVENT statements. See Section 4.49 for more information.

Each of the two axes contain the necessary circuitry for two encoders. One encoder is used to provide feedback to the axis. The other encoder can be used when gearing or cam mode is selected to provide a reference for that same axis. Each encoder input channel has the necessary circuitry for an “A” channel, "B" channel, and "Z" channel. The encoder input circuit is designed for 5 volt differential signals. A single external power supply is required to power all of the encoders connected to the module. Refer to figure 2.2 for a typical encoder input circuit.

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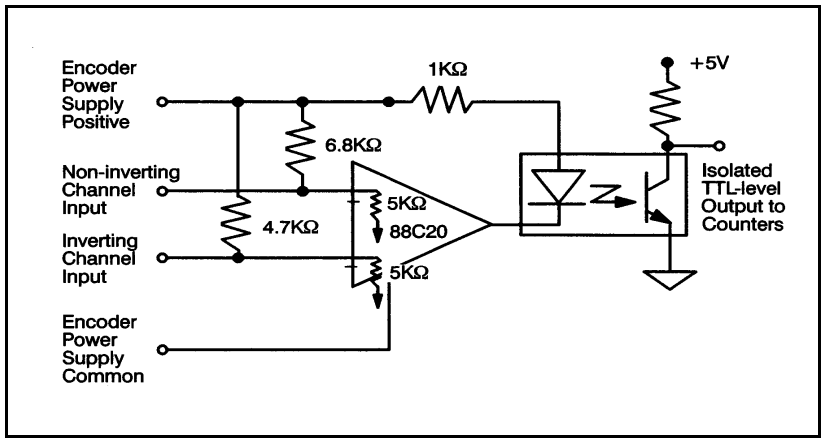


Figure 2.2 – Encoder Input Circuit

Each axis contains two registration inputs which are connected to faceplate LEDs. One input is used with the feedback encoder; the other is used with the gearing reference. These registration inputs are typically used to strobe the feedback and/or the reference position into a group of registers for use by application software which can synchronize the axis to an external event. The input may be 15-24 VDC only and there is a transport delay of approximately 25 microseconds from the time that a registration input is asserted until the isolated signal changes state. Refer to figure 2.3 for a typical input circuit. In critical applications, hard-wire your overtravel L/S into the emergency stop circuit so that the drive will be disabled regardless of the state of the control.

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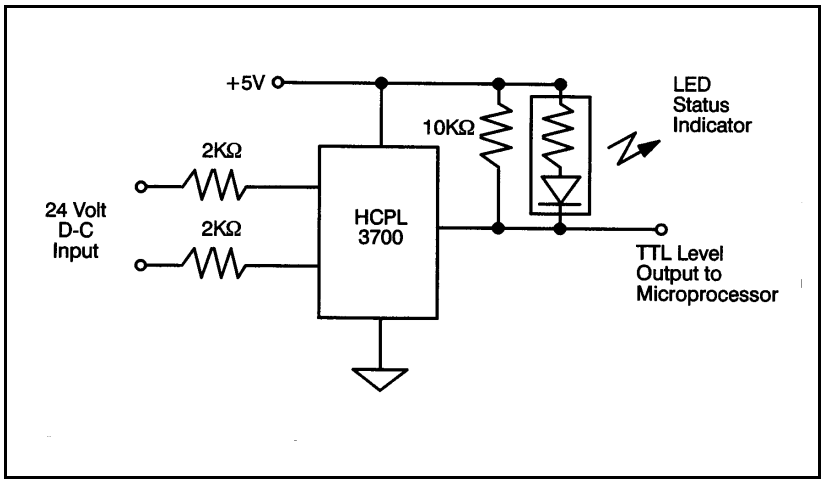


Figure 2.3 – Typical Registration Input Circuit

Each axis on the module contains digital inputs for the home L/S, drive fault, positive overtravel L/S, and negative overtravel L/S. These inputs are connected to faceplate LEDs. Each of the inputs has a 30 Hz filter and may be 24 volts A-C or D-C. Refer to figure 2.4 for a typical input circuit.

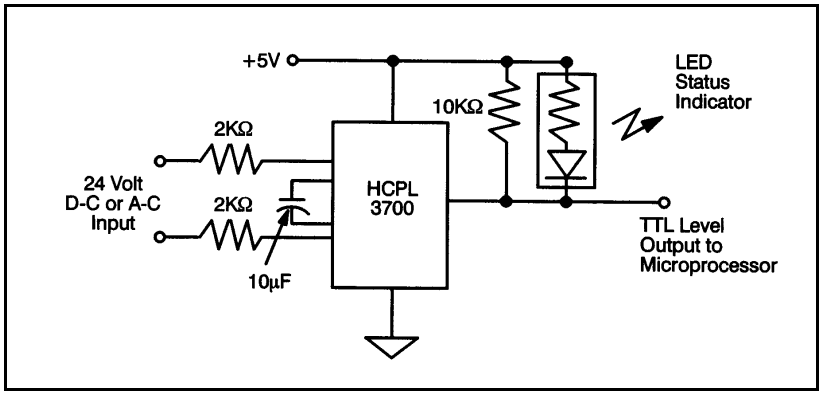


Figure 2.4 – Typical Digital Input Circuit

Each axis contains a watchdog output which can be used by the module to disable the drive if the module falls. The watchdog output is a normally open relay contact. See figure 3-7.

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In order to provide a current or velocity reference to the servo drive panel, each axis on the module contains a voltage output. The voltage output has a range of ±10 Volts and requires an externally mounted ±12 or ±15 volt power supply. The voltage output is separately isolated for each channel. Refer to figure 3.6 for a typical output circuit and isolated power supply connections

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CHAPTER 3

INSTALLATION

This section describes how to install and remove the module and its cable assembly.

WARNING

THE MACHINERY BUILDER AND/OR USER ARE RESPONSIBLE FOR INSURING THAT ALL DRIVE TRAIN MECHANISMS, THE DRIVEN MACHINE, AND PROCESS MATERIAL ARE CAPABLE OF SAFE OPERATION AT THE MAXIMUM SPEED AT WHICH THE MACHINE WILL OPERATE. FAILURE TO OBSERVE THESE PRECAUTIONS COULD RESULT IN BODILY INJURY

3.1 Wiring

DANGER

THE USER IS RESPONSIBLE FOR CONFORMING WITH THE NATIONAL ELECTRICAL CODE AND ALL OTHER APPLICABLE LOCAL CODES. WIRING PRACTICES, GROUNDING, DISCONNECTS, AND OVERCURRENT PROTECTION ARE OF PARTICULAR IMPORTANCE. FAILURE TO OBSERVE THESE PRECAUTIONS COULD RESULT IN SEVERE BODILY INJURY OR LOSS OF LIFE.

To reduce the possibility of electrical noise interfering with the proper operation of the control system, exercise care when installing the wiring from the system to the external devices. For detailed recommendations refer to IEEE 518.

3.2 Initial Installation

Use the following procedure to install the module:

Step 1. Turn off power to the system. All power to the rack as well as all power to the wiring leading to the module, servo, and encoders must be off.

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DANGER

EQUIPMENT IS AT LINE VOLTAGE WHEN A-C POWER IS CONNECTED TO THE DRIVE. ALL UNGROUNDED CONDUCTORS OF THE A-C POWER LINE MUST BE DISCONNECTED BEFORE IT IS SAFE TO TOUCH ANY INTERNAL PARTS OF THIS EQUIPMENT. FAILURE TO OBSERVE THESE PRECAUTIONS COULD RESULT IN SEVERE BODILY INJURY OR LOSS OF LIFE.

Step 2. Take the module out of its shipping container. Take the module out of the anti-static bag it came in, being careful not to touch the connectors on the back of the module.

Step 3. Insert the module into the desired slot in the rack. Refer to figure 3.1.

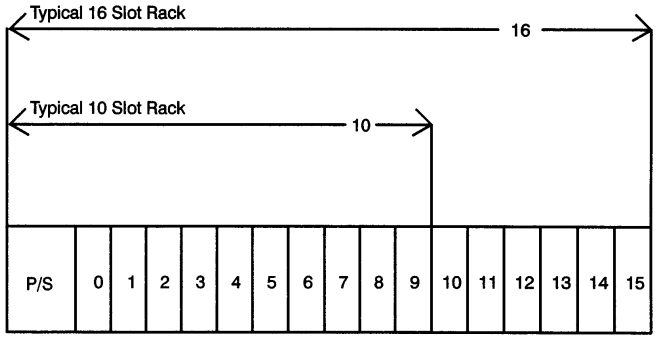


Figure 3.1 – Rack Slot Numbers

Step 4. Mount the terminal strips (M/N 57C377) on a panel. The terminal strips should be mounted to permit easy access to the screw terminals. Make certain that the terminal strips are close enough to the rack so that the cable will reach between the terminal strips and the module.

Step 5. Verify that the feedback encoder has been mounted on the back of the servo motor. Make certain that the mechanical coupling between the motor and encoder is securely fastened. If the encoder is not mounted directly on the motor, satisfactory performance may not be achievable.

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Fasten the field wires from the encoder to the terminal strip. Typical field connections are shown in figure 3.2. If you are not using the marker pulse in your application, you can leave the "Z" and "$\overline{Z}$" inputs disconnected.

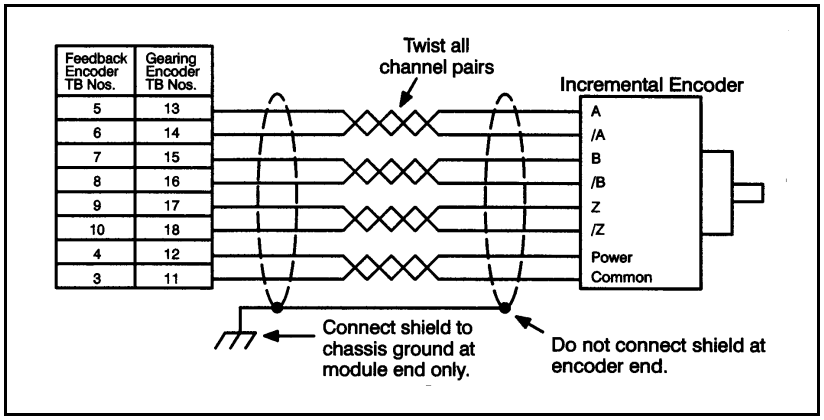


Figure 3.2 – Typical Encoder Connections

Use twisted pair cabling, connected as shown in figure 3.2, for the cabling between the encoder and the terminal strip. If you use cabling with less than 2 twists/inch, it should be shielded. Note that the shield should only be connected at one end.

If a feedback encoder is connected to the gearing reference of another axis, jumper the connections on the terminal strip.

Step 6. Mount the external 5 volt power supply for the encoders. The current rating must be sufficient for all of the encoders that will be powered from the supply as well, as the module. Check the specifications of the encoder you will be using.

Fasten the field wires from the power supply to the terminal strip. Typical field connections are shown in figure 3.3

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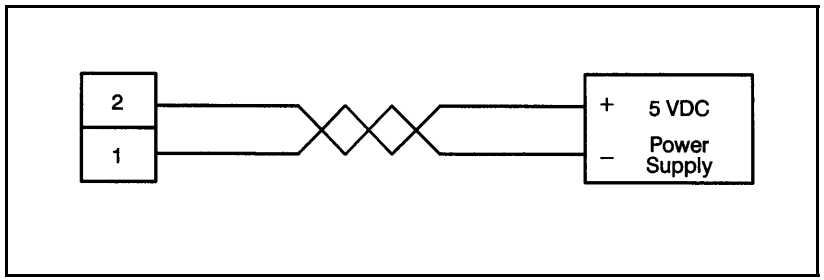


Figure 3.3 – Typical Encoder Power Supply Connection

Use twisted pair cabling, connected as shown in figure 3.3, for the cabling between the power supply and the terminal strip. If you use cabling with less than 2 twists/inch, it should be shielded. Note that the shield should only be connected at one end.

For best results, the power supply voltage should be adjusted to provide 5 volts at the furthest encoder.

Step 7. If your application requires them, mount the home L/S, positive overtravel L/S, and negative overtravel L/S on your machine. Overtravel L/S should be normally closed devices. Fasten the field wires from the limit switches to the terminal strip. Typical field connections are shown in figure 3.4.

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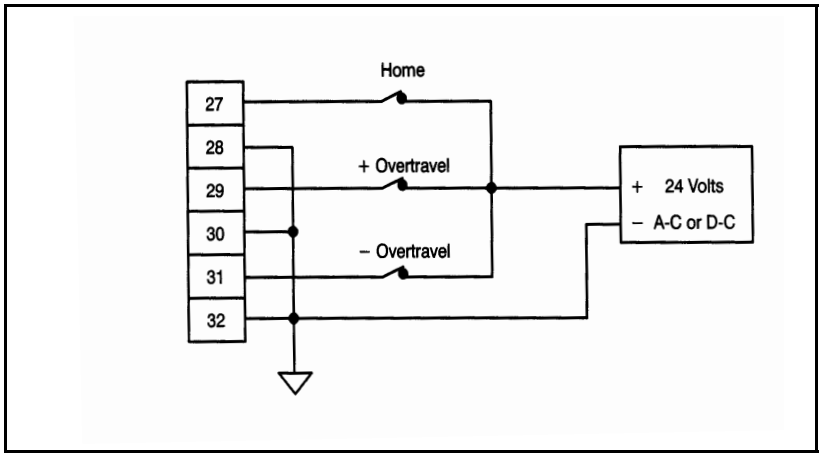


Figure 3.4 – Typical Limit Switch Connections

Step 8. Mount the registration sensors on your machine if your application requires them. Fasten the field wires from the sensors to the terminal strip. Use extra care in routing these wires because these signals are not filtered on the module. Typical field connections are shown in figure 3.5.

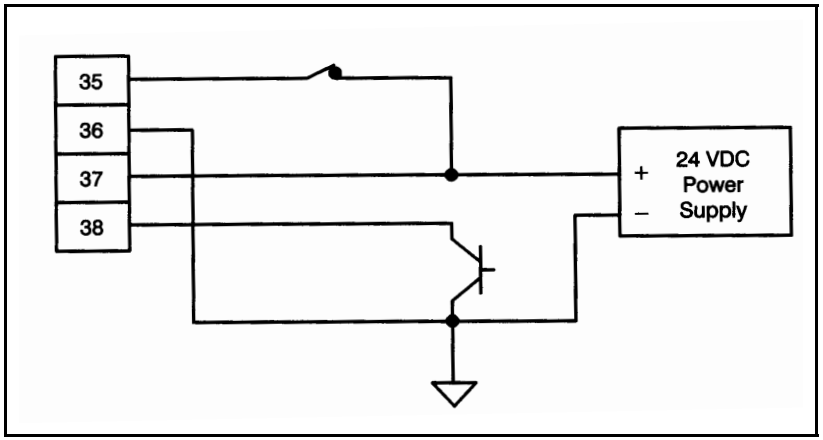


Figure 3.5 – Typical Registration Input Connections

Step 9. Install the servo amplifier according to the manufacturer's instructions. Select the proper mode of operation for the servo amplifier (current or velocity). Select current mode for most applications because all tuning can then be done

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in the software. If your application has unusually high bandwidth requirements or your servo amplifier functions as a velocity regulator only, use the velocity mode.

Step 10. Fasten the field wires from the drive reference and power supply to the terminal strip. Typical field connections are shown in figure 3.6 and 3.7.

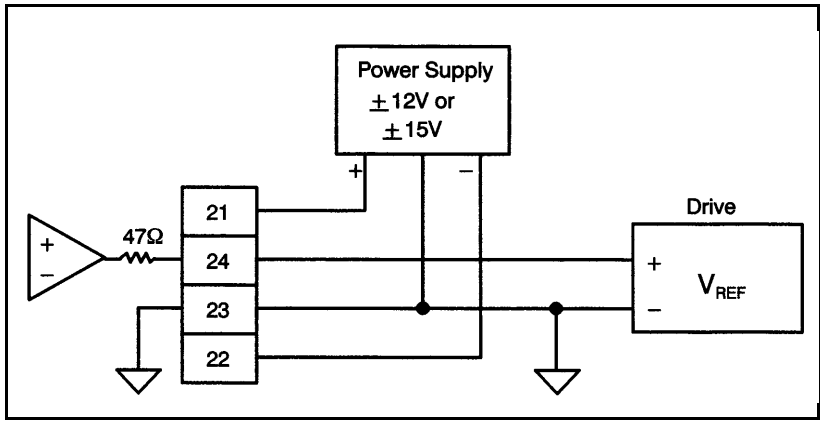


Figure 3.6 – Typical Drive Reference/Voltage Reference Connections with External P/S

Step 11. Connect the watchdog outputs on the terminal strip into the drive enable circuit. This signal is used to disable the servo if a problem develops in the module. It must be installed in combination with a hardwired E-stop circuit as well as a pair of contacts that are controlled from a digital output from DCS or AutoMax software. Typical field connections are shown in figure 3.7.

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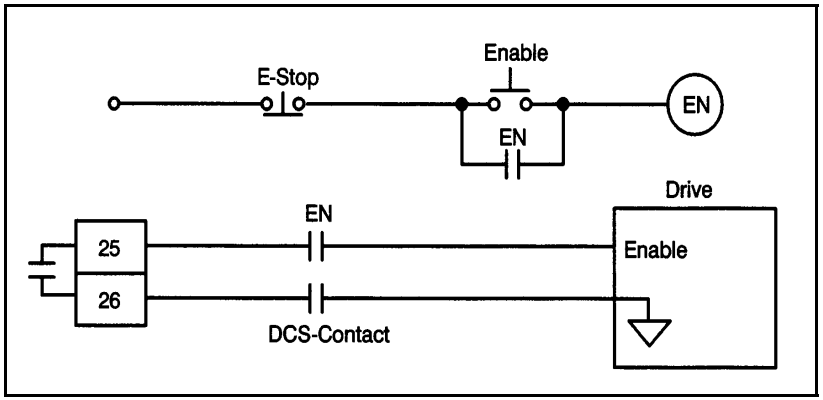


Figure 3.7 – Typical E-stop Circuit with Watchdog Output

The hardwired E-STOP ensures that you can disconnect the drive under all conditions. The contacts controlled by a DCS or AutoMax digital output allow you to disable the drive in the event of a processor failure or when faults are detected by the application software.

WARNING

RELIANCE STRONGLY RECOMMENDS THE USE OF AN EXTERNAL, HARDWIRED EMERGENCY STOP CIRCUIT THAT WILL DISABLE THE SYSTEM IN CASE OF IMPROPER OPERATION. UNCONTROLLED MACHINE OPERATION MAY RESULT IF THIS PROCEDURE IS NOT FOLLOWED. FAILURE TO OBSERVE THIS PRECAUTION COULD RESULT IN BODILY INJURY OR DAMAGE TO EQUIPMENT.

Step 12. Fasten the field wires from the drive fault inputs to the terminal strip. This signal is used to notify the module that a problem has developed in the servo. It must be connected if available. Typical field connections are shown in figure 3.8. Be sure to use the proper connections for your servo amplifier.

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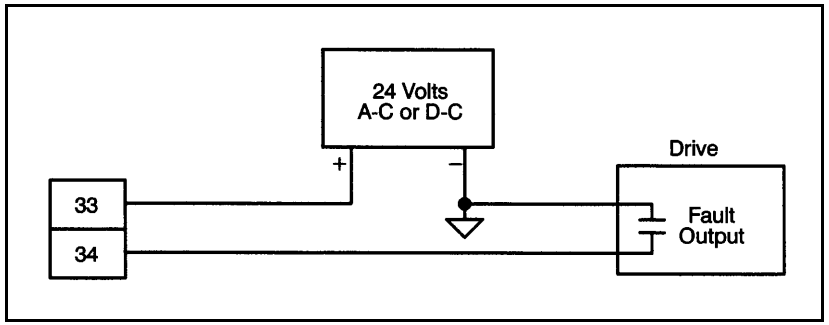


Figure 3.8 – Typical Drive Fault Connections

DANGER

ADJUSTMENTS ARE MADE WITH THE POWER ON. EXERCISE EXTREME CAUTION AS HAZARDOUS VOLTAGE EXISTS. FAILURE TO OBSERVE THIS PRECAUTION COULD RESULT IN SEVERE BODILY INJURY OR LOSS OF LIFE.

Step 13. Verify power supply connections by performing the following operations:

a. Make certain that all connectors from the module and the encoders are disconnected.

b. Turn on power to the system.

c. Verify that you can read 5 volts on the proper terminal strip and encoder connectors (terminals 1 and 2).

d. Verify that you can read ±12 volts or ±15 volts on the proper terminal strip connectors (terminals 21, 22, 23).

e. Turn off power and reattach the connectors to the module.

Step 14. Verify power supply connections at the encoder by performing the following operations:

a. Make certain that all connectors at the encoders are disconnected.

b. Turn on power to the system.

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c. Verify that you can read 5 volts on the proper pins of the encoder connector (at the encoder).

d. Turn off power and attach the connectors to the encoders.

Step 15. Verify wiring connections by performing the following operations:

a. Turn on power to the system.

b. Toggle all of the following digital inputs that you are using in your application: the home L/S, positive overtravel L/S, negative overtravel L/S, drive fault, feedback registration, and gearing registration. The appropriate LED on the faceplate of the module should change state as the input is toggled. Because the signal may be very brief, it may be necessary to use an oscilloscope to verity that it is present.

Step 16. Verify the installation by connecting the programming terminal to the system and running the Programming Executive Software. Note that if you are using a version 3.0 Programming Executive and working with the sample application program disk shipped with the Programming Executive software, you will need to do a rack import operation for the files in the 57C422 subdirectory first. See J-3684 for more information and disregard steps a and b below.

a. Load the application disk that came with your ReSource software.

b. Compile the BASIC tasks SETUPCNF.CNF AXISSETUP.BAS, AXISSUB.BAS, and AXISINIT.BAS.

c. Load the configuration and BASIC tasks onto the CPU.

d. Use the RUN ALL command to start all four tasks.

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e. Move the cable from the programming port on the processor to the port labeled "LOCAL COMM".

f. Select the menu option labeled "COMMUNICATIONS INTERFACE".

g. Type C <CR> <CR>.

h. The screen on the programming terminal should now display the test and setup menu for the module. You should progress sequentially through the menu from item 1 through item 8 before attempting to use the module.

Note that when you have finished configuring and tuning your drives, you may save all of the data to a DOS disk file. By adding this file to AXISINIT.BAS, you can eliminate the need to re-configure your drive each time you use the test and setup software.

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3.3 Module Replacement

WARNING

THE MACHINERY BUILDER AND/OR USER ARE RESPONSIBLE FOR INSURING THAT ALL DRIVE TRAIN MECHANISMS, THE DRIVEN MACHINE, AND PROCESS MATERIAL ARE CAPABLE OF SAFE OPERATION AT THE MAXIMUM SPEED AT WHICH THE MACHINE WILL OPERATE. FAILURE TO OBSERVE THESE PRECAUTIONS COULD RESULT IN BODILY INJURY.

