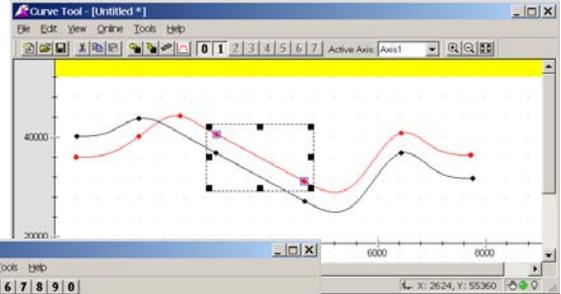
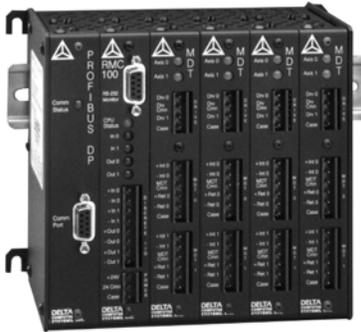


Startup Guide

for RMC100 and RMCWin

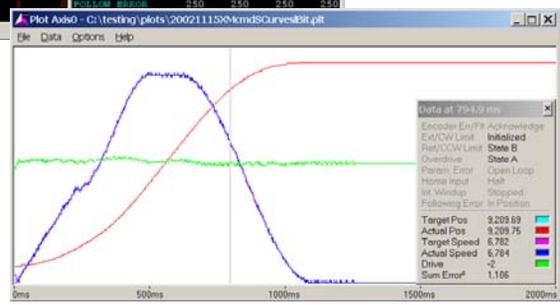
Motion Controller

Motion Software



RMCWin - Untitled*

PARAMETER	Axis0	Axis1	Axis2	Axis3
COEFFS	0x0000	0x0000	0x0002	0x0000
SCALE	30300	30300	29495	4096
OFFSET	-947	0	0	0
EXTEND LIMIT	52000	52000	20711	4096
RETRACT LIMIT	100	100	0	0
PROG. GAIN	1	1	1	1
INT. GAIN	1	1	1	1
DIF. GAIN	0	0	0	0
EXT. FEED FWD.	100	100	100	100
INT. FEED FWD.	100	100	100	100
EXT. ACCE. FF.	0	0	0	0
INT. ACCE. FF.	0	0	0	0
DRAG BAND ELM.	0	0	0	0
IN POSITION	50	50	50	50
DEVELO. RESOL.	250	250	250	250



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Overview

The RMC100 series brings the benefits of modular, high-performance motion control to a wide range of industrial applications. Communications options—ranging from high-speed field buses to discrete I/O and a four-line display/keypad—make these compact, DIN rail mounted controllers an excellent choice for large and small systems. The ability to “mix and match” position feedback transducers, plus powerful control modes—including synchronized moves, position/pressure control, gearing, splines, and teach mode—provide optimum control for a wide range of applications.

RMCWin is a powerful setup, tuning and diagnostics software package provided with the RMC100 motion controller.

Figure 1 shows a typical installation of an RMC100 controller and the RMCWin software on a PC. The PC and RMCWin software are only required when setting up and monitoring the RMC100, and are not required for normal machine operation.

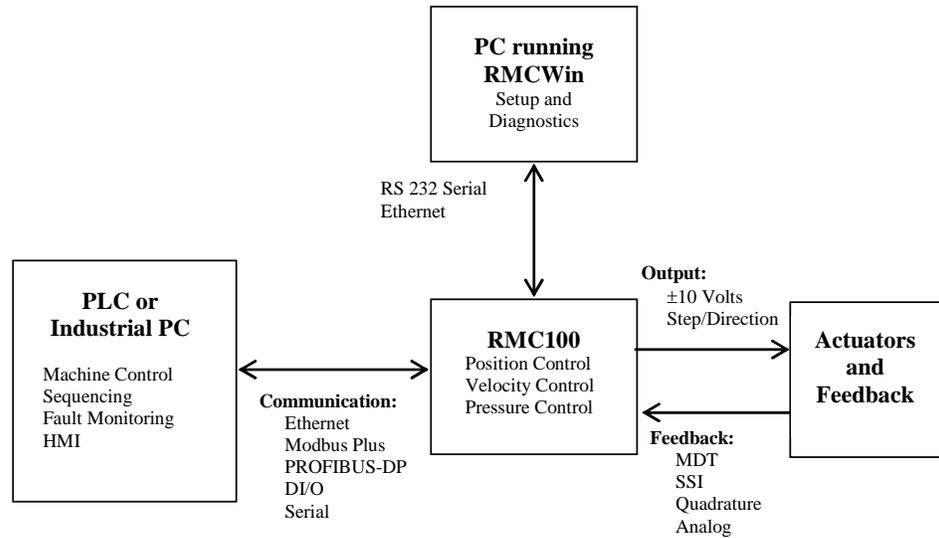


Figure 1. Typical RMC100 and RMCWin installation.

Obtaining a Manual

The RMC100 motion controller manual is available in the following formats:

- Complete and up-to-date information is available in the online help in the RMCWin software.
- A manual containing the same information as the online help is available as a Portable Document Format (PDF) file from our web site at www.deltamotion.com.
- If you need a hard-copy manual, contact Delta by telephone at 360-254-8688 or email at sales@deltamotion.com.

Getting Started

This chapter describes the minimum hardware requirements, how to install and run RMCWin, and how to set up a system with an RMC100 controller.

PC Requirements

Operating System	Windows 98/ME/NT/2000/XP/Vista/7
Disk Space	20 Mbytes
Memory	8 Mbytes
Serial Port or Ethernet	RS-232 or Ethernet connection required for communication with RMC100.

Installation

1. Obtain a copy of RMCWin either from the CD or diskettes included with the RMC100 controller or by downloading it from our web site's download page at <http://www.deltamotion.com/dloads/>.
2. If installing from CD, insert the CD and run *drive*:\SETUP.EXE where *drive* is the letter of the CD drive. Follow the instructions for installation. It is also possible to run RMCWin from the CD. Do this by running *drive*:\rmcwin\rmcwin.exe.
3. If installing from the web site, run the self-extracting zip file and follow the instructions.
4. If installing from diskette, insert disk 1 into drive a: and run SETUP.EXE. Follow the instructions for installation.

Starting RMCWin

After installing RMCWin, start it by clicking the Start menu, clicking Programs and then RMCWin.

Getting Help

RMCWin includes an extensive online help facility designed to provide information about all aspects of connecting, starting, and using RMCWin and the RMC100 controller. To access Help, click on the Help menu in the RMCWin display and select Help Topics. To access context-sensitive Help, place the cursor on the display feature where help is desired and press F1.