Use the following procedure to replace a module:

Step 1. Turn off power to the rack and all connections.

Step 2. Remove the connectors from the module.

Step 3. Loosen the screws that hold the module in the rack. Remove the module from the slot in the rack.

Step 4. Place the module in the anti-static bag IT came in, being careful not to touch the connectors on the back of the module. Place the module in the cardboard shipping container.

Step 5. Take the new module out of its anti-static bag, being careful not to touch the connectors on the back of the module.

Step 6. Insert the module into the desired slot in the rack. Use a screwdriver to secure the module into the slot.

Step 7. Attach the field terminal connectors (M/N 57C377) to the mating halves on the module. Make certain that the connectors are the proper ones for the module and for the specific axes.

Step 8. Turn on power to the rack.

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CHAPTER 4

PROGRAMMING

This section describes how the data is organized in the module and provides examples of how the module is accessed by the application software. For more detailed information on programming, refer to J-3675, J-3676, and J-3677.

The module contains a total of 4096 16-bit registers, one set of 2047 registers for each servo axis. The X axis uses registers 0-2046. The Y axis uses registers 2048-4094.

Note that there are 2 exceptions to this basic register organization scheme: registers 64 and 4095 (interrupt control) are used for both axes. In other words, the use of an interrupt on either axis will require you to perform some function In these two registers. See section 4.49 for more information on interrupts.

The following register reference conventions are used throughout this instruction manual. All register descriptions in the following sections are based on the X axis and are organized in numerical order, except for interrupt and cam registers, which are described in sections 4.49 and 4.50. The equivalent Y axis registers are given in parentheses in the figure that accompanies each register description. Appendix E is a numerical register summary with page number references.

Register numbers listed together separated by a comma (e.g., 11, 12) signify a double precision (32-bit) value. Register numbers listed together separated by a slash (e.g., 104/105) indicate that both registers have a similar function and should be considered together. This notation does not indicate a double precision value.

For ease of locating descriptions for individual bits within registers, bit names are underlined in the sections where the bits are described. Bit names are placed between quotation marks when they are only referred to. In some cases,

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registers with individual bit descriptions are shown with the bits broken up into groups of four for ease of interpretation in monitoring the registers in hexadecimal format.

At times register and bit references will be in the form of "RA,bB," where "A" is the register number and "B" is the bit number.

4.1 Configuration

Before an application program can be written, it is necessary to configure the definitions of variables that must be accessible to all tasks in the rack. This section describes how to configure the module.

If you are using V3.0 or later of the Programming Executive software, you can configure the module using a special software "form" that allows you to fill in the names of the registers and bits. See the Programming Executive instruction manual for more information on configuration forms.

If you are using an earlier version of the programming executive, you will need to create a configuration task to configure the registers/bits on the module. See Appendix H, for more information on creating a configuration task.

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4.2 Register 0: Encoder Setup

Register 0 is used to configure the gearing reference and feedback encoder inputs for the axis. Refer to figure 4.1.

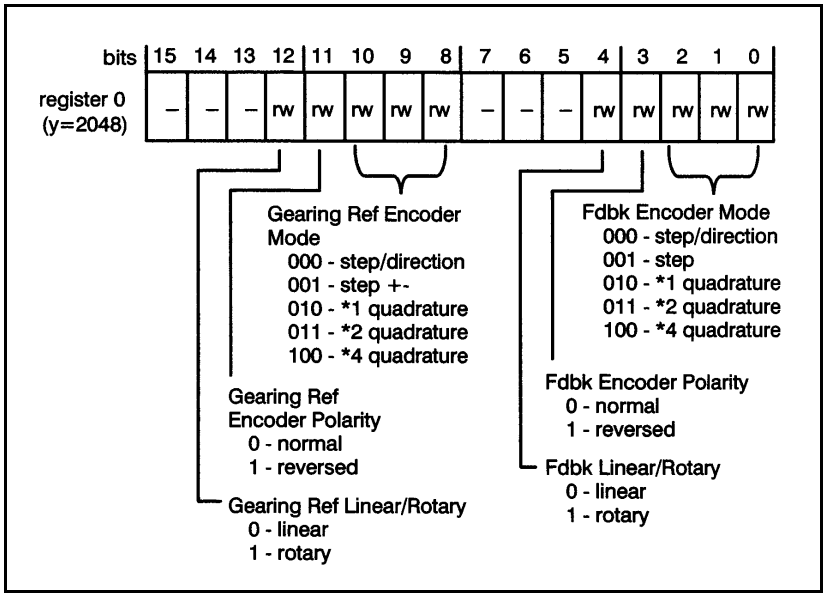


Figure 4.1 – Encoder Configuration Register

The feedback encoder mode bits specify how the A and B channels from the encoder will be interpreted by the module. If the step/direction mode is selected, a high to low transition of Channel A causes a count. If Channel B was low, the count is incremented. If Channel B was high, the count is decremented.

If the step ± mode is selected, a high to low transition of Channel A results in the count being incremented. A high to low transition of Channel B results in the count being decremented.

If the *1 quardrature is selected, only one edge of channel A is counted. (Note that *1 quadrature is available only on B/M 57422-2C and later versions of the module.) If the *2 quadrature mode is selected, both the rising and trailing edges of Channel A are counted. The direction is determined from the state of Channel B.

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If the *4 quadrature mode is selected, both edges of Channels A and B result in counts. The direction is determined by the channel changing state and the state of the opposite channel. All subsequent references to counts include the quadrature calculation.

Note: Any references to counts within this instruction manual take into account the quadrature multiplier selected in this register.

You can use the feedback encoder polarity bit to change the rotation of the encoder as seen by the application software. This is analogous to swapping the encoder leads to alter the electrical direction of rotation.

Specifying the axis as "rotary" using the feedback linear/ rotary bit causes the module to subtract or add one revolution of counts from the command position and the actual position whenever the encoder crosses the revolution boundary. This allows infinite range for rotary axis. If the axis is specified as linear, the feedback will simply increment or decrement as the axis is moved forward or in reverse.

4.3 Register 1: Drive Setup

Register 1 is used to configure the servo drive. Refer to figure 4.2.

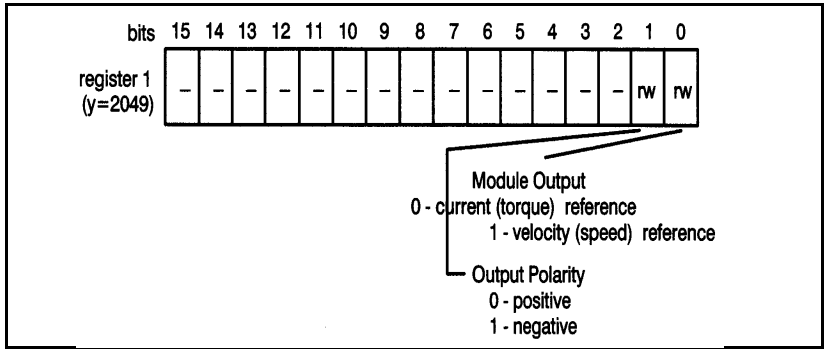


Figure 4.2 – Control Loop Configuration Register

The analog output from the module should be configured to work with the control loop on the drive (either current or velocity).

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The output polarity bit is used to alter the sign of the drive reference for a given error. This is analogous to swapping the wires for the drive reference.

4.4 Register 2: Switch Setup

Register 2 is used to configure the home and overtravel limit switches. Refer to figure 4.3.

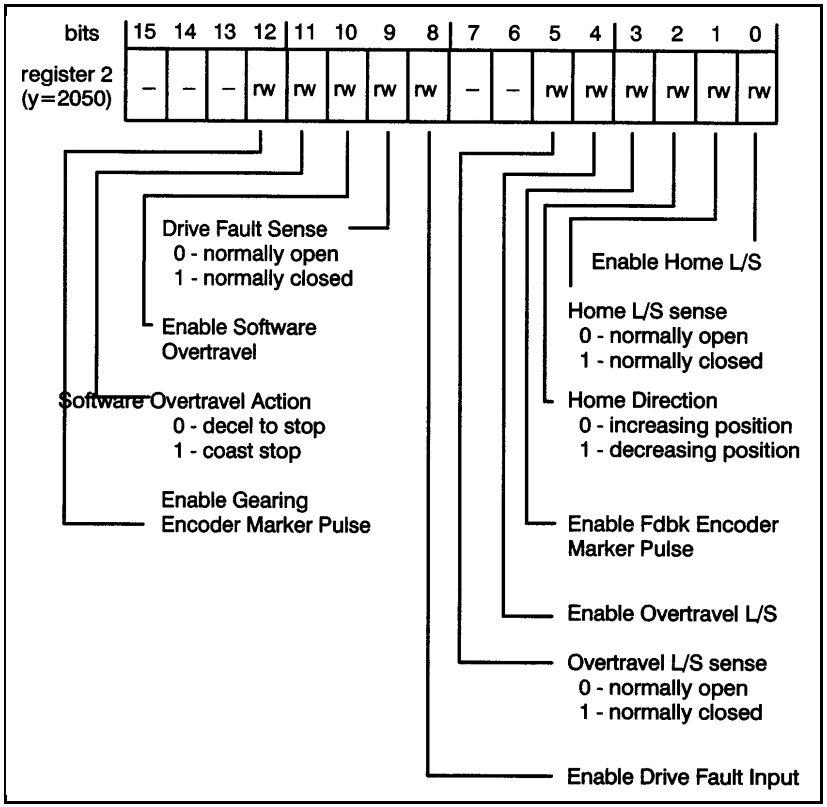


Figure 4.3 – Home and Overtravel Configuration Register

If you have a home limit switch on your machine, you should use the enable home L/S. You can define the asserted sense of the limit switch as either normally open or normally closed.

The home direction bit is used to define the direction that the drive will move during the initial phase of the homing sequence.

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If you intend to use the feedback marker during the home sequence, you should enable the feedback encoder marker pulse. Refer to section 4.35 for more information on the “home axis” command in register 66.

To prevent your machine from moving beyond specified physical limits, use the enable overtravel L/S bit. You can define the condition to be true when the limit switch is closed (normally open) or open (normally closed). If an overtravel limit switch is tripped during operation, the control will be turned off and, if programmed, the drive will coast to a stop. The machine will then have to be moved off the overtravel limit switch before the control can be re-enabled. In critical applications, hardwire the overtravel L/S into the emergency stop circuit so that the drive will be disabled regardless of the state of the control.

The drive fault input is a simple means of shutting off the axis control. This input can be either a fault signal from the drive or an E-STOP push-button. You can define the asserted sense of the input as either normally open or normally closed. If the drive fault input is tripped, the axis control will be disabled and, if programmed, the drive will coast to a stop.

WARNING

RELIANCE STRONGLY RECOMMENDS THE USE OF AN EXTERNAL, HARDWIRED EMERGENCY STOP CIRCUIT THAT WILL DISABLE THE SYSTEM IN CASE OF IMPROPER OPERATION. UNCONTROLLED MACHINE OPERATION MAY RESULT IF THIS PROCEDURE IS NOT FOLLOWED. FAILURE TO OBSERVE THIS PRECAUTION COULD RESULT IN BODILY INJURY.

The software overtravel bit is a programmable way of limiting machine travel. You can define the action that occurs when the software overtravel limit is exceeded as either a decel to stop or a coast to stop. If you have specified a decel to stop, the drive will decelerate at the specified rate to zero speed and regulate about that position. If you have specified a coast stop, the drive control will be disabled and the drive will coast to rest. When the drive has exceeded a software overtravel limit, and if you have specified a "decel to stop," the drive can be commanded to move away from the overtravel condition.

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You should enable the gearing marker pulse if you intend to use it to initialize the home position of the gearing encoder. Refer to section 4.35 for the "set gearing position" command in register 66 for more information.

4.5 Register 3: Proportional Gain

Register 3 contains the proportional gain for the module. This value is read by the module whenever the “change default setups” command in register 66 is issued. See Section 5.2 for more information on turning.

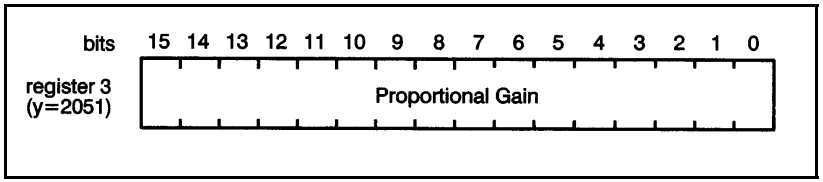


Figure 4.4 – Proportional Gain Register

4.6 Register 4: Integral Gain

Register 4 contains the integral gain for the module. This value is read by the module whenever the "change default setups" command in register 66 is issued. See Section 5.2 for more information on tuning.

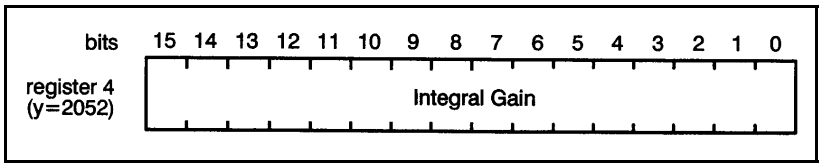


Figure 4.5 – Integral Gain Register

4.7 Register 5: Velocity Gain

Register 5 contains the velocity gain for the module. This value is read by the module whenever the "change default setups" command in register 66 is issued. See Section 5.2 for more information on tuning.

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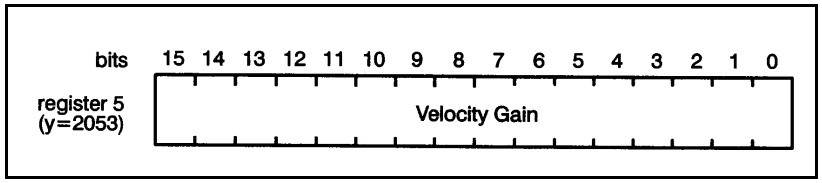


Figure 4.6 – Velocity Gain Register

4.8 Register 6: Feedforward Gain

Register 6 contains the feedforward gain for the module. This value is read by the module whenever the “change default setups” command in register 66 is issued. See section 5.2 for more information on tuning.

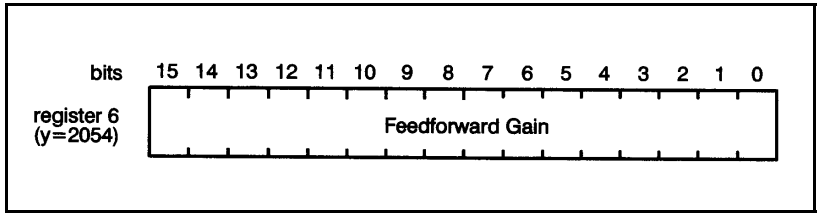


Figure 4.7 – Feedforward Gain Register

4.9 Register 7: Deadband Compensation

Register 7 contains the deadband compensation for the module. This value is read by the module whenever the "change default setups" command in register 66 is issued. See Section 5.2 for more information on tuning.

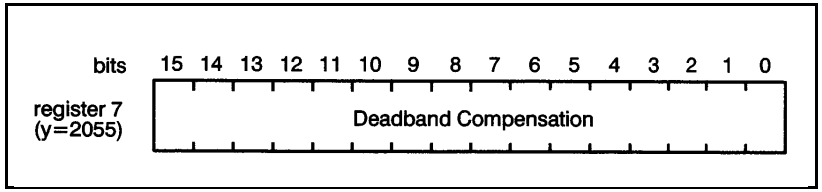


Figure 4.8 – Deadband Compensation Register

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4.10 Register 8: Maximum Position Error

Register 8 contains the maximum allowable position error that is used to determine faults. Position error is defined as the difference between commanded and actual position. The value depends on the system configuration and performance required. If this limit is exceeded, the feedback will be disabled and the appropriate fault bits will be set in the fault register (R73). Note that register 8 will be examined by the module even when it is in velocity mode. The module may respond to excessive position error while running in velocity mode.

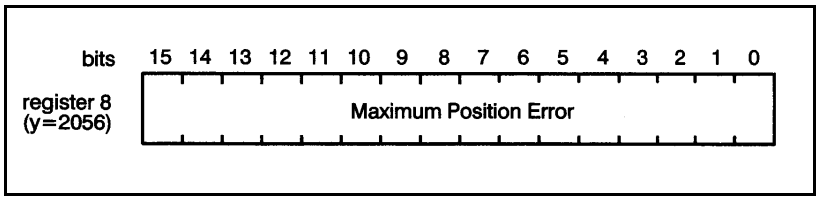


Figure 4.9 – Maximum Position Error

4.11 Register 9: Maximum Velocity Error

Register 9 contains the maximum allowable velocity error. Velocity error is the difference between the commanded and the actual velocity. Excessive velocity error usually indicates excessive acceleration, excessive deceleration, or a disconnected encoder. The maximum velocity error is determined using the following equation.

Maximum
Velocity Error=(max acceptable velocity error in eng.
units/sec*encoder counts/eng units) (.00125)

The result of the equation is in counts/scan. If this limit is exceeded, the feedback will be disabled and the appropriate fault bits will be set in the fault register (R73).

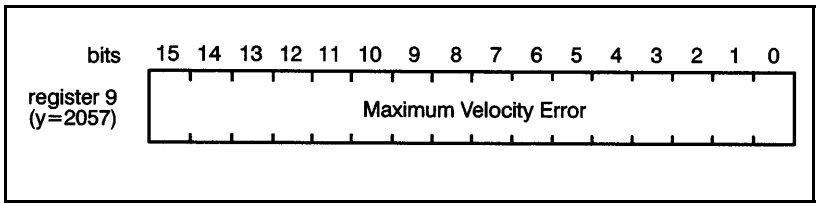


Figure 4.10 – Maximum Velocity Error Register

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4.12 Register 10: In-Position Tolerance

Register 10 defines the tolerance within which the axis is considered to be in-position. This value is read by the module whenever the "enable feedback" (register 65) or "change default setups" (register 66) command is issued. The axis is considered to be in-position if the absolute value of the difference between where the axis should be and where it actually is, is less than this tolerance. This condition is available as "axis locked" status in register 72. The in-position tolerance is in units of encoder counts. Refer to figure 4.11.

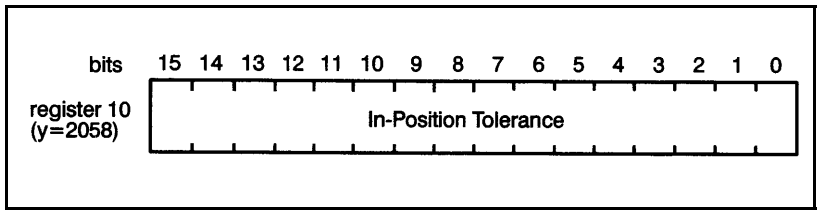


Figure 4.11 – In-Position Tolerance Register

4.13 Registers 11, 12: Positive Overtravel Limit

Registers 11, 12 define the positive overtravel limit. This value is read by the module whenever the “enable feedback” (register 65) or “change default setups” (register 66) command is issued. This limit applies only if the axis is in the linear mode (register 0, bit 4=0) and “software overtravel” was enabled in register 2. The negative overtravel limit must be algebraically less than the positive overtravel limit or a motion fault will occur. The software overtravel limits are in units of encoder counts.

Registers 11 -12 are also used to provide a maximum travel limit for the "tune dynamics" (register 66) or "tune

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feedforward" (register 66) commands.

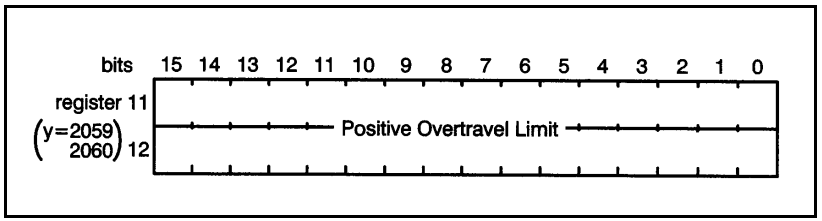


Figure 4.12 – Positive Overtravel Limit Registers

4.14 Registers 13,14: Negative Overtravel Limit

Registers 13,14 define the negative overtravel limit. This value is read by the module whenever the "enable feedback" (R65) or change default setups" (R66) command is issued. This limit applies only if the axis is in the linear mode. (RO,b4=0) and "software overtravel" in R2 has been enabled. The negative overtravel limit must be algebraically less than the positive overtravel limit (R11, 12) or a motion fault will occur. The negative overtravel limit is in units of encoder counts.

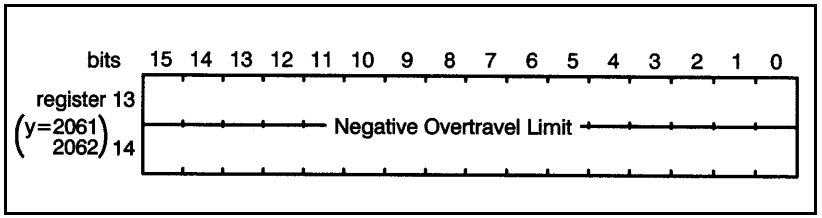


Figure 4.13 – Negative Overtravel Limit Registers

4.15 Registers 15,16: Low Speed Homing Reference

Registers 15, 16 contain the low speed reference used during the homing sequence. This value is read by the module whenever the "home axis" (register 66) command is issued. The low speed reference is used by the module whenever it is attempting to locate the feedback marker pulse. Refer to figure 4.14. The reference units are:

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(encoder counts/sec) * 65.536

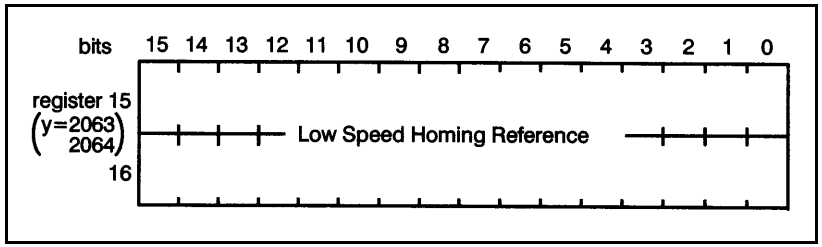


Figure 4.14 – Low Speed Homing Reference Register

4.16 Registers 17,18: Command Position

Registers 17, 18 contain numeric parameters used in various commands. All of the commands do not require the use of all of the parameters in registers 17-24. Refer to figure 4.15.

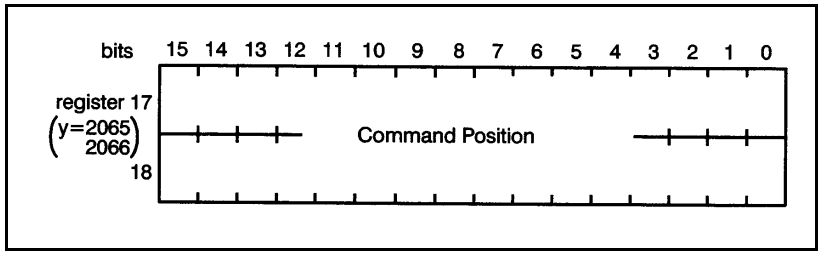


Figure 4.15 – Command Position Registers

Registers 17,18 contain the command position. This value is read by the module whenever any of the following commands are issued in register 66: "index/move," "define fdbk position," "home axis," "tune gains," "define gearing position," "set gearing position when marker occurs" and "define sync position." The units are encoder counts.

The value is also read when any of the following commands are issued in register 67: "enable passive homing on feedback encoder marker pulse," "enable passive homing on gearing encoder marker pulse,". "enable relative change in feedback position," and "enable relative change in gearing position."

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4.17 Registers 19, 20: Command Velocity

Registers 19, 20 contain the command velocity. This value is read by the module whenever the following commands are issued: "index/move", "home axis", "tune dynamics", "tune feedforward", or "change velocity" in R66; or "velocity control" in R65. The command velocity units are:

(encoder counts/sec)*65.536

The maximum speed that can be programmed is 65,536,000 counts/sec.

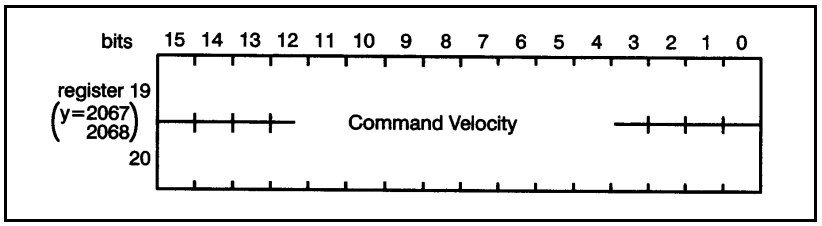


Figure 4.16 – Command Velocity Registers

4.18 Registers 21, 22: Command Acceleration

Registers 21, 22 contain the command acceleration. This value is read by the module whenever the following commands are issued: “index/move", "home axis", "tune dynamics", or "tune feedforward" in R66; or "velocity control" in R65. The command acceleration is calculated as follows:

acceleration = (eng units/sec/sec)*(encoder counts/eng units)*.065536

The maximum programmed value is 3.28×10^{10} encoder counts/sec/sec. The acceleration rate and deceleration rate (R23, 24) do not need to be equal. However, the deceleration rate must not be less than one-fifth the acceleration rate.

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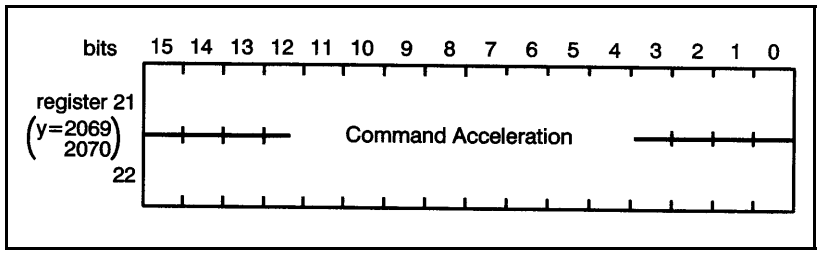


Figure 4.17 – Command Acceleration Registers

4.19 Registers 23, 24: Command Deceleration

Registers 23, 24 contains the command deceleration. This value is read by the module whenever the following commands are issued: "index/move", "home axis", "tune dynamics", or "tune feedforward" in R66; or "velocity control" in R65. The command deceleration is calculated using the same formula used for calculating "command acceleration" in R21, 22. In addition, the same maximum value applies to both command acceleration and deceleration. See section 4.18 for more information.

Note that the ratio between the deceleration rate and the acceleration rate must be between .2 to 1 and 5 to 1. The "stop motion" command in register 66 will use the value in 23, 24, depending on the state of the "stop action" bit in register 65. See sections 4.34 and 4.35 for more information.

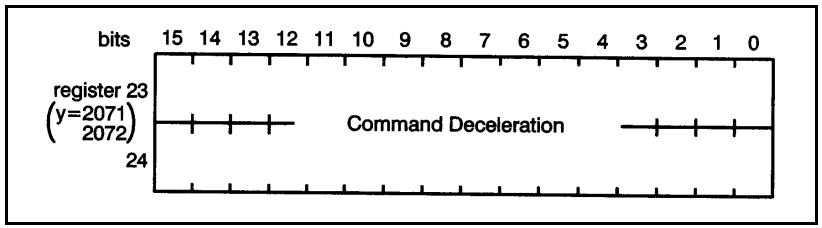


Figure 4.18 – Command Deceleration Registers

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4.20 Registers 25, 26: Gear Ratio

Registers 25,26 contain the gear ratio between the feedback and gearing reference axes. This value is read by the module whenever the "enable gearing" (register 65) or "change gear ratio" (register 67) command is issued. Refer to figure 4.19. The gear ratio calculation method depends on the value of "gear ratio format" (R38, b2). If this bit is equal to 0, the value can be calculated with the following equation:

$$\text{Gear Ratio} = \frac{(\text{feedback axis travel}) * 16777216}{\text{gearing reference axis travel})}$$

If R38, b2 is set, the gear ratio is the ratio of two 16-bit numbers in registers 25 and 26. Register 25 is the numerator. Register 26 is the denominator. The denominator cannot be a negative number or 0.

If the result of the calculation is a repeating fraction, e.g., 1/3, the module will keep track of all remainders for internal gearing calculations. The allowable ratio range is 127:1 to 1:32767.

Note that if the gearing bit mode is set (R65, b1) and any illegal condition is present in registers 25,26, gearing is not enabled. If gearing is already enabled and a "change gear ratio" command is issued (R67, b3), with illegal parameters in registers 25,26, an illegal command fault will result.

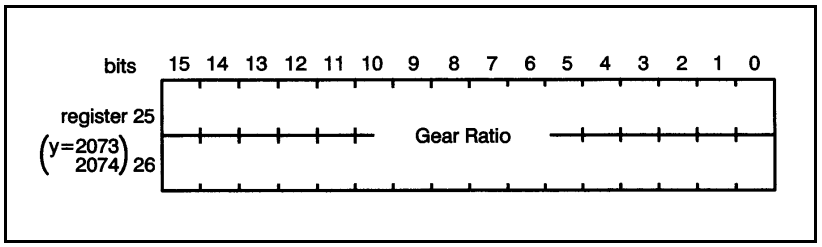


Figure 4.19 – Gear Ratio Registers

4.21 Register 27: User LEDs

Register 27 is used to drive the three user controlled LEDs on the faceplate of the module. These bits are read by the module only when the "update LEDs" (register 66) command is issued. Register 2075 (Y axis) can be used to update the

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same user LEDs when the “update LEDs" command (register 2114) is issued. Since this could lead to confusion, you should only use one register (either 27 or 2075) in an application, but not both. Refer to figure 4.20.

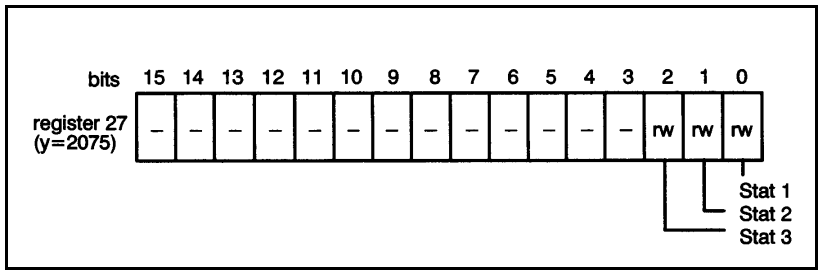


Figure 4.20 – User-Controlled LED Register

4.22 Register 28: Direct Drive Reference Command

Register 28 can be used to provide a direct reference to the drive. This value is read continuously by the module whenever the "output volts" (register 65) command is issued. The values may range from -1984 to 1984 corresponding to an output range of ±10 volts. Refer to figure 4.21.

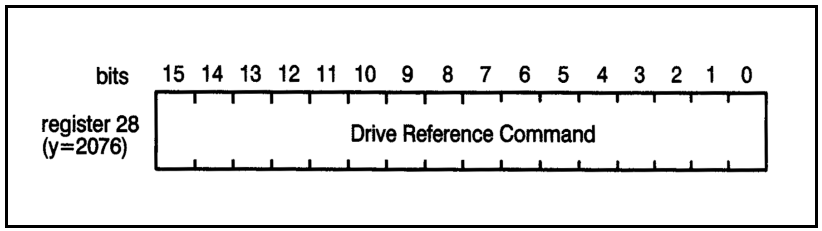


Figure 4.21 – Drive Command Reference Register

4.23 Registers 29, 30: Sync Position

Registers 29, 30 contain the sync position. The sync position register can be used to define a position where an action needs to occur. This register is read by the module whenever the "define sync position" (register 66) command is issued. The sync position is used in conjunction with "position >=" or "position <" bits in register 72. When the value in the sync

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position registers is changed, the "position >=" and "position <" bits in register 72 are undefined until another "define sync position" command is issued. The sync position will be compared to the actual current feedback position, an internal value (not registers 74/75). The units are encoder counts. Refer to figure 4.22.

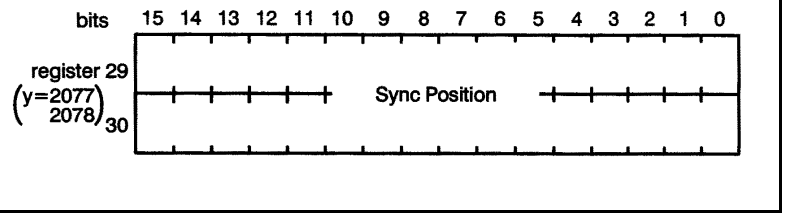


Figure 4.22 – Sync Position Registers

4.24 Register 31: Maximum Voltage Reference

Register 31 limits the maximum voltage reference to the drive. This value should be set prior to outputting any reference to the drive.

CAUTION

ALWAYS PLACE A LIMIT ON THE MAXIMUM VOLTAGE REFERENCE TO THE DRIVE. FAILURE TO OBSERVE THIS PRECAUTION COULD RESULT IN DAMAGE TO OR DESTRUCTION OF THE EOUIPMENT.

The value in register 31 is read by the module whenever the "change default setups" command in register 66 is issued. The value may range from 0 to 1984, corresponding to an output range of 0 to 10 volts. Refer to figure 4.23.

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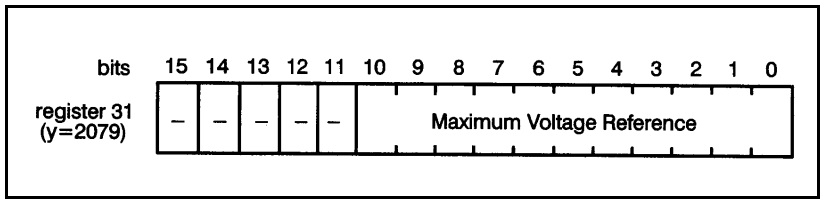


Figure 4.23 – Maximum Voltage Reference Output Register

When the drive is configured as a velocity regulator, register 31 should be used to limit the voltage reference. This feature is used if the drive requires less than 10 volts for full speed. If the drive is configured as a current regulator, register 31 can be used as a programmable current clamp. The "output clamped" bit in register 73 will be set when the voltage reference is limited by the value in register 31.

4.25 Register 32: Positive Linearization Constant

Register 32 contains the positive linearization constant for the velocity output. This value is used by the module to insure that the velocity output is linearly related to the number computed by the software. Initially, this value should be set to -1. The "tune dynamics" command in auto-tuning will adjust this number if the drive has been configured as a velocity regulator.

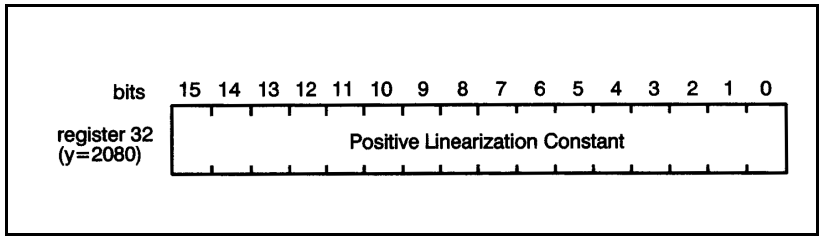


Figure 4.24 – Positive Linearization Constant Register

4.26 Register 33: Negative Linearization Constant

Register 33 contains the negative linearization constant for the velocity output. This value is used by the module to

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insure that the velocity output is linearly related to the number computed by the software. Initially, this value should be set to -1. The "tune dynamics" command in register 66 will adjust this number if the drive has been configured as a velocity regulator.

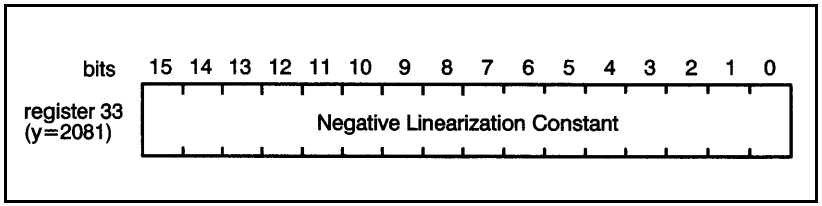


Figure 4.25 – Positive Linearization Constant Register

4.27 Registers 34, 35: Feedback Unwind Constant

Registers 34, 35 contain the unwind constant for the feedback encoder. Refer to figure 4.26. This parameter is used in the rotary mode selected in register 0 (Encoder Setup). This value is read by the module whenever the "home axis" or "change default setup" commands (register 66) are issued. The unwind constant is equal to the number of encoder counts per axis revolution. Use the following equation to determine the unwind constant:

$$\text{Unwind Constant} = \text{encoder counts/rev} * \frac{\text{encoder revolutions}}{\text{axis revolution}}$$

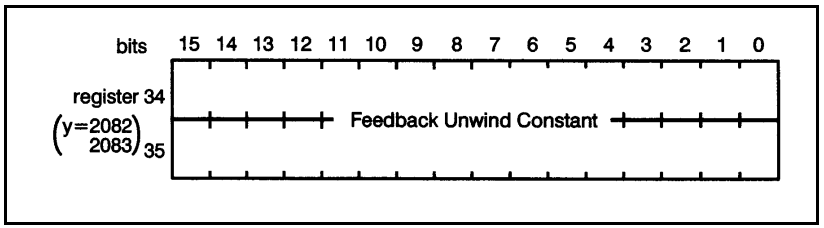


Figure 4.26 – Feedback Unwind Constant Registers

4.28 Registers 36, 37: Gearing Unwind Constant

Registers 36, 37 contain the unwind constant for the gearing encoder. This parameter is used in the rotary mode selected

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in register 0 (Encoder Setup). This value is read by the module whenever the "home axis" or "change default setup" commands in register 66 are issued. The unwind constant is equal to the number of encoder counts per axis revolution. Use the same formula in the gearing unwind constant and the feedback unwind constant. See section 4.27 above for the formula.

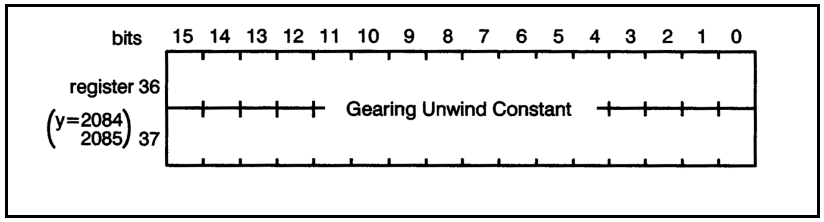


Figure 4.27 – Gearing Unwind Constant Registers

4.29 Register 38: Gearing Modes, Ratio Format, Ramp Velocity Control

Register 38 is used to determine gearing mode if bit 9 in register 65 is not set (0), to select the gear ratio format, and to enable ramp velocity control. Note that changes to registers 38 will be ignored while gearing mode is enabled in register 65. See figure 4.28.

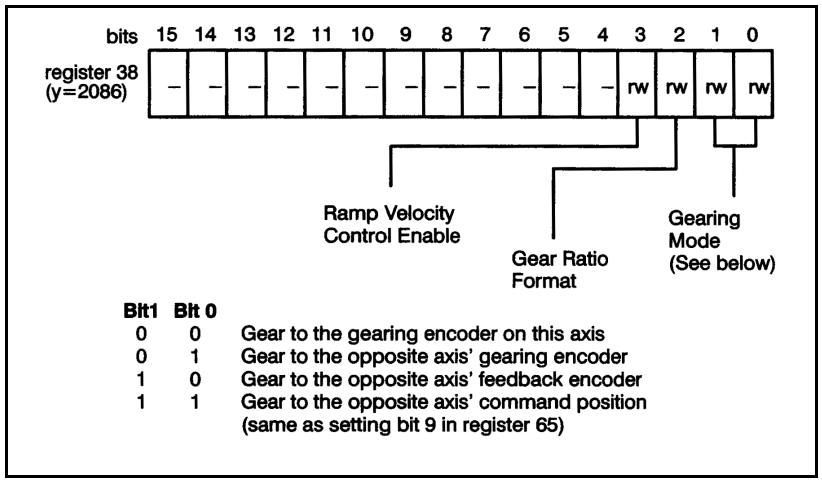


Figure 4.28 – Gearing Mode, Ratio Format, and Ramp Velocity Control Register

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Note that the strobed gearing registration position (registers 86,87) and the current gearing position (registers 76, 77) data are not affected by the selections made in register 38. X and Y axis gearing registration and current gearing position values will always be strobed from their respective hardware encoder channels.

Bit 2 in register 38 selects the format of the gear ratio. The default (0) is a 32-bit number stored in registers 25,26 scaled by 16777216. Setting bit 2 to 1 allows you to express the gear ratio as a ratio of two 16-bit numbers in registers 25 and 26. See section 4.20 for more information.

Bit 3 in register 38 enables ramp velocity control on the follower axis when the master axis is moving and gearing is enabled, when you are changing from the non-geared to the geared mode, or when the gear ratio is changed while gearing is enabled. This command will limit the rate of acceleration and deceleration until the axis is synchronized with the master. Note that this limit applies only to trapezoidal acceleration, not to S-curve acceleration. Once the axis is synchronized with the master, there is no limit on acceleration/deceleration through register 38, bit 3. When ramped velocity control is selected, if gearing is disabled while the follower axis is still moving, the follower axis will continue to move at that velocity until a stop motion command is issued in register 66, bit 6.

4.30 Registers 39, 40: Backlash Compensation

Registers 39 and 40 are used to store a signal value (in counts) that selects the amount of backlash compensation. The sign of the value corresponds to the approach direction. Refer to figure 4.29.

For example, a value of +20 entered here will mean that an incremental move of 100 counts will result in an actual move of 100 counts and then a stop. The same move in the negative direction will result in the axis moving - 120 counts, +20 counts, and then a stop.

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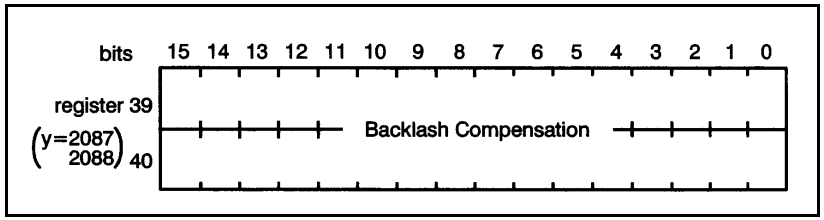


Figure 4.29 – Backlash Compensation Registers

4.31 Register 41: Registration Input Edge Detection

Register 41 selects which edge (rising and falling, or falling only) of the gearing or feedback registration input will be recognized by the module. This register is available only on the B/M 57422-2 module.

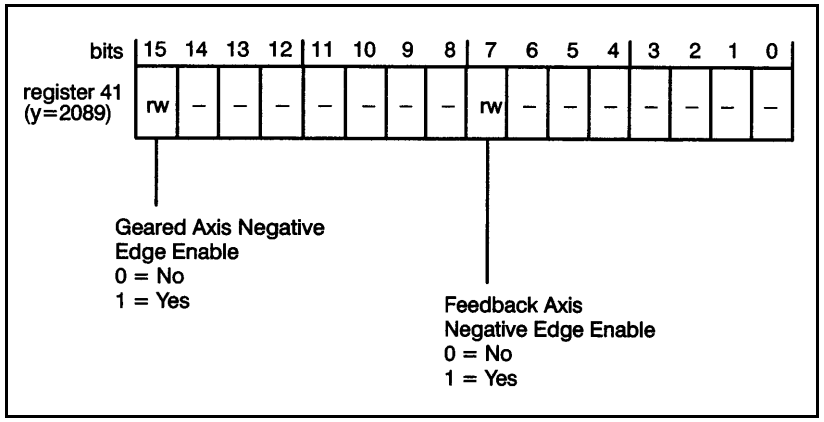


Figure 4.30 – Registration Edge Detection Register

When bits 7 and 15 are left at the default value (0), the module will recognize both the rising and failing edges of registration inputs.

4.32 Register 63: Auto-Acknowledge

Register 63 is the command auto-acknowledge register. When bit 0 is set to 1, the module will automatically clear the command registers (66 and 67) instead of requiring an application task to clear the command registers. The user

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need only wait for the value in registers 66 and 67 to be zero before issuing the next command.

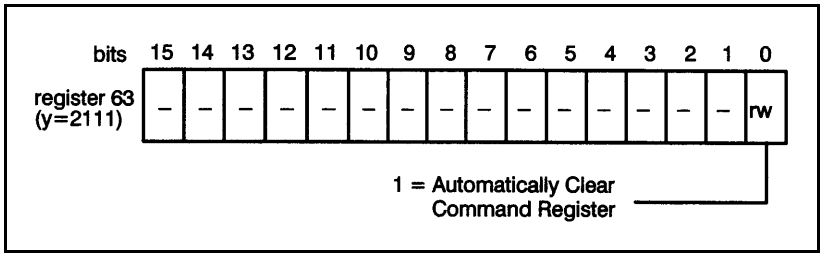


Figure 4.31 – Auto-Acknowledge Register

4.33 Register 64: Interrupt Reset

To reset the interrupt, the application task must write a zero value to register 64. **Note that register 64 Is used as the Interrupt reset register for both the X-axis and the Y-axis.** See figure 4.32.

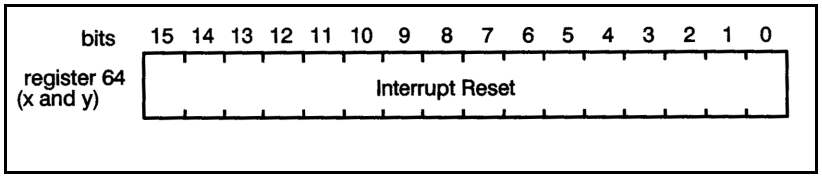


Figure 4.32 – Interrupt Reset Register

4.34 Register 65: Mode

Register 65 is a control register used to command operating modes on the module. This register is read by the module continuously. Refer to figure 4.33.