In the remaining discussion, references to online Help take one of two forms:



1. Index/stored commands/Editing the Stored Command Table.

This means to display the online Help, select the Index tab, type the words *stored command* on the edit line, and select the topic *Editing the Stored Command Table*.

2. Contents/Using RMCWin/Setup Options/Selecting a Serial Port to Use.

This means to display the online Help, select the Contents tab, display Using RMCWin, select Setup Options, and select the topic *Selecting a Serial Port to Use*.

The RMCWin Display

Figure 2 shows the RMCWin main window.

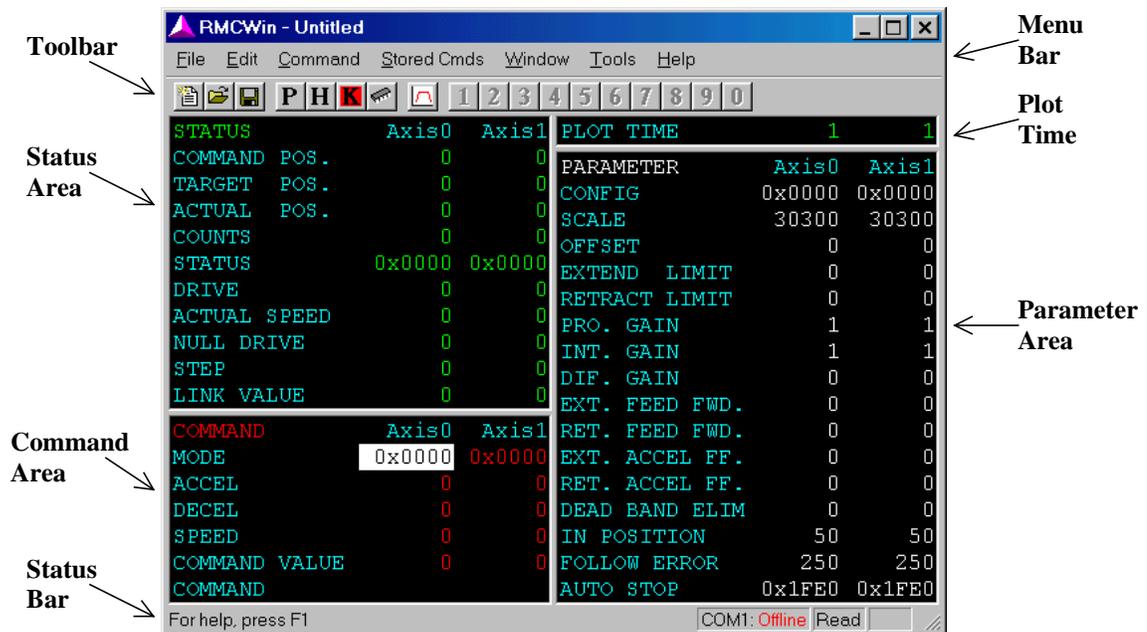


Figure 2. RMCWin Display.

Note: If RMCWin starts in Read mode (see the status bar), double click on Read to change it to Write. RMCWin should be in Write mode during RMC100 controller setup.

In the display, each feedback device has a column of associated data. For example, Axis0 is one feedback device, while Axis1 is another. Numbers displayed in the form 0xNNNN are hexadecimal numbers that represent individual bits.

- Index/views/selecting

Note: If the RMC100 has 6 or 8 axes the display may be difficult to read in the default layout. Change to the half view layout (see the help topic listed at left), and resize the window by dragging a corner with the mouse.

Status area —This area shows important information about what is happening in the RMC100 controller. It shows the actual position, the drive output, program step number, actual speed, and the status word, which contains information about the state of the controller and whether there are any faults.

Command area — The six registers in this area are used to send commands to the RMC100 controller.

Parameter area — The sixteen registers in this area are the operational parameters. This area contains information on scaling, tuning, and configuration for fault detection.

Plot Time — Specifies plot duration, or length of data log, in seconds.

Toolbar — Tools in the toolbar include:



Opens a new board file.



Opens an existing board file.



Saves the current board file.



Sends parameters listed in the Parameter area of the display to the RMC100 controller and initializes the axis.



Halts a selected axis (ramps the axis to a stop).



Kills all axes (sets the drive outputs to 0 Volts).



Saves controller information to non-volatile memory.



Retrieves a plot of the selected axis from the RMC100 controller.



These buttons are pre-programmed commands that you can execute by clicking on the appropriate number. Instead of entering values in the COMMAND area of the display you can pre-program commands into each button, then by clicking a button or pressing a shortcut key, quickly execute the pre-programmed command.



Index/stored commands/*Editing the Stored Command Table*

Status Bar — Indicates the state of the serial communications to the RMC100, Read or Write mode, and CAPS LOCK.

Starting the RMC100 Controller



Index/specification/general/*power*

1. Connect power to the RMC100 controller.

Note: The RMC100 controller requires 24 VDC at various current levels up to 750 mA, depending on the communication and transducer interface modules used.

2. Connect the PC to the RMC100 controller using one of the following two methods.

- Connect a standard null-modem DB-9 RS-232 serial cable from the PC to the RMC100 controller.
 - If the serial port is configured correctly, the Offline message in the lower right corner of the RMCWin status bar will change to Online and a pop-up message window will indicate that RMCWin can communicate with the RMC100 controller.
 - If the display indicates Offline and an RMC100 controller is connected and has power, try changing the serial port by double-clicking on COM in the lower right corner of the RMCWin status bar. The



Contents/Using RMCWin/Setup Options/*Selecting a Serial Port to Use*

Contents/Communication Types/RS-232/*Wiring.*

 Contents/Using RMCWin/Connecting to an RMC/Communication Drivers/TCP/IP Direct to RMC-ENET Configuration

- Options dialog box appears. From the Communication tab in the Options dialog box, select the correct com port.
- If the display indicates Closed after starting RMCWin, another program may be using the serial port. Try closing other programs that may be using the serial port.
- If the RMC100 is equipped with an Ethernet communications module and the PC is equipped with a TCP/IP interface (such as an Ethernet adapter or modem with TCP/IP installed), you may wish to connect the PC to the RMC100 via Ethernet for noticeably faster communication. Plug an Ethernet cable into the RMC100 Ethernet module. Use a regular patch cable when using a hub or router and a crossover cable when connected directly from the PC to the RMC.
 - On the **Tools** menu, click **Options**, and then click the **Communication** tab.
 - Under **Communication Driver**, click TCP/IP Direct to RMC-ENET.
 - Select the desired RMC. If the IP address of the RMC is all zeros, you must configure the RMC100 Ethernet by clicking the **Configure** button and entering the correct settings. See the help for more details.
 - Click OK.

Connect and Verify a Feedback Device

 Index/wiring/topic for your transducer type.