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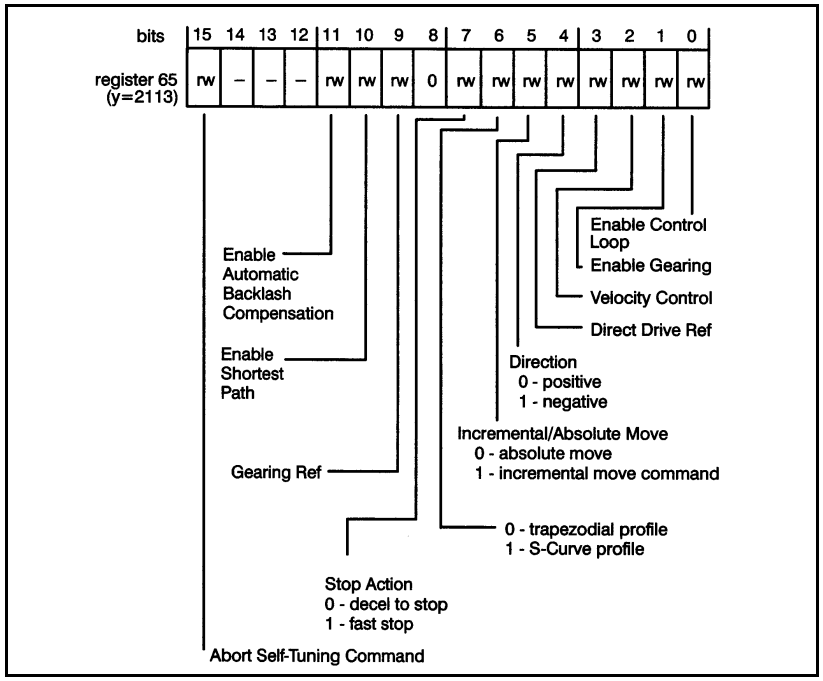


Figure 4.33 – Mode Register

The enable control loop bit commands the module to switch on the control loop (position/velocity) and enable the drive reference from the module. It also causes the microprocessor to read set-up data and reset faults when toggled.

The enable gearing bit commands the module to ratio the feedback encoder to the gearing encoder. This function is useful for electronic lineshaft applications. Note that if the gearing function is used, register 25, 26 must contain the gear ratio.

If gearing is enabled or disabled with ramp velocity control disabled, the axis will accelerate or decelerate in current limit.

If gearing is disabled with ramp velocity control enabled, it is possible to do an absolute move while the drive is still in motion. The new commanded position to which to move must be either behind the current position, or farther forward than the current position plus the distance required to

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decelerate to a stop. If the position is not beyond the distance required to decelerate, the axis will overshoot.

The velocity control bit causes the axis to run at the velocity defined by the command velocity input (registers 19, 20). This mode is used to run the axis as a velocity regulator. Velocity regulation is achieved by sending a constantly variable position reference to the position loop. This means the axis can still "trip" due to position error, i.e., the value in register 80 is greater than the value in register 8.

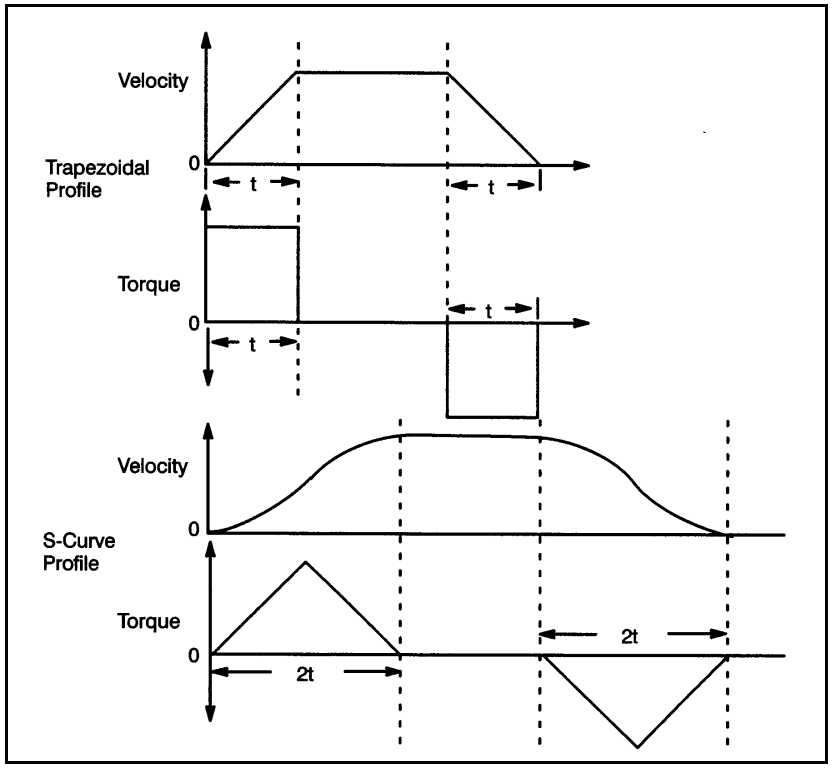
The direct drive reference bit commands the module to output the value in register 28 to the drive. This command causes the axis to function like a D/A converter.

The direction bit specifies the relationship between the gearing axis and feedback axis when gearing is used, or to specify the sign of the velocity command when velocity control is used. When gearing is active, a positive direction indicates that the gearing and feedback axis will move in the same direction. A negative direction indicates that they will move in opposite directions. If you jog into the positive or negative software travel limit, and then try to jog off the limit by changing the state of the direction bit, the axis will remain at the travel limit. To be able to jog off a software travel limit, you must first turn off the velocity control bit (bit 2), and then turn it back on with the direction bit changed. See sections 4.13 and 4.14 for more information on software overtravel limits.

The incremental/absolute move bit specifies the type of move to be made. If you specify an absolute move, the axis will move to the position specified in register 17. If an incremental move is specified, the module will add the current value in register 17 to the position of the axis to determine the next position.

The velocity profile bit specifies the type of profile the drive will execute when accelerating or decelerating, whether doing an absolute move (bit 5) or velocity control (bit 2). Using an S-Curve profile doubles the time required to accelerate and decelerate compared with the trapezoidal profile. Note that If you select S-Curve, you cannot change velocity while moving (register 66 bit 8) or an illegal command fault will be generated. See the figure below for a sample profile comparison.

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The stop action bit defines the way that the drive will stop when a "stop motion" command (register 66) is issued. If a "decel to stop" is selected and the module is not in the cam mode, the drive will ramp to a zero speed at the rate in register 23, 24 when the motion is started. If the module was in the time cam mode, it will complete the current cam cycle and return to the beginning of the profile. If the module was in position cam mode, cam execution will stop immediately. If a "fast stop" is selected, the module will command the drive to decelerate at the rate specified in register 23, 24 when the "home" command is issued. If a "fast stop" is selected, a "home", or "tune dynamics" command MUST be done to load the "fast stop" deceleration rate. If the application does not normally do a "home" command, you can use the mode of homing that does not cause any motion. See section 4.35 for more information. The feedback loop will remain enabled.

The gearing reference bit defines the source of the gearing reference. Bit 9 = 0 if you want the gearing reference to be determined by register 38. If the reference is an encoder, you

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must connect the encoder to the proper inputs on the terminal strip. If you want to gear to the opposite axis command position, set bit 9 = 1. This option does not require you to make any external wiring connections. In this mode, the geared axis will follow all changes to the command position of the reference axis.

The enable shortest path bit allows the module to determine the shortest path to take when doing an absolute move in rotary mode.

No Incremental moves can be performed if this bit is set. If rotary mode is not selected (in register 0, bits 4 and 12), setting the enable shortest path bit will cause an illegal command fault.

The enable automatic backlash compensation bit allows you to enable automatic backlash compensation as specified in registers 39 and 40.

The abort self-tuning command is used to abort a self tuning command. This is the only command that is accepted while the module is doing a self-tune.

4.35 Register 66: Command

Register 66 is used to command actions from the module. The bits in this register and in register 67 are mutually exclusive, i.e., only one function may be selected at a time from either register. This register is read by the module continuously. Refer to figure 4.34.

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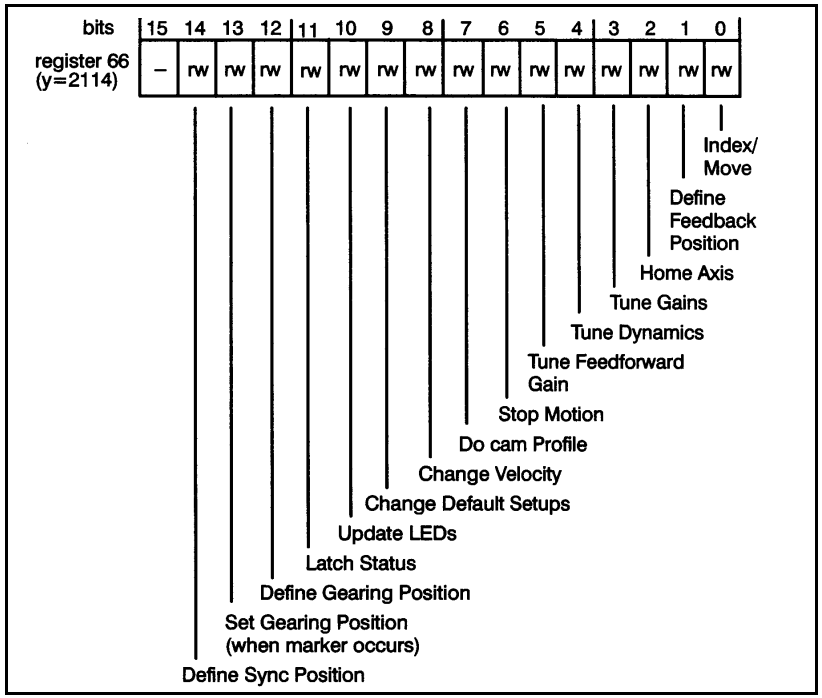


Figure 4.34 – Command Register 66

The index/move command will cause the axis to move according to the parameters defined in registers 17-24 and register 65, bit 5. Once a move has been initiated, the accel and decel rates may not be changed until the move is complete. Velocity can be changed during a move by issuing a "change velocity" command. Final position may be changed during a move by issuing another index move.

The define feedback position command will cause the current position of the feedback to be defined by the value in registers 17-18. The axis will not move.

The home axis command will cause the axis to perform the homing sequence that was defined by the bits in register 2. Four different homing sequences for the feedback axis are possible, depending on whether a home limit switch and encoder marker pulse are specified in register 2. These four sequences are described below. Note that it is also possible to home on the feedback or gearing encoder marker pulse. See section 4.36 for more information. When a "home" command is issued, the deceleration rate in registers 23, 24

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is saved and used for the "stop motion" command if the "stop action" bit is set in register 65.

1. No home limit switch and no encoder marker pulse. When the "home axis" command is issued, the value in registers 17, 18 is assigned to the current axis position. The axis does not move.
2. Encoder marker pulse only. When the "home axis" command is issued, the axis moves in the specified direction at the slow home speed (registers 15, 16) until the marker pulse is detected. The value in registers 17, 18 is then assigned to the axis position.
3. Home limit switch only. When the "home axis" command is issued, the axis moves in the specified direction at the fast home speed (registers 19, 20) until the home limit switch is detected. The axis then stops and moves in the opposite direction at the slow home speed (registers 15, 16) until the limit switch is cleared. The value in registers 17, 18 is then assigned to the axis position.
4. Both the home limit switch and encoder marker pulse. When the "home axis" command is issued, the axis moves in the specified direction at the fast home speed (registers 19, 20) until the home limit switch is detected. The axis then stops and moves in the opposite direction at the slow home speed (registers 15, 16) until the limit switch is cleared. After clearing the home limit switch, the axis continues in the same direction at slow speed until the marker pulse occurs. The value in registers 17, 18 is then assigned to the axis position.

Tune gains, tune dynamics, and tune feedforward gain are auto-tuning commands that work differently from other commands. While the auto-tuning process is underway, the module will not respond to any commands other than the "abort self-tuning" command (register 65). For this reason, you should not attempt to issue self-tuning commands for one axis while issuing any commands to the other axis. Normal operation of both axes should be halted while self-tuning is being done. Only one axis at a time may be tuned.

Note that the application software disk includes an auto-tuning procedure. See also section 5.2 for more information about tuning.

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The self-tuning of an axis should always be done in the following order:

1. Tune gains
2. Tune dynamics (if required by application)
3. Tune feedforward gain (if required by application)

The tune gains command is used to initiate self-tuning of the control loop gains. The module will tune the gains in the following order:

1. Deadband Compensation
2. Velocity Gain
3. Integral Gain
4. Proportional Gain

The tune gains command results in movement of the axis in both directions. Registers 17, 18 are used to define the tuning increment i.e., the distance that the axis will move while attempting to auto-tune. This increment is typically between .25 and .5 revolutions of the motor shaft.

The results obtained from the "tune gains" command are stored in registers 3, 4, 5, and 7.

The tune dynamics command will determine the maximum velocity and accel and decel limits for the servo system (motor and drive). Register 8 is used to define the maximum allowable following error. Registers 11, 12 are used to define the allowable travel distance, and registers 19 through 24 are used to limit the accel, decel and velocity. The feedback encoder should be in "linear" mode while this function is being performed. If there are no machine limitations, these registers may be set to any large value. In order for this command to work properly, the motor must be able to rotate in both directions for many revolutions. If this is not possible, this command should not be used.

The results obtained from the tune dynamics command are stored in registers 19 through 24. These values represent the maximum values achievable with minimum following error. You can exceed these values if you are not concerned with the amount of following error or you can use a lower value if your application requires ft.

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The tune feedforward gain command will self-tune the feedforward gain. The feedforward gain can be used whenever the reference to the drive is a current reference or a velocity reference and the speed loop in the drive is a proportional-only control. Feedforward gain should not be used if the drive contains a proportional+ integral velocity loop.

The feedforward gain is used to compensate for the offset that occurs in a proportional speed regulator between set speed and actual speed. The feedforward gain allows you to null out this offset over the entire speed range for a fixed motor load. However, overshoot can occur during incremental and absolute moves. Register 8 is used to define the maximum allowable following error. Registers 11, 12 and 13, 14 are used to limit the travel. The value chosen should be such that no mechanical interference will occur. Registers 19, 20 should be set to 80%-90% of maximum velocity. Registers 21 through 24 should be set to some reasonable value, i.e., a percentage of the maximum capable by the machine. The feedback encoder should be in "linear" mode while this function is being performed. In order for this command to work properly, the motor must be able to rotate in both directions for many revolutions. If this is not possible, this command should not be used.

The results obtained from the "tune feedforward" command are stored in register 6.

The stop motion command is used to stop the axis. This command works in conjunction with the “stop action” bit in register 65.

The do cam profile command is used to execute a cam profile stored in registers 128-2046. The time cam will be executed as soon as this command is issued. If position cam is enabled in register 130, the axis waits for the master reference position to be exceeded before entering the cam table. The axis should be less than the master reference position when this command is issued. The "do cam profile" command enables the test that determines whether master position $\geq$ master reference position.

The change velocity command is used after "velocity control" mode in register 65 is set to modify the velocity of the axis. You can also use this command to change the velocity while making a move.

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The change default setups command is used to load and update setup information, which includes registers 0-14, 31, 34-37, and 83 on the module whether the control loop is enabled or not.

The update LEDs command will transfer the data in register 27 (and 2075) to the three LEDs on the faceplate of the module.

The latch status command will update the module current status registers (74-81).

The define gearing position command allows you to define a position via register 17, 18 for the gearing encoder.

The set gearing position command is also used to define a position for the gearing encoder. If a gearing marker pulse was defined in register 2, bit 12, then the gearing position will be set when the marker pulse is detected. The status of the marker pulse is reflected in register 72, bit 10. If a marker pulse was not defined, then the position is set when the "set gearing position" command is executed. Note that this last mode is the same as the "define gearing position" command.

The define sync position command is used to define the sync position in registers 29, 30.

4.36 Register 67: Command

Register 67 is used to command actions from the module. The bits in this register and in register 66 are mutually exclusive i.e., only one function may be selected at a time from either register. This register is read by the module continuously. Refer to figure 4.35.

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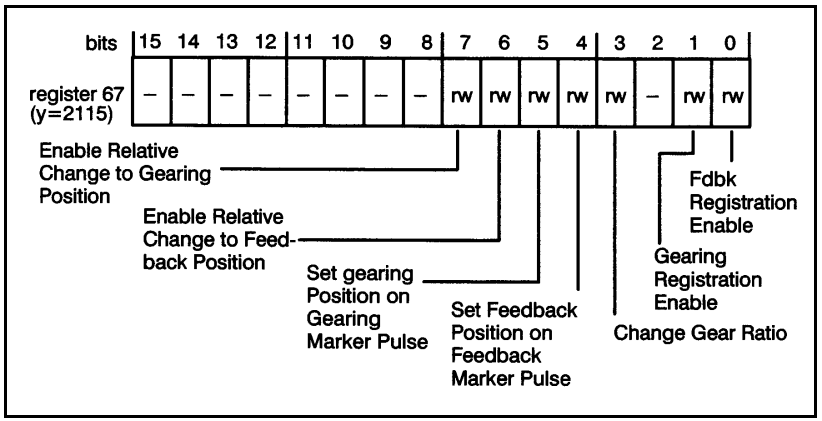


Figure 4.35 – Command Register 67

Feedback registration enable and/or gearing registration enable is used to sense the respective registration digital input. If the enable is set, any transition of the registration input will cause the current gearing or feedback position to be stored in registers 84 through 87. This is useful when attempting to synchronize the axis to an external event. See section 4.31 for more options regarding registration. Also see section 4.37 for a description of the "feedback registration sensed" and "gearing registration sensed" bits (R72, b8 and b9).

The change gear ratio command is used to alter the gear ratio set in 25/26 when you are running in the gearing mode. This command can affect physical motion in the system.

The set feedback position on feedback marker pulse command enables passive homing. This command does not cause any motion. It only enables the logic such that when a feedback marker pulse is detected, the value in registers 17, 18 is assigned to the axis feedback position. Marker pulses are enabled in register 2. Note that there are other methods of homing described in section 4.35.

The set gearing position on gearing marker pulse command enables passive homing for the gearing encoder. On the next gearing encoder marker pulse, the value in registers 17, 18 is assigned to the axis gearing position. Marker pulses are enabled in register 2. Note that there are other methods of homing described in section 4.35.

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The enable relative change to feedback position command results in the value registers 17, 18 (the command position) being added to the feedback position. This command only causes the drive to change where it "thinks" it is. It does not cause the drive to move.

The enable relative change to gearing position command results in the value in registers 17, 18 (command position) being added to the gearing position. This command does not cause the drive to move. It only causes the drive to change where it “thinks” it is.

4.37 Register 72: Status

Register 72 is the status register. This register is updated continuously by the module, except during an auto-tune operation. As soon as an auto-tune sequence is completed, updating will begin. This register is read-only. Refer to figure 4.24. See 4.49 for more information on causing interrupts on the corresponding status.

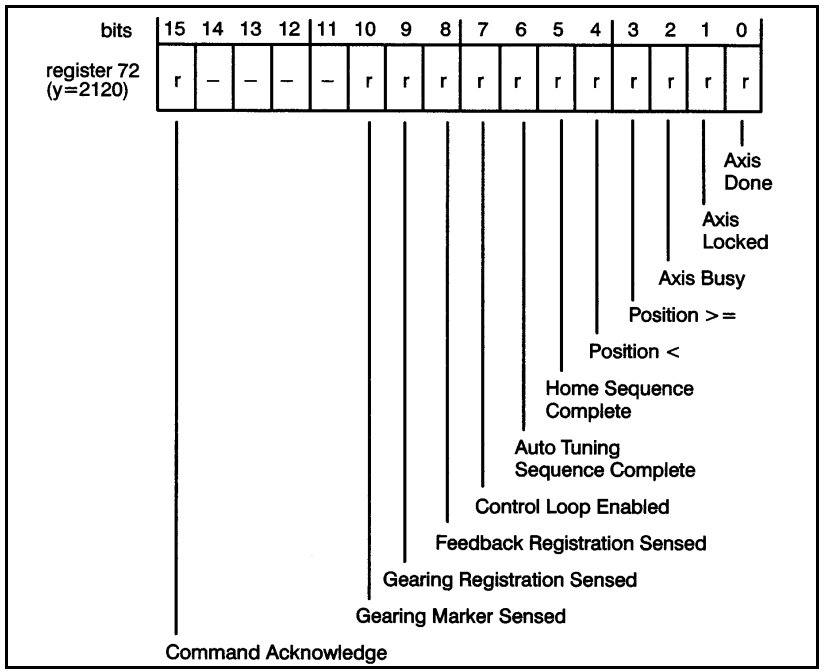


Figure 4.36 – Status Register

Axis done status indicates whether the programmed motion

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has been completed. It does not necessarily mean that the axis is at the commanded position.

Axis locked is set whenever the absolute value of the difference between where the axis is and where it should be is less than the value stored in the in-position register (register 10). Note that the axis does not have to be stopped to be in-position, and it may not be locked after an incremental move.

Axis busy status is the logical complement of "axis done."

The position > = and position < bits work in conjunction with the “sync position” contained in registers 29, 30 and the “define sync position” command in register 66.

The home sequence complete bit indicates whether a homing sequence has been successfully completed. The bit is reset by the module when it receives a “home axis” command from register 66.

The auto tuning sequence complete bit indicates whether an auto tuning sequence is complete. This is the only status bit that will be updated during auto-tuning. This bit will be set at the end of an auto-tuning sequence regardless of whether it was completed or aborted. The bit is reset by the module when it receives an "auto tune" command.

The control loop enabled bit indicates whether the control loop (velocity/position) is actively regulating the drive. This bit reflects the status of the control loop. The control loop is disabled, and this bit is reset, by any severe fault, e.g., a drive fault or hardware overtravel as reported in register 73. The control loop is also disabled by turning off bit 0 in register 65.

The feedback registration sensed bit is reset by the "enable feedback registration" command in register 67. The bit will be set by the next occurrence of the feedback registration input, and the feedback position will be stored in registers 84, 85. This bit is not set unless the "feedback registration enable" bit in register 67 is set first. The feedback registration sensed bit stays high (1) until the "feedback registration enable" bit is toggled.

The gearing registration sensed bit is reset by the "enable gearing registration" command in register 67. The bit will be

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set by the next occurrence of the gearing registration input, and the gearing position will be stored in registers 86, 87. This bit is not set unless the "gearing registration enable" bit in register 67 is set first. The gearing registration sensed bit stays high (1) until the "gearing registration enable" bit is toggled.

The gearing marker sensed bit is reset by the "reset gearing position" command in register 66. If the gearing marker pulse has been selected in register 2, the bit will be set by the next occurrence of the gearing marker pulse.

The command acknowledge bit is set by the module to indicate that a command in either register 66 or 67 was recognized by the module. When this bit is set, you should clear the command in register 66 or 67.

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4.38 Register 73: Fault

Register 73 is the fault register. This register is updated continuously by the module except during an auto-tune operation, when it will not be updated until the end of the sequence. This register is read-only. Refer to figure 4.37. See 4.49 for more information on causing interrupts on the corresponding errors.

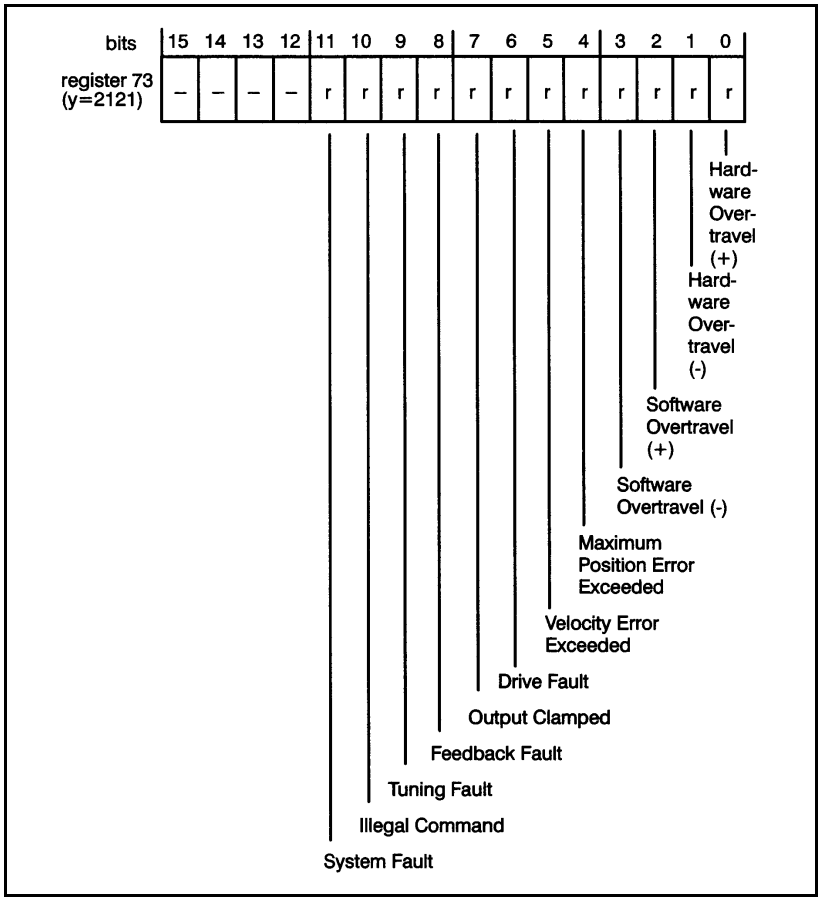


Figure 4.37 – Fault Register

The overtravel and drive fault bits can only be set if they are first enabled in register 2.

The maximum position error exceeded bit is set when the following error in register 80 has exceeded the maximum

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position error specified in register 8. Note that this bit can also be set when the axis is in the velocity mode. See 4.34 for more information about velocity mode.

The output clamped bit indicates that the output reference generated by the module is greater than or equal to the value in register 31. It does not turn the control off.

The feedback fault bit is set when the control loop is disabled due to a severe fault reflected in this same register (note that bit 7 in this register is not considered a fault bit). The feedback fault bit is also set if register 65, bit 0 is 0, i.e., the control loop is not enabled.

The illegal command bit is set in response to an illegal command. An illegal command is an attempt to issue more than one command (in registers 66 or 67) at the same time, or providing illegal parameters for a command, e.g., an acceleration rate of zero for a move command. This bit is reset by writing a zero to registers 66 and 67.

The system fault bit is set whenever the processor does a cold start, a STOP ALL / CLEAR command is issued from the programming terminal, or a processor module fails. This bit indicates that the communication between the processor module and the axis module has been broken. When this happens, feedback will be disabled, and the drive reference will be set to zero.

4.39 Registers 74, 75: Current Feedback Position

Registers 74, 75 contain the current feedback position. Registers 74, 75 are only updated when the "latch status" command in register 66 is issued. This ensures that data will be consistent while the application software interrogates it. The units are encoder counts.

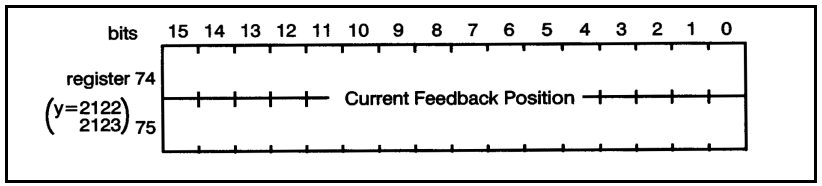


Figure 4.38 – Current Feedback Position Registers

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4.40 Registers 76, 77: Current Gearing Position

Registers 76, 77 contain the current gearing position. Registers 76, 77 are only updated when the "latch status" command in register 66 is issued. This ensures that data will be consistent while the application software interrogates it. The units are encoder counts. This data always originates from the hardware gearing inputs on the given axis, regardless of the selections made in register 65, bit 9, and register 38, bits 0 and 1.

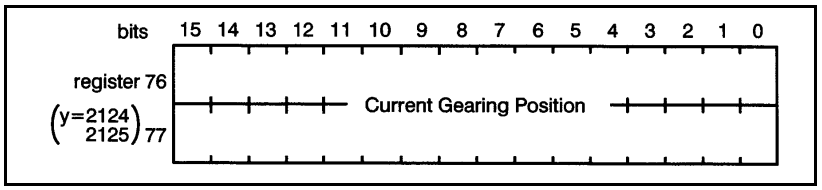


Figure 4.39 – Current Gearing Position Registers

4.41 Registers 78, 79: Current Velocity

Registers 78, 79 contain the current velocity i.e., the number of counts in the period defined in R83. Registers 78, 79 are only updated when the "latch status" command in register 66 is issued. This ensures that the data will be consistent while the application software interrogates it. The units are encoder counts.

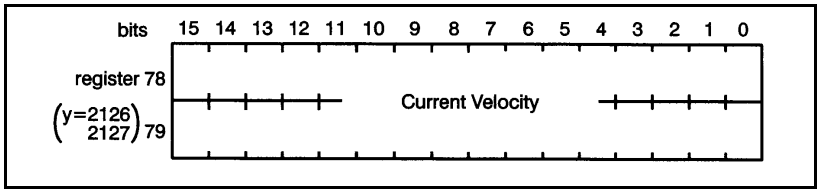


Figure 4.40 – Current Velocity Registers

4.42 Register 80: Following Error

Register 80 contains the following error. Following error is the difference between the internally commanded position and the "current feedback position" in R74, 75. Register 80 is only updated when the "latch status" command in register 66 is issued. This ensures that the data will be consistent while

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the application software interrogates it.

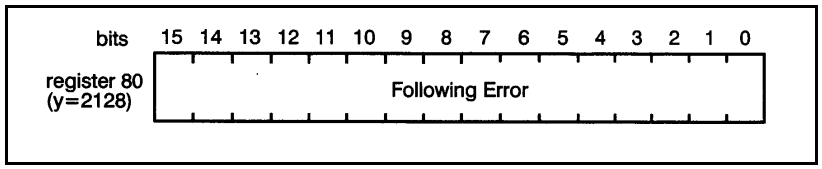


Figure 4.41 – Following Error Register

4.43 Register 81: Velocity Error

Register 81 contains the velocity error. Velocity error is the difference between the internally commanded velocity and the current velocity. Register 81 is only updated when the "latch status" command in register 66 is issued. This ensures that the data will be consistent while the application software interrogates it. Command (R66, b11) is issued. The units are encoder counts/scan.

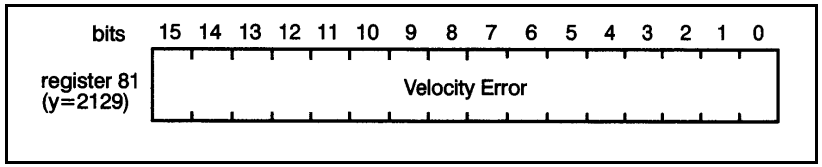


Figure 4.42 – Velocity Error Register

4.44 Register 82: Digital Input Status

Register 82 contains the digital input status. The values reported in register 82 are the actual values of the inputs without regard to the status of any bits contained in register 2. Refer to figure 4.43.

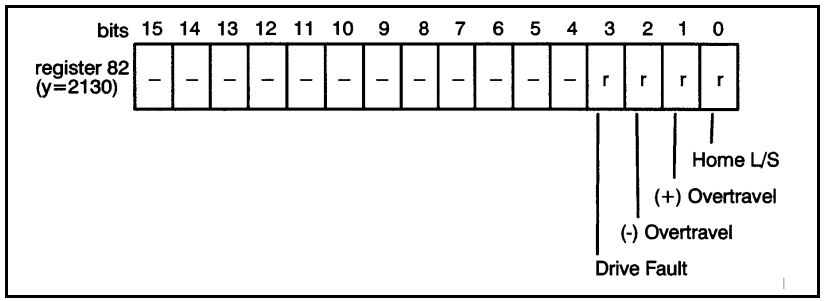


Figure 4.43 – Digital Input Status Register

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4.45 Register 83: Current Velocity Status Update Period

Register 83 contains the current velocity status update period. This value is the number of scans (1.25 msec. periods) during which data is accumulated before being supplied to registers 78, 79 when the "latch status" command is issued in register 66. The default value of R83 is 1, which can actually be loaded as 0 or 1 into the register. Note that this register is not accessed by the module until a "change default setups" command is issued in R66.

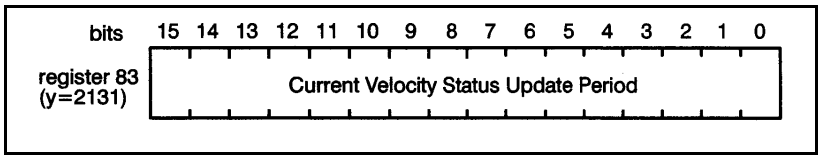


Figure 4.44 – Current Velocity Status Update Period Register

4.46 Registers 84, 85: Feedback Registration Position

Registers 84, 85 contain the feedback registration position. The value in these registers is latched if the feedback registration input is enabled (R72, b8) and the feedback registration input is activated. The status is annuciated in register 72, bit 8.

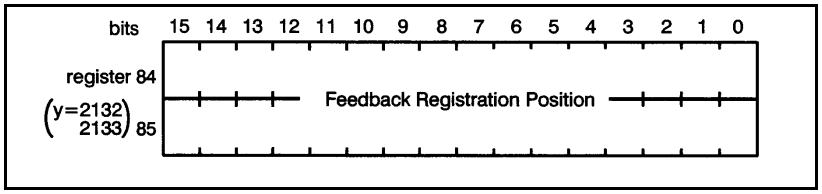


Figure 4.45 – Feedback Registration Position Registers

4.47 Registers 86, 87: Gearing Registration Position

Registers 86, 87 contain the gearing registration position. The value in these registers is latched if the gearing registration input is enabled (R72, b9) and the gearing registration input is actuated. The status is annunciated in

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register 72, bit 9.

This data always originates from the hardware gearing inputs on the given axis, regardless of the selections made in register 65, bit 9, and register 38, bits 0 and 1.

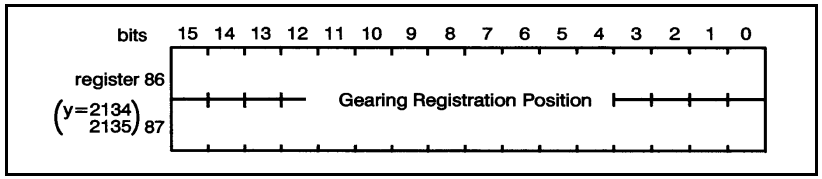


Figure 4.46 – Gearing Registration Position Registers

4.48 Registers 99-103: Software Version Number

Registers 99-103 contain the software version number as a string of 10 ASCII characters. Refer to figure 4.47.

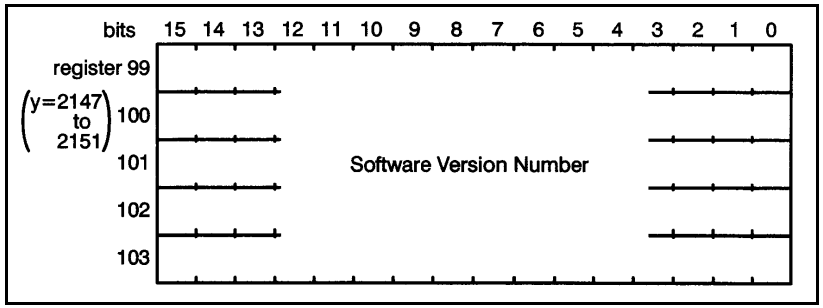


Figure 4.47 – Software Version Registers

4.49 Interrupt Registers

M/N 57C422A and later 2-Axis Servo modules support hardware interrupts. A hardware interrupt is used to trigger execution of some portion of an application task. The hardware interrupt is level-sensitive (high = true).

The interrupt is implemented through an application task task using the hardware EVENT statement. See the Enhanced BASIC language instruction manual for more information on hardware EVENT statements and the Control Block language instruction manual for more information on Control

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Block tasks.

Note that two of the registers used to implement interrupts, 64 (described in section 4.33) and 4095, are used for both the X and Y axis. To avoid any confusion, at times this section of the manual will not follow the general pattern of notation found in the remainder of this instruction manual and will explicitly refer to both the X and Y axis equivalents of the register in question instead of only the X. In other words, where the Y equivalent is given explicitly, you will not need to add 2048 to the register number given for the X axis to find the Y axis equivalent of the register number. Pairs of registers that perform one function, such as enabling interrupts, will be shown separated by a slash. For example, registers 72/73 refers to all of the bits in registers 72 and 73 as a group.

4.49.1 Registers 68/69: Interrupt Enable

Registers 72 and 73 [X-axis] and 2120 and 2121 [Y-axis) are read only registers that are used by the 2-Axis module to report motion status and fault status for the two axes on a continuous basis. You can choose to enable a hardware interrupt whenever any bit in registers 72/73 or 2120/2121 is set by the module. See section 4.37 and 4.38 for more information on these status and fault registers.

To enable interrupts, the user application program must set a bit or bits in registers 68/69, the interrupt enable masking registers, that corresponds, respectively, to a bit or bits in registers 72/73. For example, if you want to enable a hardware interrupt whenever the “axis done” bit (0) in register 72 is set by the system, set bit 0 in register 68 to enable the interrupt. If you wanted to enable an interrupt whenever the “velocity error exceeded” bit (5) in register 73 was set bit the system, you would set bit 5 in register 69.

You can set multiple bits in registers 68/69. Any bit or any combination of those bits being set by the module in the corresponding registers (72/73) will result in a hardware interrupt. See figures 4.48 and 4.49.

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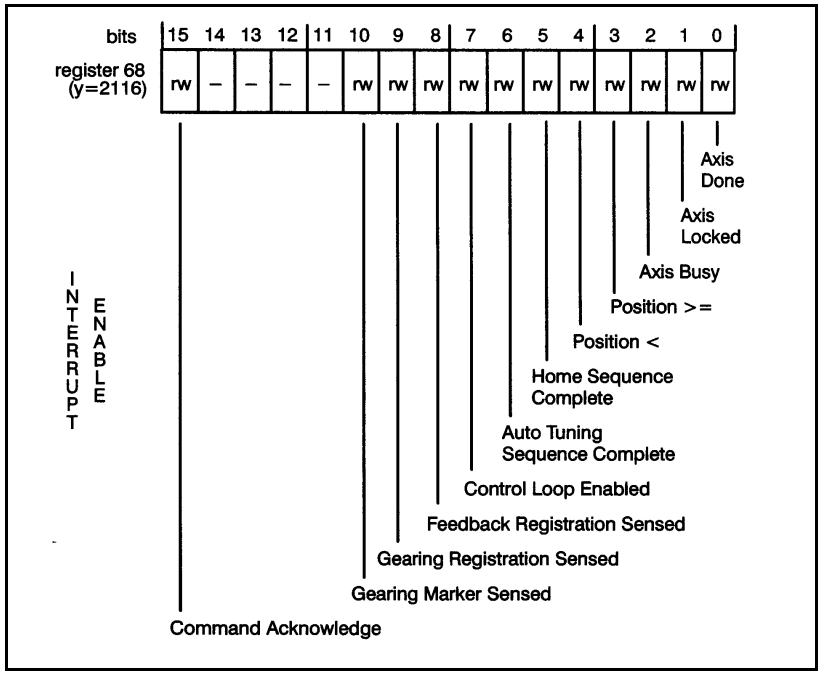


Figure 4.48 – Interrupt Enable Masking Register 68

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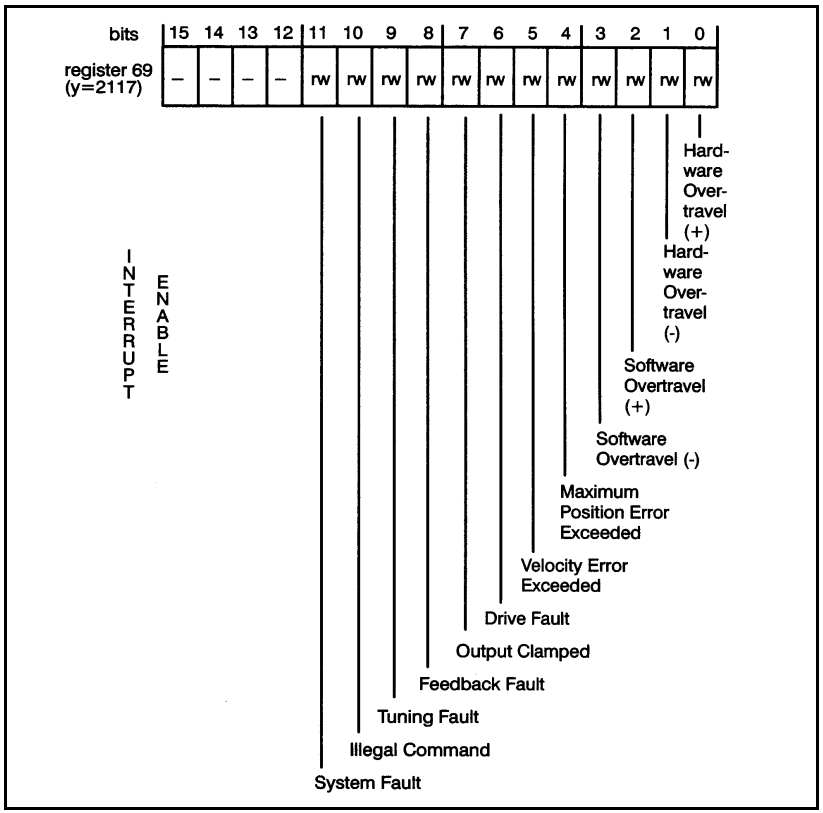


Figure 4.49 – Interrupt Enable Masking Register 69

Bits in 68/69 can be set in one of two ways. All bits in the registers can be defined separately in configuration and set to 1 in application tasks. You can also define only the registers in configuration and “mask”, the variables in application tasks with BASIC statements AND or OR.

4.49.2 Registers 104/105: Interrupt Source

Registers 104/105 are the interrupt source registers and correspond to registers 72/73 in the same manner as do registers 68/69. A user application program should read registers 104/105 to see which bit(s) were set after an interrupt occurs, i.e. after the EVENT has been set. The source of the interrupt is the corresponding bit(s) in registers 72/73. For example, to continue the example above in 4.49.1, if bit 5 in register 105 is set, the interrupt was caused

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by the allowable velocity error being exceeded (bit 5 in register 105 corresponds to bit 5 in register 73). After the EVENT has been set, the user application task must write zeroes to register 104/105. See figures 4.50 and 4.51.

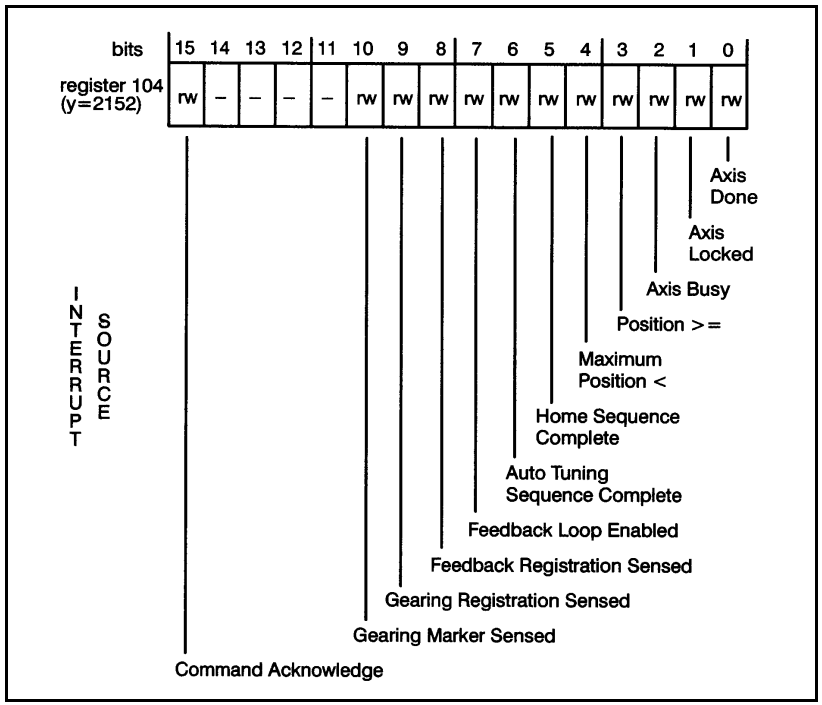


Figure 4.50 – Interrupt Source Register 104

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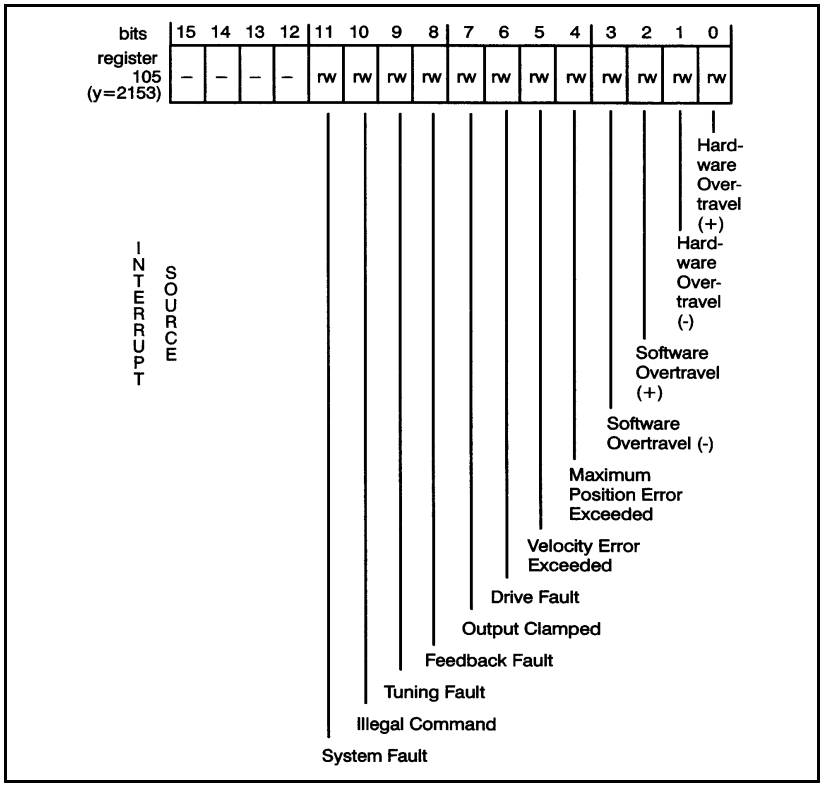


Figure 4.51 – Interrupt Source Register 105

4.49.3 Register 4095: Interrupt Status and Control (ISCR) Register

Register 4095 is the interrupt status and control register **for both the X- and the Y-axis.** This register is used by the module to allocate and manage interrupts. The variable name assigned to this register is used in the EVENT statement.