This section describes wiring and testing connections to feedback devices, such as MDTs (Magnetostrictive Displacement Transducers) and quadrature encoders.

See the Wiring section in this document for detailed wiring feedback module diagrams. The online Help also provides wiring information. In all cases, shielded twisted pair wiring must be used.

Note: Always turn off power to the RMC100 and the feedback device when connecting wiring from the device to the RMC100 controller.

Decide which axis on the selected RMC100 you want to use and connect the wiring from the feedback device to that axis according to the wiring diagrams in the Wiring section of this document. After connecting the wiring, re-apply power to the RMC100 and feedback device. When power is re-applied the RMC100 controller should indicate that it is online in the RMCWin lower right status bar.

The RMC100 needs to be configured properly before it will communicate with some types of transducers.

 Index/configuration/MDT

MDT: First, in the RMCWin Tools menu, select Module Configuration. Select the slot for the axis you are configuring, and click on Slot Option. Select either Standard or Short blanking period. This setting is transducer dependent, and is available in the transducer datasheet. Next, double click on the CONFIG parameter in the Parameter area to display the MDT Axis Configuration Word dialog box. Select the transducer type you are using. Click OK and then click the  to initialize the RMC100

 Index/configuration/SSI

SSI: In the RMCWin Tools menu, select Module Configuration. Select the slot for the axis you are configuring, and click on Slot Option. Complete the necessary information for your transducer type and your application.



Index/configuration/analog
transducer

Analog Transducers: First, in the RMCWin Tools menu, select Module Configuration. Select the tab for the axis you are configuring, and click on Slot Option. Select the option corresponding to the type of application you have. Next, double click on the CONFIG parameter in the Parameter area to display the Analog Axis Configuration Word dialog box. Select the voltage or current range for your transducer. Click OK and then click the **P** to initialize the RMC100.



Index/configuration/quadrature

Quadrature Encoders: Double click on the CONFIG parameter in the Parameter area to display the Quadrature Axis Configuration Word dialog box. Select the polarity of the Fault, Limits, Index (Z) and Home (H) inputs and the action of the Homes status bit depending on your application. Click OK and then click the **P** to initialize the RMC100.

In the Status area of the RMCWin display, the value of COUNTS should now change. Move the axis manually and look for a corresponding change in the displayed value of COUNTS, in the status area.

If COUNTS do not change, the most common problem is incorrect wiring. Refer to the online Help topics.

Connect and Verify an Actuator

This section describes wiring and testing drive output connections and testing actuator motion.



Index/drive/Drive

For most types of actuators, Drive output wiring consists of a $\pm 10V$ drive output and a common. For stepper motors a Step and a Direction signal are used.



Index/stepper/wiring

Note: Always turn off power to the RMC100 and the actuator/amplifier when connecting wiring from the actuator to the RMC100 controller.

Use the same axis number for the actuator as you did for the feedback device. Connect the wiring from the actuator to that axis. Refer to the appropriate wiring information in the online Help, or in the specification sheets. After connecting the wiring, re-apply power to the RMC100, the feedback device, and the actuator.

The axis is not currently initialized, but it reads counts and you may see a slight movement when the drive output is connected. Test the drive output in either of these ways:

1. Unplug the drive output from the system and check output voltages from the RMC. Use the open loop (“O”) command described in the following section.
2. Connect the drive output from the RMC100 to the actuator and supply output voltages to see if the actuator moves. This method is described in the following section.

Test Actuator Motion

Connecting drive output from the RMC100 to the actuator and supplying output voltage is the quickest method of testing actuator motion and direction. If there is no movement, remove the connector and verify that the actuator receives a voltage.

Note: Read this section completely before executing any commands on the RMC.

Note: Verify the Simulate bit is NOT set in the CONFIG word.

In the Command area of the RMCWin display, select the correct axis and enter the following (see Figure 3):

```

MODE          0x0001
ACCEL         10
DECEL         10
SPEED         0
COMMAND VALUE 100
    
```

These values cause the output voltage to change to 100 mV at a rate of 10 mV/ms.

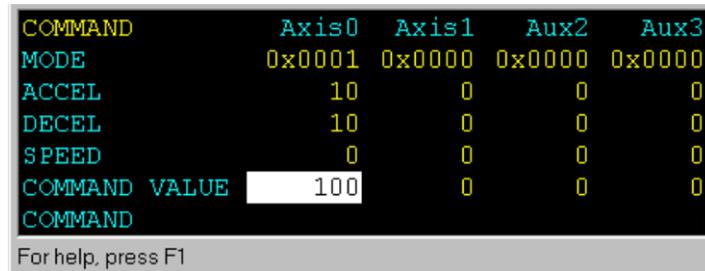


Figure 3. Initial values to verify drive.

Note: Be prepared to stop the system with the **K** button or ALT+K. Both issue a Kill (K) command, which will set the drive output to 0 volts.

Send an open loop command by typing O and then ENTER in the Command field or by pressing ALT+SHIFT+O. You should see the value of DRIVE in the status area of the RMCWin display change to 100. You should be able to measure roughly 100 mV with a voltmeter on the drive output connector.

Observe the COUNTS value in the RMCWin display Status Area, and note whether the value is increasing or decreasing.

One of three things could have happened at this point:

1. The actuator moved and the COUNTS increased. In this case you are ready to go to the next section and set the SCALE.
2. The actuator moved and the COUNTS decreased. In this case you must use the Reverse Drive Mode bit in the CONFIG parameter to reverse the direction. Double click on the CONFIG parameter, check the Reverse Drive Mode option in the dialog box (see Figure 4). Click OK, and then click the **P** to initialize the RMC100.

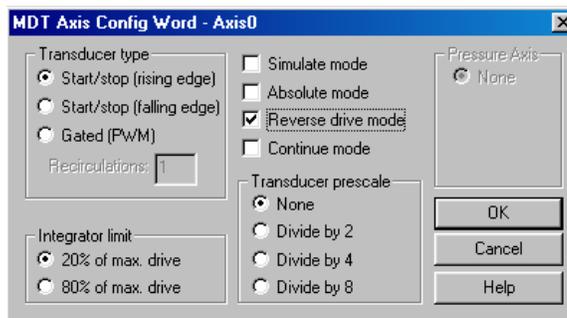


Figure 4. Setting Reverse drive mode.

3. The actuator does not move. In this case check the output voltage, check that the actuator is enabled, verify the Simulate bit is not set in the CONFIG word, increase the voltage and repeat the process above.

Note: It is essential that the COUNTS increase when a positive output voltage is specified with the "O" command. If this condition is not met, you will not be able to control the axis in closed loop.

At this point the drive has moved in one direction. Verify that it moves in the opposite direction with the following steps:

1. Click  or press ALT+K to turn drive voltage off.
2. In the COMMAND area of the RMCWin display, select the drive axis and enter a -100 for the COMMAND VALUE (-100 mV).
3. Send an open loop command by entering ALT+SHIFT+O.

You should see the value of DRIVE in the status area of the RMCWin display change to -100 and the drive should move in the opposite direction.

Setting the Scale

 Index/scale/scale and offset calibration utility

Contents/Transducer Types/Your Transducer Type/Scaling

It is important to specify the measurement units to be used. Setting the SCALE converts the information from the transducer into meaningful measurement units. Most transducer types use this parameter with the Prescale Divisor bits in the CONFIG parameter to convert from the change in transducer counts to a change in the actual position. Refer to the online Help topics at left for more information.

Note: SCALE is a signed number. If you want your system's position units to increase when the COUNTS decrease, set the SCALE to a negative value.

Tuning the System

 Contents/Starting Up the RMC/Setup Details/Tuning a Position Axis

Once the system is set up, it must be tuned in order to operate. Tuning gets the system to move in a controlled manner, with minimal oscillation, overshoot, or lag error. Tuning allows the system to achieve the best efficiency and stability.

See the Tuning section in this document for instructions on how to tune your system.

Saving Configuration Settings

 Index/step-by-step startup. Scroll to Step 10.

Make sure you save your configuration settings or they may be lost! There are three ways to save configuration settings.

1. Save settings on the controller in FLASH. Certain types of configuration settings may only be set via RMCWin on the PC and stored in FLASH.

To save configuration information to FLASH, click the  button or issue an Update Flash (U) command.

2. Save settings on disk on the PC.
3. Save settings on the PLC. The PLC can then send this information to the controller on startup.

After performing the startup, save your configuration settings. See the appropriate online Help topic for more information.

Step-by-Step Example

Appendix D contains a step-by-step, illustrated example of setting up and tuning a hydraulic cylinder. Read this to see the practical details of setup and to learn how to use the plots to tune the axis. This will help you to quickly set up and control a hydraulic system!

Communications



Index/digital
I/O/communication

Index/step-by-step startup. Scroll to Step 9.

After setting up and tuning your system, it is ready to be programmed and integrated into the rest of your application. The RMC100 offers numerous communication options for this purpose.

The purpose of communications is to issue commands and read back status information. Available RMC100 communications modules include Modbus Plus, PROFIBUS-DP, Serial, and Ethernet. A simple communications interface between the RMC100 and the system controller or Programmable Controller (P/C) is also provided by the Digital I/O module.

See the RMC Modules section of this document for a short overview of each, and the communications section of the online Help for more detailed information.

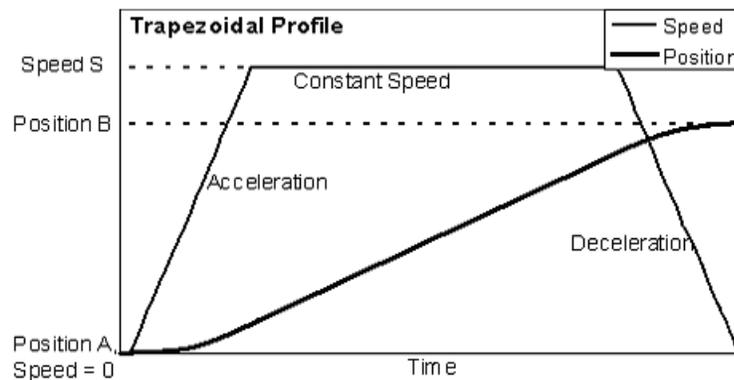
Features of the RMC100

The RMC100 contains a host of useful features that will enable you to precisely and efficiently control any complex motion application. These features include powerful control options, flexible programming capabilities, effective diagnostic tools, a diverse set of feedback options, and support for many popular communication types.

Control Options

Trapezoidal Profile

Closed-loop motion moves made with the RMC100 have a trapezoidal speed profile, as shown in the following figure.



The axis moves from position A to position B in the following manner:

- Accelerates from zero speed to speed S.
- Moves at a constant speed S.
- Decelerates to zero speed and ends at position B.

The RMC100 allows the user to independently specify the acceleration, deceleration, and speed portions of the move. This flexibility is a powerful tool for any motion control application.

Open Loop (Direct Drive Output)



Index/Open Loop/Open Loop

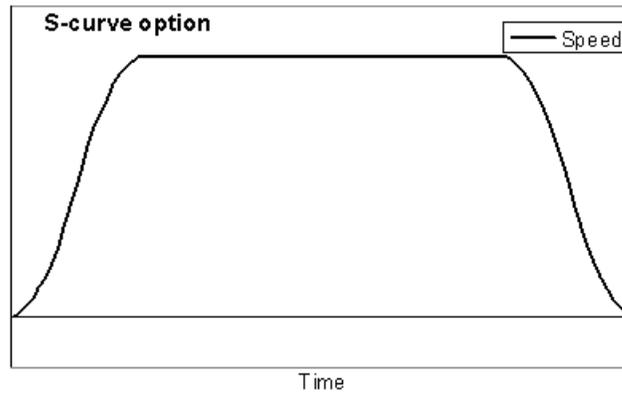
Although the RMC100 is designed for precise closed-loop motion control, it does have an open-loop mode. In open-loop mode, the user specifies the amount of drive, and the RMC100 outputs that amount. The RMC100 automatically reverts to the open-loop state after certain faults.

Open loop is useful for jogging the axis under manual control and determining whether the system is working correctly after initial setup.

S Curves

 [Index/s curves/S curves](#)
scroll to bit 7

For applications requiring smooth motion with more gradual starts and stops and higher peak speeds, the RMC100 offers an "S-curve" option for the trapezoidal motion profile. When this option is selected, the RMC100 calculates an s-shaped target as shown below.



Splines

 [Index/Splines/Spline Overview](#)

Some applications require that the motion controller move between a number of given positions. The splines feature of the RMC100 greatly simplifies such applications. The user only needs to enter the desired points at certain intervals and the RMC100 automatically calculates the intermediate positions while maintaining smooth motion free from jerks or discontinuities.

The splines positions can be placed as a function of time, position units from an axis, or counter ticks from a digital I/O input. This makes the splines feature a powerful tool for applications such as curve sawing, animatronics, cyclical testing and electronic camming among others.

Gearing

 [Index/gearing/Gearing Axes](#)

Gearing is used when one axis (the geared axis) must move incrementally and proportionately to another axis (the gear master). The RMC100 easily performs this so-called electronic gearing (as opposed to mechanical gearing) and allows the user many options.

The RMC100 allows any axis to be geared to another axis or to a position input encoder. Setup is simple since the master axis does not need to do anything to be the master. Multiple axes may be geared to the same master.