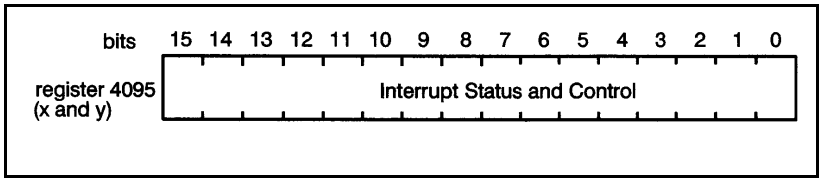


Figure 4.52 – Interrupt Status and Control Register

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4.49.4 Sample Application Task with Interrupt

The following sample application task illustrates the use of interrupts on the 2-Axis module. This is not a complete program, only a sample illustration using an interrupt. Note that this sample assumes that the raw feedback from the pulse generator is 1000 counts per revolution.

```
2000   LOCAL FDBK_SCALING
2010   LOCAL COMMAND%
2020   LOCAL DISTANCE
2030   LOCAL SPD
2040   LOCAL ACCEL
3000   INT_SRC_X! = 0                \! Initialize interrupt source
3010   INT_ENA_X! = 0                \! and enable registers and the
3020   REG_64% = 0                   \! interrupt reset register;
3021                                 ! INT_SRC_X! and INT_ENA_X! are
3022                                 ! double precision variables
3023   !
3025   EVENT NAME=HW_EVENT, INTERRUPT_STATUS= ISCR%, &
       TIMEOUT= DISABLED
3030   ! line 3025 connects the variable name ISCR% to the
3035   ! interrupt status and control register
3040   ENCODER_SETUP%=1414H          \! X-Axis gearing and feedback
3042                                 ! encoders are in rotary
3045                                 ! w/ *4 quadrature
3050   DRIVE SETUP%=0H
3060   SWITCHES%=011CH               \! enables drive fault input,
3065                                 ! overtravel L/S, feedback
3067                                 ! encoder marker pulse; home
3068                                 ! direction is in the decreasing
3069                                 ! position
3070   PGAIN%=17595
3080   IGAIN%=768
3090   VGAIN%=78
3100   FGAIN%=8320
3110   DBCOMP%=28
3120   MAX_FOLL_ERR%=2000            \! error is = to 0.5 axis revolutions
3130   MAX_VEL_ERR%=4000             \! 1 revolution of the axis
3140   IN_TOLERANCE%=10
3150   GEAR_RATIO!=0
3160   MAX_VOLTS%=1984               \! maximum volts = 10
3170   P_CONST%=-1
3180   N_CONST%=-1
3190   FDBK_UNWIND!=1600000          \! 400 axis revolutions
3200   GEAR_UNWINDI=4000             \! 4000 counts = 1 rev.
3201                                 ! from regs. 36,37
3210   COMMAND%=0200H \ GOSUB 15010 \! change default setups
3211   MODES% = 0
3215   DELAY 10 TICKS
3217   MODES% = 21H                  \! enable incremental index move
3218                                 ! and position loop
3230   FDBK_SCALING=4000             \DISTANCE=20 \ SPD =40.0 \ ACCEL = 50.0
4000   ! Index move
4010   CMD_POS! = FDBK_SCALING*DISTANCE
4020   CMD_VEL! = SPD*FDBK_SCALING*65.536
4030   CMD_ACC! = (ACCEL/4)*FDBK_SCALING*.065536
4040   CMD_DEC! =  CMD_ACC!
4050   COMMAND% = 1                  \GOSUB 15010
4055   !
4060   ! Subroutine to wait for axis done
4070   INT_ENA-X! = 00010000H
4080   WAIT ON HW_EVENT
4090   IF X_AXIS_DONE@ THEN INT_SRC_X! = 0 \ INT_ENA_X! = 0
4110   REG_64% = 0
4120   IF (INT_ENA_XI <> 0) THEN GOTO 4080
4130   GOTO 4010
4140   !
15000  ! Subroutine to wait for command ack
15010  INT_ENA_X! = INT_ENA_XI OR 80000000H
```


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```
15014  ! line 15010 ORs INT_ENA_X! with 80000000H
15020  ! to enable interrupts from bit 15 of register 72
15030  CMD66% = COMMAND%          \! loads value in COMMAND% into CMD66%
15032                             ! which is the first command
15034                             ! register on the X axis
15040  WAIT ON HW_EVENT
15042  ! after seeing the hardware event occur, test to see
15044  ! which interrupt occurred; if more than one interrupt
15046  ! is enabled, each must be chocked to see what caused
15048  ! the interrupt.
15049  !
15050  IF X_CMD_ACK@ THEN INT_SRC_X! = 0 \ INT_ENA_X!  = 0 \ CMD66% = 0
15052  ! waiting on the hardware event here ensures that the
15054  ! Axis module responds with a command acknowledge
15056  ! before anything else is allowed to occur.
15060  !
15070  REG_64% = 0 \! reset interrupts (reg 64 for both X and Y)
15080  IF (INT_ENA_X! <> 0) THEN GOTO 15040
15082  ! line 15080 checks for an interrupt on the X axis
15090  RETURN
```

4.50 Cam Registers

The following sections describe how to implement the cam profile registers. Two types of cam tables are available, position-based, and time-based. The values in the cam table are signed integers. These values represent either the relative change in position for successive intervals of time in the time-based cam, or the position of the axis with respect to a master reference position in registers 126,127 if the position-based cam is selected. Cam type is selected in register 130, bit 8. The number of positions actually stored in both the time-based cam and the position-based cam table is defined in register 128.

Time Cam

The time-based cam table can be stored either as bytes or words (16 bit registers). Byte values may range from -128 to 127 in encoder counts and are packed two per register. The lower numbered byte is stored as the least significant 8 bits of the register. There are a maximum of 3830 byte values in the table. Note that if you use the byte format, you cannot configure the values in the cam table in a configuration task or in the Programming Executive variable configurator application. You must use BASIC IOWRITE statements to write the values to the cam table within your application program.

Word values may range from -32768 to 32767 in encoder counts. There are a maximum of 1915 word values in the table. The values in the table represent the distance to move in the selected amount of time.

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In order to select the value format (bytes or words), you need to consider the number of points that are required to represent the profile and the largest value that will be required. In general, a profile can be described more accurately with more points. The largest value that can be stored in the table when time cam is selected can be calculated using the following equation:

largest value = speed * encoder * time * .00125

where: speed = max. axis velocity in eng. units/sec
encoder = encoder counts/eng. unit
time = the value in register 129

If the absolute value of the above calculation exceeds 127, you must choose the word format.

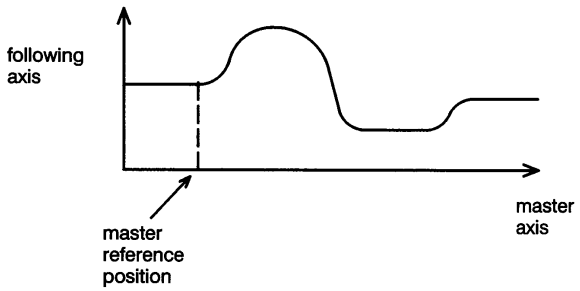
Position Cam

Register 38, bits 0 and 1 define what the axis will follow for the purposes of position-based cam. Register 125 selects the master axis position increment, i.e., the amount of travel the master moves to increment to the next position in the table, thus resulting in all points being the same distance apart. Position cam values must be in double precision integer format (32 bit values). Note that there are 956 total points possible. For the X axis, register 2044, 2045 is the last possible point in the cam table. For the Y axis, register 4092, 4093 is the last possible point in the cam table.

Linear Mode: When the master axis and the axis under control are configured for linear mode in register 0, the position cam operates in linear mode. In this mode, the first point in the table should have a value of 0.

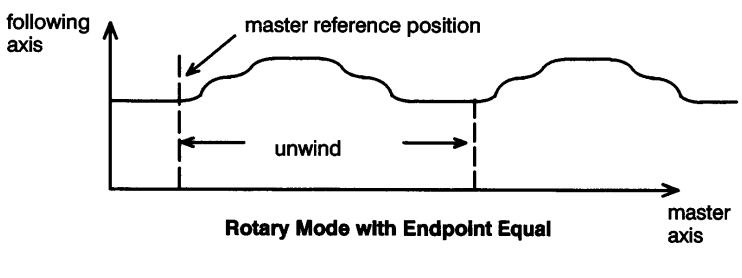
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When the master axis moves past the master reference position, the following axis saves its own current position as the base position. It then adds the position from the cam table to the base position to arrive at the absolute position at which it should be, using linear interpolation between points.



Linear Mode

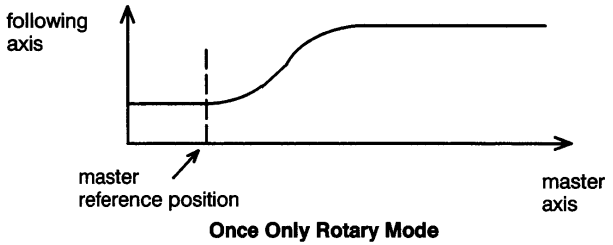
Rotary Mode with Endpoints Equal: When the master axis and the axis under control are configured for rotary mode in register 0, but the rotary position cam endpoints bit in register 130 is set to 0, the position cam will actually operate in linear mode. The beginning and ending points of the table must be equal and all positions in the table must be positive and less than the unwind constant. After the master reaches the unwind point, the following axis will repeat the cam motion. The motion of the axis under control must be completed before the master axis reaches the unwind position. If the master axis runs in reverse, the position cam will work backwards through the table. The cam will continue to execute even if the master axis backs up behind the master reference position.



Rotary Mode with Endpoint Equal

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Once Only Rotary Mode: When the master axis and the axis under control are configured for rotary mode in register 0, the rotary position cam endpoints bit in register 130 is set to 1, and the run mode bit is set to 0, the position cam will operate in the rotary mode once only. In this mode, the beginning and ending points of the table do not need to be equal. After the cam is enabled and the master axis moves past the master reference position, the cam is executed once. To enable the cam to run again, the "do cam profile" command must be issued again. When re-enabling the cam, you must ensure that the master axis is behind the master reference position.

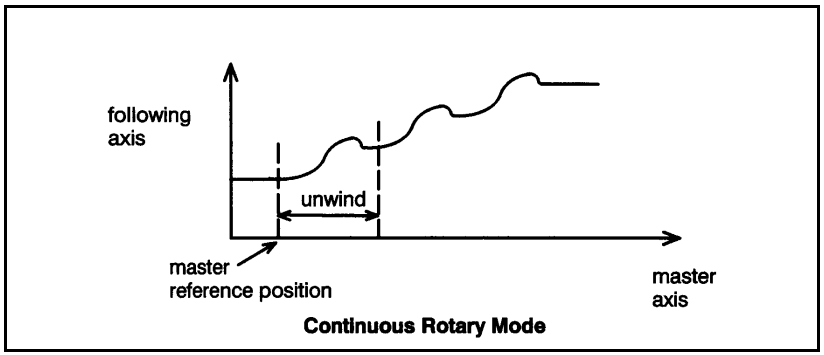


Once Only Rotary Mode

Continuous Rotary Mode: When the master axis and the axis under control are configured for rotary mode in register 0, the rotary position cam endpoints bit in register 130 is set to 1, and the run mode bit in register 130 is set to 1, the position cam will operate in continuous rotary mode. In this mode, the beginning and ending points of the table do not need to be equal. After the cam is enabled and the master axis moves past the master reference position, the cam is executed once. Then, whenever the master unwinds, the following axis will execute the cam again from its current position. If the master axis runs in reverse, the position cam will work backwards through the table. The cam will continue to execute even if the master axis backs up behind the

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master reference position.



Each point in the position cam table consists of four bytes (double precision integers). There are a maximum of 956 positions in the table if position cam is selected.

4.50.1 Register 125: Master Axis Position Increment

Register 125 is used to store the master axis position increment (in counts) for the position cam. This value selects the number of counts the master axis moves to increment to the next position in the position cam table. This value cannot be a negative number. This value must not exceed 32767. All points in the table are the same distance apart.

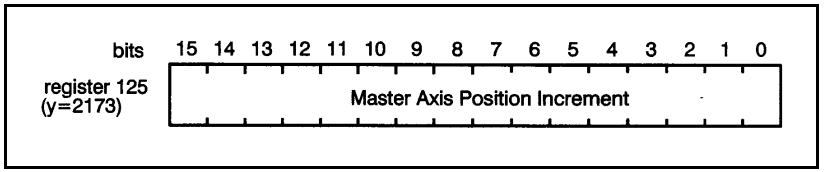


Figure 4.53 – Master Axis Position Increment Register

4.50.2 Registers 126, 127: Master Reference Position

Registers 126 and 127 are used to store the master axis position for the position cam. This double precision integer selects the position for the master at which the cam will enable movement of the following axis. Before the position cam can be enabled, the master axis must be behind the master reference position. In rotary mode, the master reference position must be less than the unwind limit or the

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cam will never be started. The value is in counts.

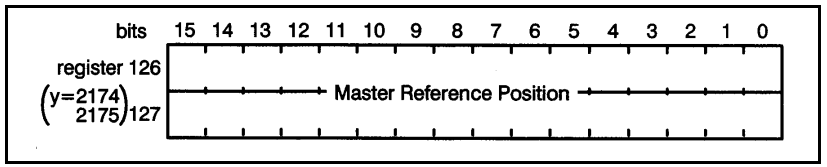


Figure 4.54 – Master Reference Position

4.50.3 Register 128: Number of Points in Cam Table

Register 128 is used to select the number of points in the cam table that are filled-in. This number represents bytes or words for a time cam profile or double precision integers for a position cam table. This register is read by the module whenever the "do cam profile" bit is set in register 66. Attempts to modify register 128 while the axis is moving will be ignored by the module. See figure 4.55.

4.50.4 Register 129: Time Between Points in Cam Table

Register 129 defines the time between points in the cam table. The unit is scans. The time can be calculated with the following equation:

$$\text{Time} = \frac{\text{cam cycle time}}{\text{number of profile points in the cam table} * .00125}$$

The time must be greater than or equal to 1. See figure 4.55.

4.50.5 Register 130: Cam Mode

Register 130 is used to select setup information about both time and position type cams and to enable the position cam. If position cam is selected, only bits 3 and 7 are used. See figure 4.55.

The data format bit defines the data in the cam profile table as either bytes or words.

If the table direction bit is set to forward, the cam moves from the lowest register (132) to the highest defined register (<=2046) in sequence. If it is set to reverse, the cam will move from the highest defined register (<=2046) to the

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lowest register (132) in sequence. As a general rule, the table should be accessed forward unless it is necessary to exactly reverse a motion. In this case, the reverse direction would be specified along with a negative motion direction.

If the run mode bit is set to 0, the cam profile is executed once according to the settings of the other cam mode bits. The loopback register (131) is not used. If "run mode" is set to 1, the time cam profile will be executed continuously according to the settings of the other cam mode bits. At the end of a time cam cycle, the module will return to the point defined in the loopback register (131). The position cam does not use register 131. See 4.50 for more information.

If the mirror image bit is set, the module will start with the data in register 132 and automatically reverse direction when the last point in the table is reached and continue back to the beginning. If "continuous mode" was selected (bit 5), the mirror will be between the last point in the table and the loopback point. If the cam is only executed once, the mirror will be from the last point in the table to register 132. This feature allows symmetrical profiles (like sine and cosine) to be defined with only half of the data points.

The motion direction bit determines the direction that the axis will move when the cam profile is executed. If the direction is positive, the axis will move in the same direction as the sign of the cam profile points. If the direction is negative, the axis will move in the opposite direction as the sign of the cam profile points.

The rotary position cam end point bit is used to select the cam table beginning/ending points if the rotary mode is selected. The default (0) means the beginning and ending points must be equal. Setting the bit to 1 means the end points may or may not be equal. See 4.50 for more information.

The cam type bit is used to select either the position or time cam. If position cam is selected (bit 8=1) then only bits 3 and 7 of the remaining bits in the register apply.

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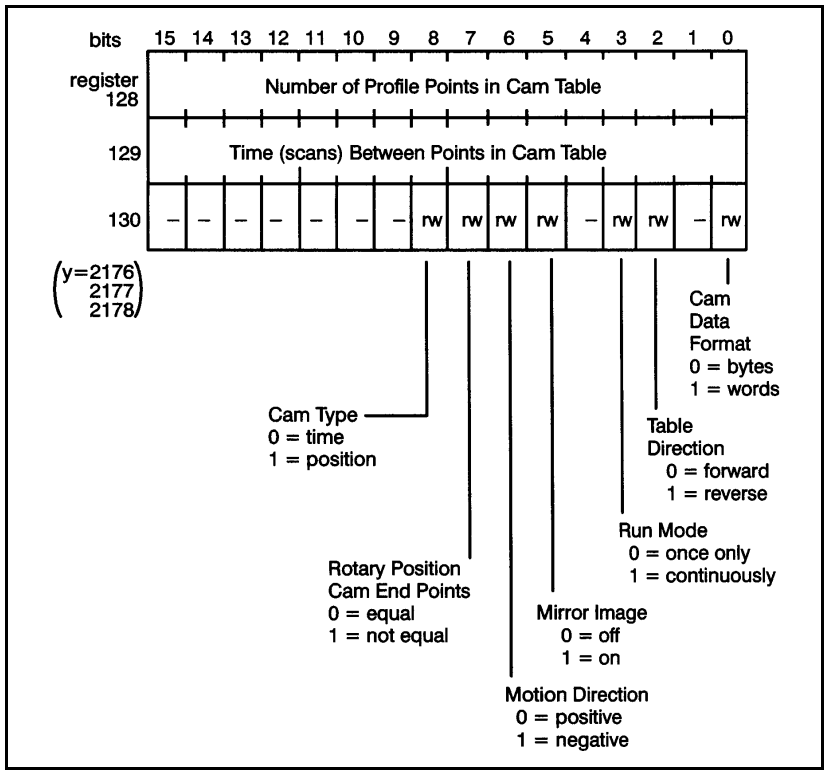


Figure 4.55 – Cam Profile Registers

4.50.6 Register 131: Loop Back Point in Cam Table

Register 131 contains the loop back point in the time cam profile. This register is not used when position cam is selected. The loop back point is the profile point to which the axis will return after reaching the end of the defined profile. If this register is used, you must ensure that both the value for the last point in the cam profile table and the value for the loopback point are within the accel/decel capability of the servo drive. The profile points between the first profile point and the loop back point are executed only once even in the continuous mode. This allows these initial profile points to be used to accelerate the axis into and out of the profile. The loopback register is not used if the cam profile is executed only once. Note that the first point in the cam table is point zero (0). Refer to figure 4.56.

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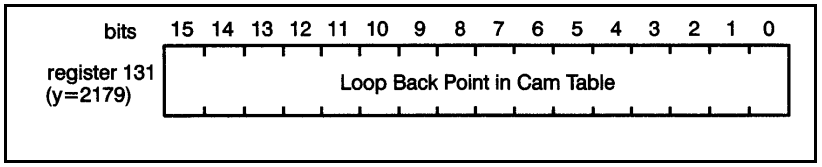


Figure 4.56 – Cam Loop Back Register

4.50.7 Cam Data Registers

Cam data is stored in registers 132-2046 for the X axis and in registers 2180-4094 for the Y axis. The number of usable points within this register range depends upon whether you have selected time cam or position cam via register 130, bit 8.

Time cam data is stored either as single precision integers (16 bits, i.e., one register) or as bytes (8 bits). The largest number of points that can be defined for a time cam is 1915 if stored as registers, and 3830 if stored as bytes. See figure 4.57 for the first and last possible points that can be defined for a time cam.

Position cam data is stored as double precision integers (32 bits, i.e., two registers), with the even number register being the lower order 16 bits. The largest number of points that can be defined for a position cam is 956. See figure 4.58 for the first and last possible points that can be defined for a position cam.

For both the time and position cam modes, the total number of points that is defined must be specified in registers 128 for the X axis and in register 2176 for the Y axis. The values in the table must be in the proper format. See section 4.50 and 4.50.5 for more information.

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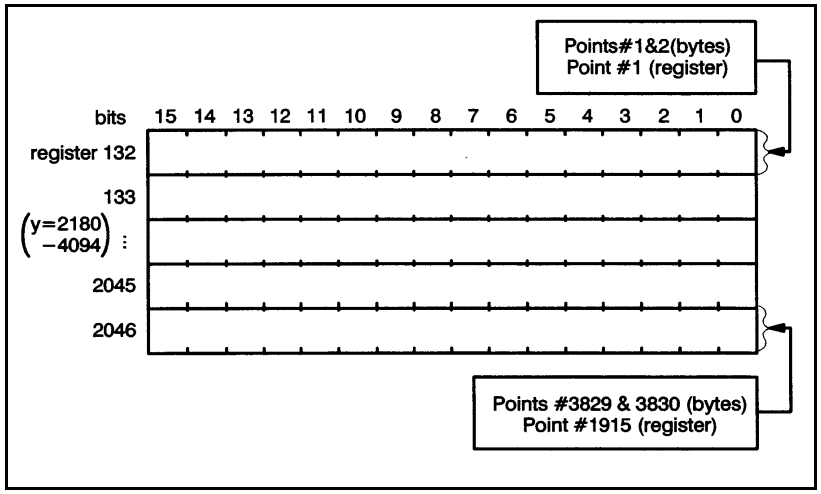


Figure 4.57 – Time Cam Data Registers

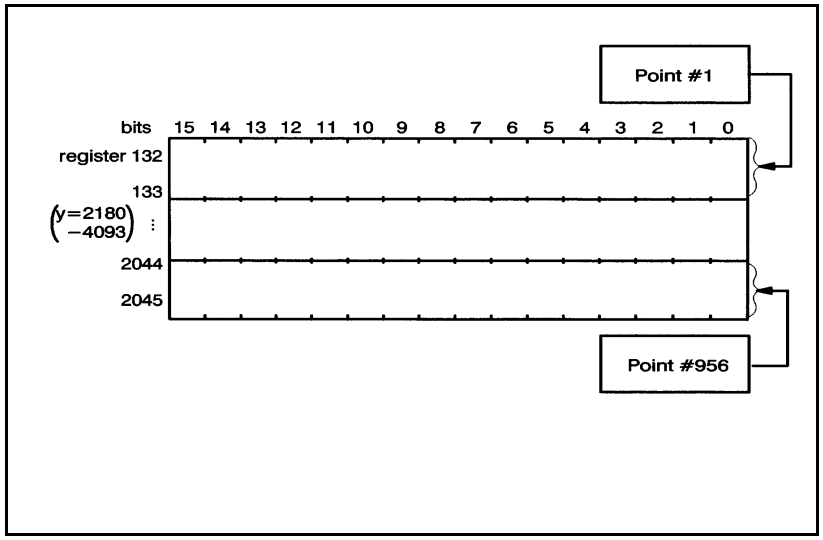


Figure 4.58 – Position Cam Data Registers

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CHAPTER 5

APPLYING THE MODULE

5.1 Required System Information

Before attempting to use this module you will need to know the following information about your existing hardware:

1. Motor/Drive Regulator
   - Maximum velocity
   - Current or speed regulation in the drive. If the drive is a speed regulator, does it use a proportional + integral control?
   - Maximum voltage for full scale reference to the drive
2. Encoder(s)
   - Mode (step/direction, stepper motor, *2 quad, or *4 quad)
   - Pulses/rev
   - Whether marker pulse will be used for homing
3. System
   - Mechanical gear-in (inches of travel/encoder revolution
   - Whether limit switches will be used for home, overtravel, and drive fault. If so what is sense of limit switches (normally open or closed)?
   - If using gearing, what is the gear ratio between the two axis?

5.2 Tuning

Before attempting to use the 2 Axis module in your application, you should first tune the drive. This can either be done manually or with the auto-tuning procedures supplied on the application disk that came with your ReSource

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software.

5.2.1 Auto-Tuning

The auto-tuning procedure on the application disk should work satisfactorily if the following conditions apply:

1. The feedback encoder is connected to the motor shaft.
2. You have a servo drive with reasonable performance characteristics.
3. You have a mechanical system that can move in both directions.
4. The motor is able to run at or near maximum velocity for a number of revolutions (for the purposes of auto-tune dynamics and feedforward gain).

5.2.2 Manual Tuning

If auto-tuning does not yield satisfactory performance or your system does not permit auto tuning you will need to tune your system manually. The five gain parameters must be adjusted in the following order:

1. Deadband Compensation (set to zero)
2. Velocity Gain
3. Proportional Gain
4. Integral Gain
5. Feedforward Gain

In general, each parameter is tuned by starting with a small value, evaluating the response of the system, and then increasing the value until the desired response is achieved. Once a gain has been tuned, it should be left at its tuned value and the next gain should be adjusted.

Use the following steps to tune the axis manually. When adjusting gains, double or halve the previous value, whichever is appropriate, until you are close to the desired gain. Then use smaller increments to reach the precise

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value.

WARNING

RELIANCE STRONGLY RECOMMENDS THE USE OF AN EXTERNAL, HARDWIRED EMERGENCY STOP CIRCUIT THAT WILL DISABLE THE SYSTEM IN CASE OF IMPROPER OPERATION. UNCONTROLLED MACHINE OPERATION MAY RESULT IF THIS PROCEDURE IS NOT FOLLOWED. FAILURE TO OBSERVE THIS PRECAUTION COULD RESULT IN BODILY INJURY.

1. Initialize the axis using either the Resource application software (see step 16 in section 5.3) or by following the example in 4.3.3. Set the gains to the following initial values.

   Proportional Gain = 100
   Integral Gain = 0
   Velocity Gain = 25*
   Feedforward Gain = 0

   *If the servo is expecting a velocity reference, set to 0 instead.

   Set the following error and velocity error to large values that will ensure safe operation of the machine without nuisance faults, and then enable feedback (register 65, bit 0).

2. If the servo is expecting a velocity reference, the software velocity loop in the module is disabled and the velocity gain does not need to be tuned. You can skip steps three and four if the servo is expecting a velocity reference.

3. If the servo is expecting a current reference, you will need to put the drive in the velocity mode (register 65, bit 0) with velocity to set approximately half of the maximum speed that your application will run at.

   If the drive trips out with a following error (indicted in register 73, bits 4 or 5), the initial value of the proportional gain is too low. Double it and repeat the step until the drive runs continuously.

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4. Next, adjust the velocity gain. Continue to increase the gain and observe the motor shaft. Ideally, the shaft should regulate with very little noise or vibration. When the shaft begins to vibrate, reduce the gain until the shaft becomes relatively quiet.

   Run the drive in the velocity mode at half of top speed. The velocity error should be nearly zero (indicated in register 81). Stop the drive. When the drive is stopped, it should stop smoothly and cleanly.

5. Adjust the final value of the proportional gain. Continue to increase the gain and observe the motor shaft. Ideally, the shaft should regulate with very little noise or vibration. When the shaft begins to vibrate, reduce the gain until the shaft becomes relatively quiet.

   Run the drive in the velocity mode at half of top speed. The velocity error should be nearly zero (indicated in register 81). Stop the drive. When the drive is stopped, it should stop smoothly and cleanly.

6. Start with an integral gain of 10 and observe the motor's response as you attempt to make small incremental moves. The integral gain will enable the shaft to hold a rest position with zero error. A gain that is too large will cause instability.

7. If you are using a servo drive that expects a velocity reference and it contains an integrator in its a velocity loop, the feedforward gain should be set at zero.

   For all other drives, start with a gain of zero and run the axis at or near its maximum velocity. Read the following error (indicated in register 80). Increase the gain until the following error as small as possible without going negative.

8. Set the following error and velocity error to reasonable values for your application.

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5.3 Initialization

The following example illustrates the software required to initialize one axis. The variables reference the configuration data in Appendix H.