The user specifies the gear ratio, which can be changed at any time. When issuing a gearing command, the geared axis must change its speed to the speed dictated by the user-specified gear ratio. This is called clutching. The RMC100 has 3 methods of specifying clutching, which makes the task of synchronizing the axis to the rest of the system simple.

Pressure or Differential Force

 Index/pressure control/*Using Analog Channels as Pressure Inputs*

The RMC100 excels in pressure control applications. Control can be performed with either single-ended or double-ended pressure feedback. With double-ended pressure feedback on a hydraulic systems, the differential force on the piston can be calculated, allowing force to be controlled. The RMC100 firmware is specifically designed to handle the characteristics of hydraulic pressure and force control.

Position/Pressure or Position/Differential force.

 Index/position-pressure transition/*Position-Pressure Overview*

The RMC100 not only excels at pressure and force control, but is also designed to smoothly transition from position control to pressure control. This functionality makes the RMC100 perfect for applications such as injection molding, powder metal presses, hydroforming and many others.

Pressure Regulating Mode

Pressure or force is controlled in the RMC100 in the same manner as position. That is, the pressure is made to go to the value to which it is commanded. The RMC100 corrects for any errors while the pressure is changing and when it has reached the commanded pressure.

Pressure or Differential Force Limit

To fill the needs of pressure control applications requiring more than the standard pressure regulating mode, the RMC100 has a pressure control mode available with special firmware: Pressure (or force) Limit. This type of pressure control allows the user to set a maximum value of pressure which is not to be exceeded. The axis can then be controlled for position. If the pressure approaches the user-defined maximum pressure, the position is limited so that the pressure does not surpass this value.

This functionality is very useful in applications where movement is made while required to remain under a certain pressure, such as molding, extrusion, gripping and many others.

Quick Mode

 Index/quick mode/*quick mode scroll to Bit 6.*

A typical move in closed-loop control with the RMC100 is constrained to follow a certain target path defined by the user. In some applications, the user does not care about the target path during the initial portion of the move.

For these applications, the Quick Mode can be used. The RMC100 simply outputs an open-loop drive defined by the user and does not enter closed loop control until the axis approaches the commanded position. It then ramps the speed down and reaches the commanded position.

This is useful for quickly reaching the commanded position because full drive can be given to the axis initially. Normally, this might cause the axis to fault if it were in full closed-loop control.

Analog Reference

 [Index/analog transducer/overview](#)

The RMC100 analog modules can be used as reference inputs. This is very useful for applications requiring an external target generator or joystick. This externally generated voltage or current signal can then be used to generate a position or velocity target for another axis.

Filtered Reference

 [Index/reference command/Reference Command](#)

The RMC100 has very flexible and powerful reference capabilities, allowing any input axis to be used as a reference axis. Thus, an MDT, SSI, quadrature or analog signal can be used as a reference. In addition, the RMC100 has digital filtering capabilities that can be applied to any reference axis to reduce noise.

Programming

Commands

 [Index/command/command](#)

The RMC100 has a simple and consistent, yet versatile command structure. In addition to the command itself, there are 5 command fields that may contain information for each command. These fields are:

- Mode
- Acceleration
- Deceleration
- Speed
- Command Value

For example, the Go ("G") command uses the Mode to determine what type of move to make, the Acceleration and Deceleration fields determine the accelerations, and the Speed determines the speed of the move.

Other commands use these same fields, although they may not have anything to do with accelerations or speeds. Every command that is issued, regardless of the method, must also have all the fields set correctly.

Event Control

 [Index/event control/overview](#)

The Event Control feature allows a sequence of commands to be executed without intervention from the Programmable Controller (P/C). This lets the module respond to events within the control-loop time (1ms or 2ms) rather than the scan rate of the P/C. It also reduces the controller programming required.

Event Control consists of a series of Steps that are linked together in sequences. The Steps consist of a command area containing the instruction to be executed and a link area that specifies the next Step number and its trigger. There are a total of 256 Steps that can be shared by all axes.

The Event Control has many functions that allow powerful programming of complex motion applications. Some are listed here:

- Wait for inputs or states

- Compare functions
- Math capabilities
- Trigger an event sequence from a digital input
- Conditional branching

Master Control (PLC or PC)

The RMC100 may be controlled from a PLC, a PC or other programmable controller. The RMC100 provides a full range of communication options between the RMC and the programmable controller. This enables the user to choose between broadband control of the RMC for complex applications or limited control for simpler applications.

The RMCWin on-line help contains highly detailed information for controlling the RMC with each method of communication. The www.deltamotion.com web site also contains many demonstration PLC programs.

This complete programming ability allows complex motions to easily be performed by the RMC100.

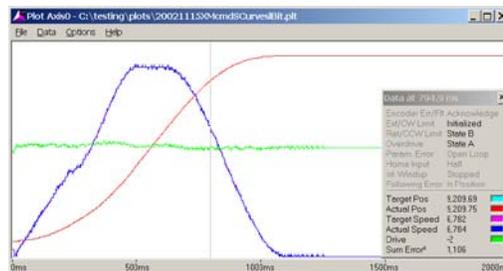
Diagnostic Tools

 Index/plots/using

The RMC100 contains diagnostic tools for monitoring and troubleshooting every aspect of any motion it performs. A description of each follows.

Plots

The plotting utility in the RMC100 is very powerful. Each move automatically initiates a plot, in addition to the user being able to start a plot at any time. Each plot contains the following useful information from an axis:



- Actual Position
- Target Position
- Drive
- Status Word
- Actual Speed
- Target Speed
- 2 user-selected pieces of data

The plotting utility is essential for tuning an axis. The user can view exactly what happens at a resolution of down to 1 msec. The plotting utility also calculates the Sum Error², a quantitative measure of how close the actual trajectory follows the target trajectory.

The plot data can also be viewed in numerical spreadsheet form.

Command Log

 Index/command log/*Command Log*

When debugging problems with a system that is using the RMC, it is often difficult to determine whether the problem is caused by an action of the RMC or the Programmable Controller (P/C). To help with this problem, the Command Log is available. The Command Log holds the last 256 commands received through the communication module; commands sent by RMCWin or the event step table are not displayed. Therefore, the Command Log can be used to determine which commands were actually received by the RMC.

Status Words

 Index/status word/*status word*

The Status Words are values showing the state of certain axis properties. These status words are updated constantly and can be viewed from RMCWin or read from the RMCWin by a PLC or PC. The status words provide a complete picture of what is happening in the RMC100. The status words are:

Command Position	Drive
Target Position	Actual Speed
Actual Position	Null Drive
Transducer Counts	Step
Axis Status Word	Link Value

Status Bits and Status Bits Window

 Index/status/*Using the Status Bits Window*

The Status register is a collection of 16 bits to provide a summary of the state of the axis. Eight bits are generally used for error bits. Each of the error bits latch on when the error is detected.

The Status register is displayed in RMCWin as a 16-bit hexadecimal number. To make it easier to view each bit, RMCWin provides the Status Bits Window, which labels each bit independently. These bits are very useful for showing the state of the axis.

These bits can also be captured and viewed in the plots.

I/O Bit Monitor

 Index/ i/o Bit Monitor /*Using the I/O Bit Monitor*

The RMC100 provides a visual tool, called the I/O Bit Monitor, for keeping track of all the digital inputs and digital outputs. This tool constantly updates the state of each input for the viewer to see. This simplifies design and verification of digital I/O.

Parameter Error List

 Index/ parameter error:list/*parameter error:list*

Problems related to user-issued commands cause the Parameter Error bit to be set. There are dozens of specific problems that can lead to this bit being set. These problems can be identified by using the Parameter Error List Window. This window lists the most recent parameter errors along with a short description.

Stored Commands

 Index/ stored commands/
using

Stored Commands are useful when setting up and tuning an axis. Setup and tuning require repetitively moving the axis. Stored Commands allow the user to enter the desired moves, and issue them with a simple key combination (e.g. CTRL-2) or by the click of a button in RMCWin. This speeds up an otherwise monotonous and time-consuming task.

RMC100 Modules

This section gives an overview of the communications and feedback capabilities of the modules available for the RMC100.

Configuring an RMC100

The RMC100 series motion controllers have a modular design for configuration flexibility to meet the needs of a wide variety of applications. Due to this modular design, Delta is typically able to ship any of the more than 500 available configurations in 2 weeks or less. However, unlike many modular systems, each RMC controller is configured at the factory and fully assembled and tested as a complete unit before shipping.

The RMC100 controllers are packaged in compact din-rail mount enclosures. Within the package, the first two modules are the communications and the CPU. Then, one to four modules are added for I/O. Each module adds 1 inch to the package width, resulting in four different footprints ranging from 4.12 x 5.95 to 7.12 x 5.95 inches. All of the RMC100 motion modules handle two axes resulting in configurations with two, four, six, or eight axes. Almost any combination can be specified to fit almost any application: linear or rotary, position, pressure, or position/pressure control.

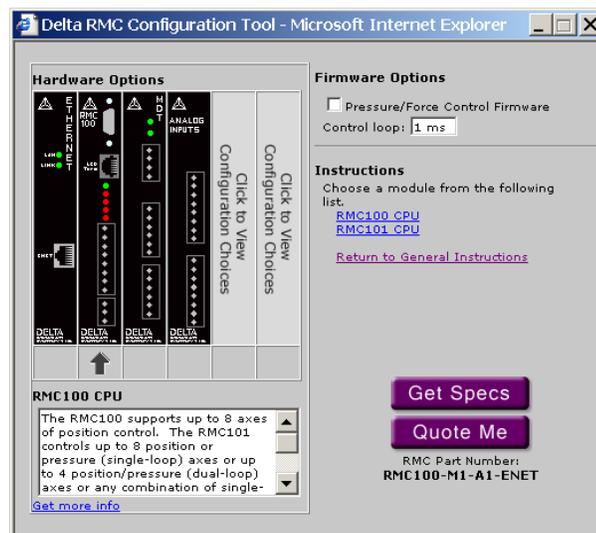
Configuration Tool

Look for this button on the website!



The RMC Configuration Tool on the Delta website at www.deltamotion.com, makes determining the best motion controller for a specific application quick and easy.

The RMC Configuration Tool provides informative screens that show all communication, control, and interface choices that are available for the RMC100 family of motion controllers. Links are provided to detailed information on every RMC100 module, and users can request a price quote and additional information on any specific configuration.



Communications Choices

The versatile RMC100 Motion Controllers can be configured with one of five different communication modules supporting more than 25 protocols. The bus-based communication modules are not just for motion data acquisition—they support full motion control via the host system. (RMC100 motion controllers also have an RS232 serial port for use with Delta’s RMCWin setup, tuning and diagnostics package.) Your choice of a Comm Module will depend on the required performance and compatibility match with your communication architecture.

Comm Module	Protocols and Modes	Performance
-ENET	EtherNet/IP, CSP, Modbus/TCP, CAMP, ISO-on-TPC, FINS, HEI	10Mb, non-deterministic, High data transfer, update times vary
-PROFI	PROFIBUS DP Message Mode or Compact Modes	9.6kb to 12Mb, deterministic, high data transfer with Message mode
-MB+	Modbus Plus with or without Global Data	1Mb, deterministic, flexibility allows high data transfer
-SERIAL	A-B DF1, Modbus/RTU, Mitsubishi No Protocol Mode, consult Delta for others	RS232/RS422/RS485, 9.6kb to 115,200kb data transfer. Update times vary
-D/I/O	Command Mode, Input to Event, Parallel Event, Parallel Position	Low data transfer. Events can be triggered quickly

A short description of each communication module follows. The RMC part number designation of each module is in parentheses.

Ethernet (-ENET)

 [Index/ENET/RMC Ethernet Module Overview](#)

The RMC100 offers a communication module for EtherNet/IP. This protocol is an open protocol that has steadily been gaining popularity in the industrial world. EtherNet/IP is innovative in that it combines the traditional messaging services with higher-performance and more deterministic I/O services. The RMC ENET supports both EtherNet/IP messaging and I/O. The Ethernet module can be used to communicate with RMCWin.

Profibus (-PROFI)

 [Index/Profibus/Overview](#)

The RMC100 offers a communication module for the PROFIBUS-DP open industrial Fieldbus. This Fieldbus is vendor independent and therefore a large range of Programmable Controllers (P/C) or other PROFIBUS masters can control the RMC100.

- Operating baud-rates: 9.6Kbaud to 12Mbaud
- Supported: Freeze mode, sync mode, automatic baud-rate detect, set slave address
- Modularity: the RMC100 is a modular station that can have one module selected at a time.

Modbus Plus (-MB+)

 [Index/Modbus plus/Overview](#)

The RMC100 offers a communication module for the Modbus Plus local area network system, which supports up to 64 devices (nodes) and transfers data at 1 million bits per second (1Mbaud). The RMC100 acts as a slave, which means it will respond to master requests, but will not initiate requests.