```
1000    !
1010    ! Initialize Axis Parameters
1020    !
2000    ENCODER_SETUP%=01414H\!Rotary, polarity reversed, *4
2010    DRIVE_SETUP%=02H        \!Polarity reversed, current ref
2020    SWITCHES%=01DH          \!Marker pulse, home negative
2030    PGAIN%=18700            \!Position Gain
2040    IGAIN%=1575             \!Integral Gain
2050    VGAIN%=140 \!Velocity Gain
2060    FGAIN%=8256             \!V Feedforward Gain
2070    DBCOMP%=27              \!Deadband Compensation
2080    MAX_FOLL_ERR%=1000      \!Maximum following error
2090    MAX_VEL_ERR%=8          \!Maximum velocity error
2100    IN_TOLERANCE%=40        \!In position tolerance
2110    GEAR_RATIO!=16777216    \!Gear ratio
2120    MAX_VOLTS%=1984         \!Maximum drive reference value
2130    P_CONST%=-1             \!Positive linearization constant
2140    N_CONST%=-1             \!Negative linearization constant
2150    FDBK_UNWIND!=4000       \!V Fdbk unwind = 1 revolution
2160    GEAR_UNWIND!=4000       \!Gearing unwind = 1 revolution
2170    MODES%=0
2180    CMD66%=0200H\GOSUB 25000\!Change default setups
2190    !
10000   !
24997   !
24998   ! Subroutine to write command to module
24999   !
25000   DELAY 2 TICKS \IF NOT (CMD_ACK@ OR ILLEGAL_CMD@)
        THEN GOTO 25000
25005   FAULT@= ILLEGAL_CMD@
25010   CMD66%=0 \CMD67%=0
25015   DELAY 2 TICKS \IF CMD_ACK@ THEN GOTO 25015
25020   RETURN
30000   END
```


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5.4 Homing

The following is a sample routine that will home the axis. If the setup parameters defined in section 5.3 are used, the axis will first move in the direction of decreasing encoder counts (negative) towards the home limit switch. After the home limit switch has been tripped, the axis will then move at slow speed in the opposite direction until it reaches the marker pulse. This same routine will correctly perform all of the other home sequences based on the configuration data in register 2.

```
4991  !
4992  ! Homing Sequence
4993  !
4994  ! FDBK-SCALING              = encoder counts/engineering unit
4995  ! FDBK-POS                 = position (in engineering units)
4996  ! SPD                      = velocity (in engineering units)
4997  ! ACCEL                    = acceleration (in engineering units)
4998  ! FAULT@                   = fault status
4999  !
5000  HOME_SPD!=(SPD/100.)*FDBK_SCALING*65.536      \!Slow home velocity
5010  CMD_POS!=FDBK_POS*FDBK_SCALING                \!Home position
5020  CMD_VEL! =(SPD/10.)*FDBK_SCALING*65.536       \!Fast home velocity
5030  CMD_ACC!=(ACCEL/4.)*FDBK_SCALING*.065536      \!Maximum accel
5040  CMD_DEC!=CMD_ACC!                             \!Maximum decel
5050  MODES%=MODES% AND 0FEH                        \!Disable fdbk
5060  DELAY 10 TICKS
5070  MODES%=MODES% OR 1                            \!Enable fdbk loop
5080  CMD66%=4 \GOSUB 25000                         \!HOME COMMAND
5090  IF FAULT@ THEN RETURN
5100  DELAY 20 TICKS VF NOT HOME_COMPLETE@ THEN GOTO 5100
5110  DELAY 20 TICKS
5120  FAULT@= (FAULTS% AND 037FH) < > 0
5130  RETURN
```


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5.5 Moving

The following example illustrates the software required to move the axis. The move could be either an incremental or absolute move depending on the state of register 65, bit 5.

```
5990    !
5991    ! Move Sequence
5992    !
5993    ! FDBK_SCALING        = encoder counts/engineering unit
5994    ! FDBK_POS            = position (in engineering units)
5995    ! SPD                 = velocity (in engineering units)
5996    ! ACCEL               = acceleration (in engineering units)
5997    ! DECEL               = deceleration (in engineering units)
5998    ! FAULT@              = fault status
5999    !
6000    CMD_ POS!=FDBK_POS*FDBK_SCALING
6005    CMD_VEL!=SPD*FDBK_SCALING*65.536
6010    CMD_ACC!=ACCEL*FDBK_SCALING*.065536
6015    CMD_DEC!=DECEL*FDBK _SCALING*.065536
6020    CMD66%= 1 \GOSUB 25000 \IF FAULT@THEN RETURN
6047    REM
6D48    REM Loop until MOVE complete or a fault occurs
6049    REM
6050    DELAY 20 TICKS \IF AXIS_BUSY@ THEN GOTO 6050
6055    FAULT@=(FAULTS% AND 037FH)<>0
6060    RETURN
```


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5.6 Electronic Gearing

The following example illustrates the software necessary to use electronic gearing. Three examples are provided, one each for turning the gearing mode on, changing the gear ratio while the drive is active, and turning the gearing mode off.

```
6992  !
6993  ! Turn on gearing mode
6994  !
6995  ! FDBK_SCALING          = feedback encoder counts/engineering unit
6996  ! REF_SCALING           = gearing encoder counts/engineering unit
6997  ! GEAR                  = gear ratio
6998  ! GEAR_DIR_SAME@        = gear direction switch
6999  !
7000  GEAR_RATIO!=(FDBK_SCALING*GEAR/REF_SCALING\ *65536.*256.
7005  MODES%=MODES% AND 0ADH
7010  IF NOT GEAR_DIR_SAME@ THEN MODES%= MODES% OR 010H
7015  MODES%=MODES% OR 2
7020  RETURN
7100  !
7293  !
7294  ! Change gear ratio while drive is active
7295  !
7296  ! FDBK_SCALING          = feedback encoder counts/engineering unit
7297  ! REF_SCALING           = gearing encoder counts/engineering unit
7298  ! GEAR                  = gear ratio
7299  !
7300  GEAR_RATIO!=(FDBK_SCALING*GEAR/REF_SCALING) *65536.*256.
7305  CMD67%=8 \GOSUB 25000
7310  RETURN
7400  !
7497  !
7498  ! Turn off gearing mode
7499  !
7500  MODES%= MODES% AND 0ADH
7505  RETURN
```


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5.7 Velocity

The following example illustrates the software necessary to use the axis in the velocity mode. Three examples are provided, one each for turning velocity on, changing the velocity while the drive is active, and turning velocity off.

```
7991  !
7992  Turn on velocity mode
7993  !
7994  ! FDBK_SCALING      = encoder counts/engineering unit
7995  ! SPD              = velocity (in engineering units)
7996  ! ACCEL            = acceleration (in engineering units)
7997  ! DECEL            = deceleration (in engineering units)
7998  FAULT@             = fault status
7999  !
8000  MODES%=MODES% AND 0AFH
8005  IF SPD < 0. THEN MODES%=MODES% OR 01 OH \SPD=-SPD
8047  REM
8048  REM Issue VELOCITY command to axis
8049  REM
8050  CMD_VEL!=SPD*FDBK_SCALING*65.536
8055  CMD_ ACC!=ACCEL*FDBK_SCALING*.065536
8060  CMD_DEC! =DECEL*FDBK_SCALING*.065536
8065  MODES%=MODES% OR 4
8070  FAULT@= (FAULTS% AND 037FH) < > 0
8075  RETURN
8100  !
8294  !
8295  ! Change velocity while drive is running
8296  !
8297  ! FDBK_SCALING = encoder counts/engineering unit
8298  ! SPD = velocity (in engineering units)
8299  !
8300  IF SPD < 0. THEN SPD=-SPD
8305  CMD_VEL!=SPD*FDBK_SCALING*65.536
8310  CMD66%=0100H \GOSUB 25000
8315  RETURN
8400  !
8497  !
8498  ! Turn off velocity mode
8499  !
8500  MODES%=MODES% AND 0BBH
8505  RETURN
```


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5.8 Cam Mode

The following example illustrates the software necessary to use the axis in the cam mode. The example is a time cam. It illustrates how to calculate cam parameters and the values in the cam table itself. It also shows how to start cam execution.