Serial (-SERIAL)

 [Index/Serial module/RMC Serial overview](#)

The SERIAL module adds a single serial port to the RMC for communications with other devices such as HMIs and PLCs. This port cannot be used for RMCWin or RMCCOM communications, but has a great amount of flexibility:

- **Protocols:** Modbus/RTU, Allen-Bradley DF1 (Full- and Half-duplex), Mitsubishi Binary
- **Baud Rate:** 9,600 to 115,200.
- **Parity:** Odd, Even, or None
- **Line Drivers:** RS-232, RS-422, and RS-485
- **Flow Control (RS-232 only):** None or Hardware (RTS/CTS)
- **Termination and Biasing (RS-422/485 only):** Both software selectable on Rx and Tx wire pairs

DI/O (-DI/O)

 [Index/digital i/o / communication](#)

The Digital I/O module provides a simple communications interface between the motion controller and the system controller or Programmable Controller (P/C). The Communication Digital I/O can operate in four modes:

- Parallel Position Mode
 - The user can give simple Go and Open Loop commands using just the discrete inputs.
- Input to Event Mode
 - Each input is used to trigger certain Event Steps. Can be used when the positions to which an axis will be moved are known and can be pre-programmed.

- Command Mode
 - Allows any command to be sent to the motion controller and allows a wide range of status information to be sent back. This mode is more complicated than the other modes and requires a PLC for the communications, is much more capable than the other Communication Digital I/O modes.
- Parallel Event Mode
 - Can give commands to up to four axes at a time. This mode is intended for use with devices that can provide parallel outputs, such as PLCs and thumb-wheel switches.

Communications Compatibility with Common Host Systems

Host System	RMC100 Family Communication Module			
	-ENET	-PROFI	-MB+	-SERIAL
A-B CompactLogix	A-B# 1761-NET-ENI			A-B DF1
A-B ControlLogix	A-B# 1756-ENBT	SST# SST-PFB-CLX		A-B DF1
A-B MicroLogix	A-B# 1761-NET-ENI			A-B DF1 (1500 LRP Recommnd)
A-B PLC-2, PLC-3			ProSoft# 3300-MBP	A-B DF1
A-B PLC5/x0	Built-in with PLC-5/x0E PLCs or use A-B# 1785-ENET	SST# SST-PFB-PLC5	ProSoft# 3300-MBP	A-B DF1
A-B SLC500	Built-in with SLC 5/05. Others use A-B# 1761-NET-ENI	(SLC 5/03 or later) SST# SST-PFB-SLC	(SLC 5/02 or later) ProSoft# 3350-MBP	A-B DF1
A-B SoftLogix 5800	Any Windows comp Ethernet card			A-B DF1
A-B SoftLogix 5	Any Windows comp Ethernet card	SST# 5136-PFB-PCI or 5136-PFB-ISA		
DirectLogic DL205/405	Automation Direct# H2-COM, H4-COM			Modicon Modbus/RTU
GE Fanuc Series 90-30	Ethernet available on new models	Horner Electric# HE693PBM101		RS-232 – Call Delta for info
GE Fanuc Series 90-70		SST# SST-PFB-GE		
Mitsubishi FX2N				Use No Protocol Mode
Modicon 800 Series (*1), other			Many options available from Schneider Electric	Modicon Modbus/RTU
Modicon Premium	Modicon# TSXETY110	Modicon# TXSPBY100	Many options available from Schneider Electric	Modicon Modbus/RTU
Modicon TSX Momentum		Modicon# 170 DNT 110 00	Many options available from Schneider Electric	Modicon Modbus/RTU

Modicon TSX Quantum (*2)	Modicon# 140 NOE 211 00	Modicon# 140 GRP 811 00	Many options available from Schneider Electric	Modicon Modbus/RTU
Omron C200				RS-422/485 – Call Delta for info
Omron CJ1, CJ1M and CS1	Omron# CS1W			
Omron CV	Omron# CV500-ETN01			
PC (ISA)	PC-based SCADA or control software that supports any of the controllers in this chart that can communicate over Ethernet	SST# 5136-PFB-ISA or 5136-PBMS-ISA Lan# SMS-CIF30-PB or SMS-CIF30-DPM	Schneider Electric# SA85 Lan# SMS-CIF30-MBP	PC-based software that supports DF1 or Modbus/RTU
PC (PCI)		SST# 5136-PFB-PCI Lan# SMS-CIF50-PB App# Several versions	App# PCI2000MBP	
PC (3U CompactPCI)		App# CPC11000PFB or CPC1-DPIO		
PC (PC/104)		SST# 5136-PFB-104 Lan# SMS-CIF104-PB or SMS-CIF104-DPM App# PC104PFB or PC104-DPI	Lan# SMS-CIF104-MBP	
PC (PCMCIA)		SST# 5136-PFB-PCM Lan# SMS-CIF60-PB		
Reliance AutoMax		SST# SST-PFB-REL		
Siemens Simatic 505 (*3), S5	(505) CTI# CTI 2572	Many options available from Siemens		
Siemens Simatic S7-300, S7-400	Siemens# CP 343/443-1	Many options available from Siemens		
SoftPLC	PC-based—Ethernet support standard			
VMEbus (*4)		SST# 5136-PFB-VME		
	-ENET	-PROFI	-MB+	-SERIAL

*See Delta’s Bus-based Products for other Motion Control options for these platforms: (*1) MMC188/40, MMC188/41, (*2) MMC120, (*3) TMC188/40, TMC188/40-Q, TMC188/40-TA, TMC188/40-TQ, TMC188/40-TQA, (*4) VMC186/40, VMC186/40-A, VMC186/40-Q

This is only partial list. The RMC100 motion controllers can communicate with the above PLCs or any other PLC using the DI/O module. The RMC100 can also communicate directly to many HMIs via Ethernet, A-B DF1, or Modbus RTU or other protocols.

This list is provided for the convenience of our customers. Delta shall have no liability whatsoever for the use of this information, the accuracy or completeness of the list or of the availability or suitability of any products referenced.

All registered or trademarked names are the property of their respective companies.

A-B: Allen-Bradley (www.ab.com)
App: Applicom (www.applicom-int.com)

Automation Direct (www.automationdirect.com)
CTI: Control Technology, Inc. (www.controltechnology.com)
Delta: Delta Computer Systems, Inc. (www.deltamotion.com)
GE Fanuc (www.geindustrial.com, www.gefanuc.com)
Hilscher (www.hilscher.com) available through Lantronix
Horner Electric APG (www.heapg.com)
Lan: Lantronix (formerly Synergetic Micro Systems, Inc.) (www.synergetic.com)
Mitsubishi (www.mitsubishielectric.com)
Modicon or Schnieder Electric: (www.modicon.com)
Omron (oeiweb.omron.com)
Reliance (www.reliance.com)
ProSoft Technology, Inc. (www.psft.com)
Siemens (www.sea.siemens.com) or (www.aut.sea.siemens.com)
SoftPLC Corp (www.softplc.com)
SST: (www.mysst.com)

Drive and Transducer Interface Choices

Nine different I/O modules are available for the RMC100 Motion Controllers. Each motion I/O module handles two axes, and RMC100 controllers can be configured with one, two, three, or four I/O modules. I/O modules can be “mixed and matched” for control of as many as eight axes with one motion controller. When combined with the communication module choices, this I/O module flexibility results in more than 500 configurations of the RMC100 motion controller available off-the-shelf. Motion I/O modules are available with analog or stepper drive outputs and interfaces for a wide variety of position feedback devices. Your choice of Interface Modules will depend on the required performance and compatibility match with your feedback devices and physical system.