```
8992  !
8993  ! Compute cam parameters
8994  !
8995  ! FDBK_SCALING          = encoder counts/engineering units
8996  ! CAM_CYCLE_TIME        = time (in seconds) for one complete
                                cam cycle
8997  ! SPD                  = maximum speed (in engineering units)
8998  ! MAX_SPD              = maximum speed (encoder counts/cam
                                time interval)
8999  !
9000  IF CAM_CYCLE_TIME <1915*.00125 THEN STEP_TIME=1 \GOTO 9010
9005  STEP_TIME%=CAM_CYCLE_TIME/(1915*.00125)+.999
9010  TOTAL_PTS%=CAM_CYCLE_TIME/(STEP_TIME%*.00125)+.999
9015  IF TOTAL_PTS% > 1915 THEN TOTAL_PTS%= 1915
9020  MAX_SPD=SPD*FDBK_SCALING*STEP_TIME%*.00125
9025  RETURN
9297  !
9298  ! Calculate Cam Profile Points
9299  !
9300  ADDRESS!=VARPTR!(CAM_TABLE%) \!Starting address for cam profile
9310  FOR I%=0 TO TOTAL_PTS%_1
9315  ! DATA_POINT%=change in position for next time interval
9320        IOWRITE(3, DATA_POINT%, ADDRESS!)
9325        ADDRESS!=ADDRESS! +2
9330  NEXT I%
9335  RETURN
9400  !
9497  !
9498  ! Start cam cycle
9499  !
9500  CAM_LOOPBACK%=0       !No loopback point.
9505  CAM_MODE%=9           \!Run continuously, word format
9510  CMD66%=080H \GOSUB 25000 \! Do cam profile
9515  RETURN
```


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CHAPTER 6

RESTRICTIONS

This section describes limitations and restrictions on the use of this module.

6.1 Remote Racks

This module must not be used in a remote rack.

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APPENDIX A

Technical Specifications

Ambient Conditions

- Storage Temperature: -40°C - 85°C
- Operating Temperature: 0°C - 60°C
- Humidity: 5-90% non-condensing

Maximum Module Power Dissipation

- 8 Watts average

Dimensions

- Height: 11.75 inches
- Width: 1.25 inches
- Depth: 7.375 inches

System Power Requirements

- +5 Volts: 1.6 Amps average
- +12 Volts: 100 mA per axis channel*
- -12 Volts: 100 mA per axis channel*
- ±12 Volts supplied externally by the user for isolation

Encoder Specifications

- Signal type: Differential CMOS or TTL
- Signal level: 5 Volts
- Maximum input current: 4.5 mA
- Maximum frequency: 250 khz/channel

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Registration Input Specifications

- Signal type: Electronic
- Maximum operating voltage: 24 Volts D-C ±20%
- Maximum ON current: 6 mA
- Transport delay: 50 microseconds

Limit Switch Input Specifications

- Signal Type: Contact or electronic
- Maximum operating voltage: 24 Volts A-C or D-C ±20%
- Maximum ON current: 6 mA
- Input Filter: 30 Hz

Watchdog Output Specifications

- Signal Type: Contact
- Signal level: 5-24 volts A-C or D-C
- Current rating: 1000 mA max

Drive Reference Specifications

- Signal range: ±10 Volts into a 10K ohm load

External Encoder Power Supply

- Voltage: +5 VDC
- Current: 250 mA + encoder requirements
- Regulation: 1%

Drive Reference Power Supply Specifications

- Voltage: ±12 to ±15 VDC
- Current: 25 mA
- Regulation: .1%

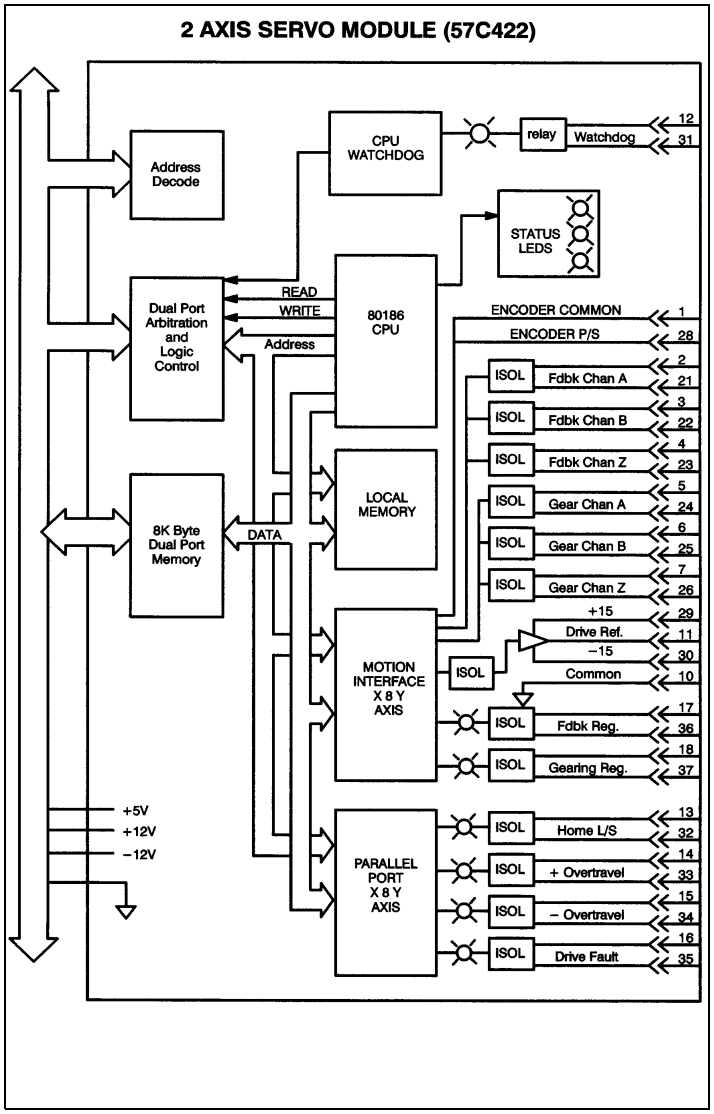
Scan Time

- 1.25 msec. update rate for velocity and position loops

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APPENDIX B

Module Black Diagram



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APPENDIX C

Field Connections

X and Y Axis

Conn No.	Function	Term No.	Wire Color: Main (Stripes)
1	Encoder Power Common	1	Black
28	+Ve: Encoder Power (5 Volt Pwr. Sup.)	2	White
9	COMe: Encoder Power Common	3	Red
8	+Ve: Encoder Power (to encoder)	4	Green
2	FchA: Feedback Encoder Channel A	5	Oranges
21	/FchA: Feedback Encoder Channel /A	6	Blue
3	FchB: Feedback Encoder Channel B	7	White/Black
22	/FchB: Feedback Encoder Channel /B	8	Red/Black
4	FchZ: Feedback Encoder Channel Z	9	Green/Black
23	/FchZ: Feedback Encoder Channel /Z	10	Orange/Black
20	COMe: Encoder Power Common	11	Blue/Black
27	+Ve: Encoder Power (to encoder)	12	Black/White
5	RchA: Reference Encoder Channel A	13	Red/White
24	/RchA: Reference Encoder Channel /A	14	Green/White
6	RchB: Reference Encoder Channel B	15	Blue/White
25	/RchB: Reference Encoder Channel /B	16	Black/Red
7	RchZ: Reference Encoder Channel Z	17	White/Red
26	/RchZ: Reference Encoder Channel /Z	18	Orange/Red
-	No Connection	19	N.C.
-	No Connection	20	N.C.

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Field Connections (Continued)

Conn No.	Function	Term No.	Wire Color: Main (Stripes)
29	+Vp: Drive Ref. Pwr. Sup. (+12/+15 VDC)	21	Blue/Red
30	-Vp: Drive Ref. Pwr. Sup. (-12/-15 VDC)	22	Red/Green
10	COMp: Drive Reference Common	23	Orange/Green
11	Vout: Drive Reference Output	24	Black/White/Red
12	ENABLE: Drive Enable Output	25	White/Black/Red
31	/ENABLE: Drive Enable Input	26	Red/Black/White
13	HOME: Home L/S Input	27	Green/Black/White
32	/HOME: Home L/S Common	28	Orange/Black/White
14	+OTRAV: Positive Overtravel L/S Input	29	Blue/Black/White
33	/+OTRAV: Positive Overtravel L/S Common	30	Black/Red/Green
15	-OTRAV: Positive Overtravel L/S Input	31	White/Red/Green
34	/-OTRAV: Positive Overtravel L/S Common	32	Red/Black/Green
16	DFLT: Drive Fault Input	33	Green/Black/Orange
35	/DFLT: Drive Fault Common	34	Orange/Black/Green
17	FREG: Feedback Registration Input	35	Blue/White/Orange
36	/FREG: Feedback Registration Common	36	Black/White/Orange
18	RREG: Feedback Registration Input	37	White/Red/Orange
37	/RREG: Feedback Registration Common	38	Orange/White/Blue
-	No Connection	39	N.C.
-	GRND Wire Soldered to Drain	40	White/Red/Blue

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Field Connections (Continued)

Conn No.	Function	Term No.	Wire Color: Main (Stripes)
1	Encoder Power Common	1	Wht
28	Encoder Power (from 5 Volt DC P/S)	2	Org (Blu/Wht)
9	Encoder Power Common	3	Blu (Wht-Org)
8	Encoder Power (to feedback encoder)	4	Wht (Red-Blu)
2	Feedback Encoder Channel A	5	Wht (Red-Grn)
21	Feedback Encoder Channel /A	6	Red (Grn)
3	Feedback Encoder Channel B	7	Wht (Red)
22	Feedback Encoder Channel /B	8	Red
4	Feedback Encoder Channel Z	9	Wht (Red-Org)
23	Feedback Encoder Channel /Z	10	Org
20	Encoder Power Common	11	Blk
27	Encoder Power (to Gearing Ref. encoder)	12	Blu (Blk-Wht)
5	Gearing Reference Encoder Channel A	13	Blk (Wht)
24	Gearing Reference Encoder Channel /A	14	Blk (Red-Wht)
6	Gearing Reference Encoder Channel B	15	Wht (Blk-Grn)
25	Gearing Reference Encoder Channel /B	16	Grn
7	Gearing Reference Encoder Channel Z	17	Blu (Wht)
26	Gearing Reference Encoder Channel /Z	18	Blu
-	No Connection	19	
-	No Connection	20	

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Field Connections (Continued)

Conn No.	Function	Term No.	Wire Color: Main (Stripes)
29	Drive Reference Power Supply (12/15 VDC)	21	Red (Wht)
30	Drive Reference Power Supply (-12/-15VDC)	22	Red (Wht-Blk)
10	Drive Reference Common	23	Blk (Wht-Org)
11	Drive Reference Output	24	Org (Blk-Wht)
12	Watchdog Output (+)	25	Blk (Brn)
31	Watchdog Output (-)	26	Red (Blk)
13	Home L/S (+)	27	Org (Blk)
32	Home L/S (-)	28	Org (Red)
14	Positive Overtravel L/S (+)	29	Blk (Wht-Grn)
33	Positive Overtravel L/S (-)	30	Wht (Blk)
15	Negative Overtravel L/S (+)	31	Grn (Blk)
34	Negative Overtravel L/S (-)	32	Grn (Wht)
16	Drive Fault Input (+)	33	Blu (Blk)
35	Drive Fault Input (-)	34	Blu (Brn)
17	Feedback Registration (+)	35	Blk (Red-Grn)
36	Feedback Registration (-)	36	Red (Blk-Grn)
18	Gearing Reference Registration (+)	37	Grn (Blk-Org)
37	Gearing Reference Registration (-)	38	Org (Blk-Grn)
-	No Connection	39	
-	No Connection	40	

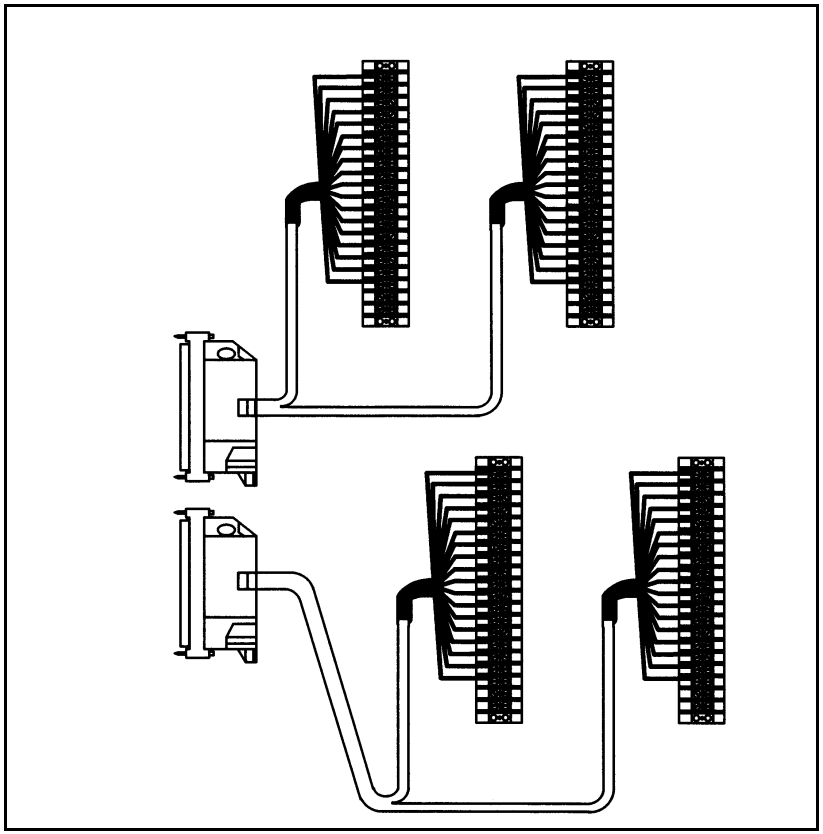
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APPENDIX D

Related Components

57C377 - Terminal Strip/Cable Assembly

This model number consists of two assemblies. Each assembly consists of two terminal strips, cable and a mating connector. The assemblies are used to connect field signals to the faceplate of the module.



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APPENDIX E

Register Summary

X Register	Y Register	Function	Page No.
0	2048	Encoder setup	4-2
1	2049	Drive setup	4-3
2	2050	Switch setup	4-4
3	2051	Proportional gain	4-5
4	2052	Integral gain	4-6
5	2053	Velocity Loop Gain	4-6
6	2054	Feedforward Gain	4-6
7	2055	Deadband Compensation	4-7
8	2056	Maximum Position Error	4-7
9	2057	Maximum Velocity Error	4-7
10	2058	In-position tolerance	4-8
11,12	2059,2060	Positive Travel Limit	4-8
13,14	2061,2062	Negative Travel Limit	4-9
15,16	2063,2064	Low speed Homing Reference	4-9
17,18	2065,2066	Command Position	4-10
19,20	2067,2068	Command Velocity	4-10
21,22	2069,2070	Command Acceleration	4-11
23,24	2071,2072	Command Deceleration	4-11
25,26	2073,2074	Gear Ratio	4-12
27	2075	User LED Register	4-12
28	2076	Direct Drive Reference Command	4-13
29,30	2077,2078	Sync Position	4-13
31	2079	Maximum Voltage Reference	4-14
32	2080	Positive Linearization Constant	4-14
33	2081	Negative Linearization Constant	4-15
34,35	2082,2083	Feedback Unwind Constant	4-15
36,37	2084,2085	Gearing Unwind Constant	4-16
38	2086	Gearing Modes, Ratio Format, Ramp Velocity Control	4-16

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Register Summary
continued

X Register	Y Register	Function	Page No.
39-40	2087,2088	Backlash Compensation	4-17
41	2089	Registration Input Edge Detection	4-18
63	2111	Auto-Acknowledge	4-18
64	(Same)	Interrupt Reset (X and Y)	4-19
65	2113	Mode	4-19
66	2114	Command	4-22
67	2115	Command	4-25
68/69	2116/2117	Interrupt Enable	4-36
72	2120	Status	4-27
73	2121	Fault	4-29
74,75	2122,2123	Current Feedback Position	4-30
76,77	2124,2125	Current Gearing Position	4-31
78,79	2126,2127	Current Velocity	4-31
80	2128	Following Error	4-32
81	2129	Velocity Error	4-32
82	2130	Digital Input Status	4-33
83	2131	Current Velocity Status Update Period	4-33
84,85	2132,2133	Feedback Registration Position	4-34
86,87	2134.2135	Gearing Registration Position	4-34
99,103	2147-2151	Software Version Number	4-35
104/105	2152/2153	Interrupt Source	4-37
125	2173	Master Axis Position Increment (Position Cam)	4-45
126,127	2174/2175	Master Reference Position (Position Cam)	4-45
128	2176	Number of Points in Cam Table	4-45
129	2177	Time between Points in Cam Table	4-45
130	2178	Cam Mode	4-45
131	2179	Loop Back Point in Cam Table	4-47
132-2046	2180-4094	Cam Data Table	4-48
4095	(Same)	Interrupt Status and Control (X and Y)	4-40

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APPENDIX F

Enhancements

This appendix lists the features that were added to the module in versions 57C422A and 57C422B.

Note that some modules which do not have 57C422A on the faceplate may also support the features implemented in 57C422A. If the "B/M" designation on the side of the module is "B/M 57422-1 ", the module will function as a 57C422A regardless of whether the faceplate reads 57C422 or 57C422A.

M/N 57C422A

1. Interrupts (registers 64, 68, 69, 104, 105, 4095)*
2. Current velocity status update period (register 83)
3. Current velocity in double precision integer (registers 78 and 79). (Note that register 79 is now the lower order 16 bits.)
4. S-curve profile (register 65 bit 6)
5. Shortest path rotary move (register 65 bit 10)
6. Automatic backlash compensation (register 65 bit 11)
7. Backlash compensation (registers 39 and 40)
8. Passive home on marker pulse for feedback encoder (register 67 bit 4)
9. Passive home on marker pulse for gearing encoder (register 67 bit 5)
10. Relative change in feedback position (register 67 bit 6)
11. Expanded gearing modes (register 38 bits 0 and 1)
12. Gear ratio as two integers (register 38 bit 2)
13. Ramp velocity control during gearing changes (register 38 bit 3)
14. Position cam (registers 125 - 127, register 130 bit 8)

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M/N 57C422B

If the "B/M" designation on the side of the module is "B/M 57422-2, " all of the features listed below are supported. If the label reads "B/M 57422-1B," the module supports only items 2, 3, and 4.

1. Programmable edge detection (register 41)
2. Programmable auto-acknowledge (register 63)
3. Bit 7 in register 130 allows for programming a position cam in which the end points are not equal
4. Absolute moves after ramped gear disable are supported.

* As in other parts of this instruction manual, register numbers refer to the X axis; Y axis registers = X axis register + 2048. Only registers 64 and 4095 are exceptions; they are used for both the X and Y axes.

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APPENDIX G

Compatibility with Earlier Versions

Stop Motion Command

If you are replacing a 57C422 module with a different version of the same module, the Stop Motion command (Register 66 Bit 6)* may now operate differently than it did in the module being replaced. To determine the version number of the 57C422 module you are working with, examine the label on the side of the module. This label will reference a "B/M" number designation, which is the version number.

The Stop Motion command has two modes of operation which are selected by the Stop Action bit (Register 65 Bit 7). If the Stop Action bit is off, issuing the Stop Motion command will cause the drive to decelerate to a stop at the rate specified when the motion was started. It is when the Stop Action bit is set, i.e., "fast stop" is enabled, that the difference between versions of the module is important. If your application program does not set the Stop Action bit, this difference between versions is immaterial. If, however, your application does set the Stop Action bit, you must note the following.

In B/M-57422, if the Stop Action bit is set when the Stop Motion command is issued, the drive will try to stop immediately with no limit on the rate of deceleration. This can cause the drive to turn off because of position or velocity error, and then coast to a stop.

In B/M-57422-1, B/M-57422-1A, B/M-57422-1B, and B/M-57422-2, the Stop Action bit works differently. If the Stop Action bit is set when the Stop Motion command is issued, the drive will control the rate of deceleration. This control can only be accomplished through the deceleration rate used by the Home command. For this reason, if your application program does a Stop Motion command with the Stop Action bit set you MUST first perform a Home command. If this is not done, the deceleration rate for the "fast stop" will be zero and the drive will not stop.

For applications that don't normally use the Home command,

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there is a mode of homing in which the axis does not move. This is selected with register 2 bits 0 and 3* both off. The application program would need to go through the following steps to use the Home command to set the deceleration rate for a fast stop. Note that this is not a complete program. It is intended only to show the flow of control.

1. Enable the drive
2. Low Speed Homing Reference = Slow Velocity
3. Command Position= 0
4. Command Velocity = Fast Velocity
5. Command Acceleration = Fast Acceleration Rate
6. Command Deceleration = Fast Deceleration Rate
7. Register 2 Bit 0 = 0
8. Register 2 Bit 3 = 0
9. Issue the Home Axis command (Register 66 Bit 2 = 1)

After the Home command is complete, the command position, velocity, acceleration, and deceleration registers can then be loaded with other values for other commands.

* Note that all references to register numbers are only for the X axis and that the information given here also applies to the corresponding registers on the Y axis.

For applications that already do a Home command, you must keep in mind that the value in registers 23, 24 when the Home command is issued will be the deceleration rate for the Stop Motion command if the Stop Action bit is set. For this reason register 23, 24 should be loaded with the fast deceleration rate when doing a Home command.

* Note that all references to register numbers are only for the X axis and that the information given here also applies to the corresponding registers on the Y axis.

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APPENDIX H

Configuration Task Sample

This appendix describes how to configure the module in systems using AutoMax Programming Executive software version 2.1 or earlier. Note that the definition of registers given in the sample task below is the basis of application task examples in this instruction manual.

See J-3649, the Configuration Task instruction manual for more information on configuration for 2.1 or earlier systems.

32 Bit Register Reference

Use the following method to reference 32 bits as a single register. One statement is required in the configuration task for each variable. The symbolic name of each register should be as meaningful as possible.

```
nnnnn    IODEF
SYMBOLIC_NAME![SLOT=s,REGISTER=r]
```

When referenced as a long register of 32 bits, register "r" is the high order 16 bits, and register "r+1 " is the low order 16 bits.

16 Bit Register Reference

Use the following method to reference 16 bits as a single register. One statement is required in the configuration task for each variable. The symbolic name of each register should be as meaningful as possible.

```
nnnnn    IODEF
SYMBOLIC_NAME%[SLOT=s,REGISTER=r]
```

Bit Reference

Use the following method to reference individual bits in a register. One statement is required in the configuration task for each variable. The symbolic name of each bit should be as meaningful as possible.

```
nnnnn    IODEF
SYMBOLIC_NAME@[SLOT=s,REGISTER=r, BIT=b]
```


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where:

nnnnn - BASIC statement number. This number may range from 1-32767.

SYMBOLIC_NAME! - A symbolic name chosen by the user and ending with (!). This indicates a LONG INTEGER data type and all references will access registers "r" and "r+ 1 ".

SYMBOLIC_NAME% - A symbolic name chosen by the user and ending with (%). This indicates an INTEGER data type and all references will acces register “r”.

SYMBOLIC_NAME@ - A symbolic name chosen by the user and ending with (@). This iridicates a BOOLEAN data type and all references will access bit number "b" in register "r."

SLOT - Slot number that the module is plugged into. This number may range from 0-15.

REGISTER - Specifies the register that is being referenced. This number may range from 0-4095.

BIT - Used with boolean data types only. Specifies the bit in the register that is being referenced. This number may range from 0-15.

Sample Configuration Task

The following is a sample configuration for the X axis of a module located in slot 8. Note that version 3.0 or later Programming Executive software allows you to enter the variable names and comments below on a customized form and does not require a separate task.

```
1000  IODEF  ENCODER_SETUP%[  SLOT =8,  REGISTER=0]
1010  IODEF  DRIVE_SETUP%[    SLOT =8,  REGISTER=1]
1020  IODEF  SWITCHES%[       SLOT =8,  REGISTER=2]
1030  IODEF  PGAIN%[          SLOT =8,  REGISTER=3]
1040  IODEF  IGAIN%[          SLOT =8,  REGISTER=4]
1050  IODEF  VGAIN%[          SLOT =8,  REGISTER=5]
1060  IODEF  FGAIN%[          SLOT =8,  REGISTER=6]
1070  IODEF  DBCOMP%[         SLOT =8,  REGISTER=7]
1080  IODEF  MAX_FOLL_ERR%[   SLOT =8,  REGISTER=8]
1090  IODEF  MAX_VEL_ERR%[    SLOT =8,  REGISTER=9]
1100  IODEF  IN_TOLERANCE%[   SLOT =8,  REGISTER=10]
1110  IODEF  HOME_SPDI[       SLOT =8,  REGISTER=15]
1120  IODEF  CMD_POSI[        SLOT =8,  REGISTER=17]
1130  IODEF  CMD_VELI[        SLOT =8,  REGISTER=19]
1140  IODEF  CMD_ACC![        SLOT =8,  REGISTER=21]
1150  IODEF  CMD_DECI[        SLOT =8,  REGISTER=23]
1160  IODEF  GEAR_RATIO![     SLOT =8,  REGISTER=25]
1170  IODEF  MAX_VOLTS%[      SLOT =8,  REGISTER=31]
```


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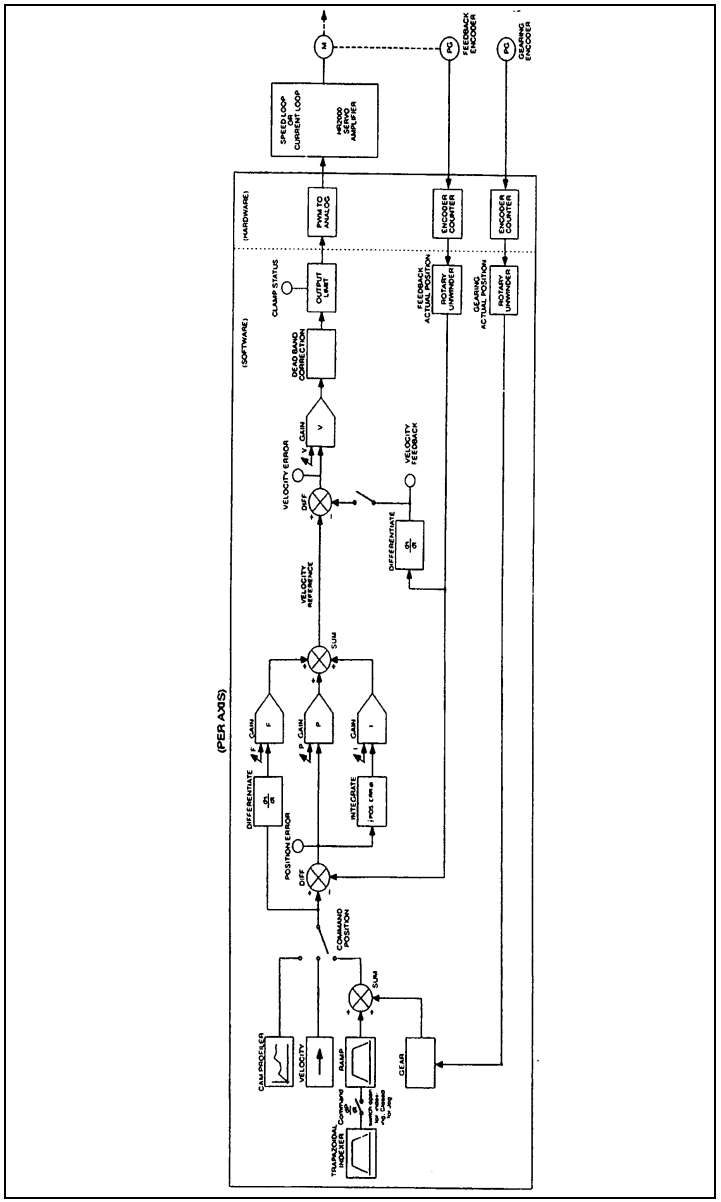
```
1180   IODEF    P_CONST%[              SLOT =8,   REGISTER=32]
1190   IODEF    N_CONST%[              SLOT =8,   REGISTER=33]
1200   IODEF    FDBK_UNWINDI[          SLOT =8,   REGISTER=34]
1210   IODEF    GEAR_UNWINDI[          SLOT =8,   REGISTER=36]
1220   IODEF    MODES%[                SLOT =8,   REGISTER=65]
1230   IODEF    CMD66%[                SLOT =8,   REGISTER=66]
1240   IODEF    CMD67%[                SLOT =8,   REGISTER=67]
1250   IODEF    STATUS%[               SLOT =8,   REGISTER=72]
1260   IODEF    HOME_COMPLETE@[        SLOT =8,   REGISTER=72,BIT=5]
1270   IODEF    CMD_ACK@[              SLOT =8,   REGISTER=72,BIT=15]
1280   IODEF    AXIS_BUSY@[            SLOT =8,   REGISTER=72,BIT=2]
1290   IODEF    FAULTS%[               SLOT =8,   REGISTER=73]
1300   IODEF    ILLEGAL_CMD@[          SLOT =8,   REGISTER=73,BIT=10]
1310   IODEF    TOTAL_PTS%[            SLOT =8,   REGISTER=128]
1320   IODEF    STEP_TIME%[            SLOT =8,   REGISTER=129]
1330   IODEF    CAM_MODE%[             SLOT =8,   REGISTER=130]
1340   IODEF    CAM_LOOPBACK%[         SLOT =8,   REGISTER=131]
1350   IODEF    CAM_TABLE%[            SLOT =8,   REGISTER=132]
1360   IODEF    X_CMD_ACK@[            SLOT =8,   REGISTER=104,BIT=15]
1370   IODEF    X_AXIS_DONE@[          SLOT =8,   REGISTER=104,BIIT=0]
1380   IODEF    INT ENA XI [           SLOT =8,   REGISTER=68]
1381   ! INT_ENA_X! is a double precision variable (32 bits)
1382   ! assigned to registers 68 and 69
1400   IODEF    INT_SRC_X![            SLOT =8,   REGISTER=104]
1401   ! INT_SRC_X! is a double precision variable (32 bits)
1402   ! assigned to registers 104 and 105
1410   IODEF ISCR%[                    SLOT =8,   REGISTER=4095]
1412   ! register 4095 is the interrupt status and control
1413   ! register for both the X axis and Y axis
1420   IODEF REG_64%[                  SLOT =8,   REGISTER=64]
1430   ! register 64 is the interrupt reset register for both
1440   ! the X and Y axes
20000  END
```


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APPENDIX I

Digital Servo Loop Block Diagram



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1 Allen-Bradley Drive
Mayfield Heights, Ohio 44124 USA
Tel: (800) 241-2886 or (440) 646-3599
http://www.reliance.com/automax

www.rockwellautomation.com

Corporate Headquarters
Rockwell Automation, 777 East Wisconsin Avenue, Suite 1400, Milwaukee, WI, 53202-5302 USA, Tel: (1) 414.212.5200, Fax: (1) 414.212.5201

Headquarters for Allen-Bradley Products, Rockwell Software Products and Global Manufacturing Solutions
Americas: Rockwell Automation, 1201 South Second Street, Milwaukee, WI 53204-2496 USA, Tel: (1) 414.382.2000, Fax: (1) 414.382.4444
Europe/Middle East/Africa: Rockwell Automation SA/NV, Vorstlaan/Boulevard du Souverain 36, 1170 Brussels, Belgium, Tel: (32) 2 663 0600, Fax: (32) 2 663 0640
Asia Pacific: Rockwell Automation, 27/F Citicorp Centre, 18 Whitfield Road, Causeway Bay, Hong Kong, Tel: (852) 2887 4788, Fax: (852) 2508 1846

Headquarters for Dodge and Reliance Electric Products
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Europe/Middle East/Africa: Rockwell Automation, Brühlstraße 22, D-74834 Elztal-Dallau, Germany, Tel: (49) 6261 9410, Fax: (49) 6261 17741
Asia Pacific: Rockwell Automation, 55 Newton Road, #11-01/02 Revenue House, Singapore 307987, Tel: (65) 6356-9077, Fax: (65) 6356-9011

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