RMC100 Interface Module	Outputs	Inputs	Transducer Compatibility	Performance
Motion Modules (Position Interface, Drive Outputs)				
-M_n	2 Drive, ±10V*, 12-bit analog	2 MDT, PWM or Start/Stop, RS-422 differential	Most MTS (Temposonics), Balluff, and similar types	Absolute position, 120MHz count rate for 0.001” res (one circ)
-S_n	2 Drive, ±10V*, 12-bit analog	2 SSI, Binary or Gray Code, 8-25 bits, RS-422 differential	Absolute rotary encoders, MDTs with compatible SSI	Absolute or incremental position, High resolution, noise immunity
-Q_n	2 Drive, ±10V*, 12-bit analog, 2 Enables	2 Quadrature (A, B, Z), RS422 differential, and 6 discrete, 5-24Vdc	Quadrature encoders with RS422 signals	Incremental position, 4,000,000 counts/sec, fast response to index and home
-QST_n	2 Drive, Step & Direction, 2 Enables	2 Quadrature (A, B, Z) RS422 differential, and 6 discrete, 5-24 Vdc	Quadrature encoder optional (with RS422 signals)	Drives up to 1 MHz, open or closed loop, 4,000,000 counts/sec quadrature
-SST_n	2 Drive, Step & Direction, 2 Enables	2 SSI, Binary or Gray Code, 8-25 bits, RS-422 differential	SSI transducer optional (Absolute rotary encoders, MDTs with compatible SSI)	Drives up to 1 MHz, open or closed loop, High resolution, high noise immunity SSI, absolute position
Motion or Auxiliary Modules (Analog Inputs for Position, Pressure, etc. Drive Outputs)				
-H_n	2 Drive, ±10V* 12-bit analog, +10V Exciter	4, 16-bit differential analog	0-10V, ±10V, 0-5V, ±5V, 4-20mA	Absolute Position, Pressure or Force, Position/Pressure
-G_n	2 Drive, ±10V* 12-bit analog, +10V Exciter	2, 16-bit differential analog	0-10V, ±10V	Absolute Position, Pressure or Force, Position/Pressure
Auxiliary Modules				
-A_n	None	4, 12-bit differential analog	0-10V, ±10V, 0-5V, ±5V, 4-20mA	Analog reference, Pressure or Force
-D_n	8 discrete SSR (Solid State Relay), 2.5kV isolation	18 discrete, sinking, Logic Polarity configurable, 2.5kV isolation	Outputs: ±30V, ±100mA, 1.5ms propagation delay Inputs: 5-24V 6-10mA max 2.0ms response	Comm DI/O, Fast response to / triggering external events

*Use Delta’s VC2100 Voltage-to Current converter to convert ±10 Volts to current

drive for servo valves. The full-scale output of the VC2100 is adjustable from ± 10 to ± 200 mA in 10mA steps.

A short description of each communication module follows. The RMC part number designation of each module is in parentheses.

MDT Input with Analog Output (-Mn)

 [Index/MDT/Overview](#)

Magnetostrictive displacement transducers are designed for use in rugged industrial environments. They are non-contact, wear-free, highly reliable, and offer accurate and repeatable linear position measurement. In the motion control industry magnetostrictive displacement transducers are typically inserted into hydraulic cylinders for measurement of the cylinders' extension/retraction position.

An MDT transducer communicates the position measurement via Start/Stop pulse or Pulse Width Modulation.

SSI Input with Analog Output (-Sn)

 [Index/SSI/Overview](#)

Synchronous Serial Interface (SSI) is a widely accepted controller interface. Position data from the sensor is encoded in a binary or Gray Code format and transmitted over a high-speed synchronous interface.

SSI transducers and absolute encoders offer the following advantages:

- Linear or Rotary
- High resolution. Up to 2 μ m (approx. 0.00008")
- Noise immunity
- Cost effective data transfer (only one 6-wire cable is needed)
- Transmission rate independent of data length and resolution
- Transmission over long distances
- Direct connection to the RMC's SSI interface module

Quadrature Input with Analog Output (-Sn)

 [Index/quadrature/Overview](#)

The QUAD interface allows the RMC100 control a wide range of motors and linear actuators with quadrature encoder feedback.

- Features of the Quadrature Encoder Interface:
 - 4,000,000 counts/second
 - A and B Inputs
 - Index Input with High-speed 125ns Position Latch
- Drive Amplifier Interface:
 - Isolated ± 10 V, 12-bit Analog Drive Output
 - Amplifier Enable Output
 - Amplifier Fault Input

- Additional Inputs:
 - Extend (CW) Travel Limit Input
 - Retract (CCW) Travel Limit Input
 - Home Input with High-speed 50 μ s Position Latch
 - Status LED
- Digital Noise Filters on All Inputs
- All Discrete Inputs are Isolated
- Use with Servo Drives in Velocity or Torque/Force Modes

Analog Input (-An)



Index/analog/Overview

The RMC100 offers a 12-bit Analog Input module with no output and with optional pressure control capabilities.

- Four analog inputs with 12-bit Analog/Digital Converters.
- No analog outputs.
- Able to utilize Pressure control firmware.
- Uses: speed reference (joystick), position reference (joystick), transitioned pressure control, transitioned differential force control, and pressure reference.

Analog Input with Analog Output (-Hn, -Gn)



Index/analog/Overview

The RMC100 offers a 16-bit Analog module with input and output and with optional pressure control capabilities.

- Four analog inputs with 16-bit Analog/Digital Converters.
- Two analog outputs with 12-bit Digital/Analog Converters assigned to analog channels 0 and 2.
- Uses: position control, velocity control, speed reference (joystick), position reference (joystick), pressure control, differential force control, and pressure reference.

Stepper Output with Quadrature Input (-QSTn)



Index/stepper/Overview

The RMC100 offers a quadrature interface module with stepper output. The quadrature-encoder interface does not have to be used; the motor can be controlled open loop, but still can take advantage of the RMC's host of target generating methods including trapezoidal and s-curve point-to-point moves, gearing, synchronization, and splines.

When used with quadrature feedback, faults can be triggered on following errors, and motor compensation can be enabled. See Stepper Compensation for details on this feature.

The stepper has the same features as the quadrature except for the Stepper Motor Interface:

- 1 MHz Maximum Output Frequency

- Step Output
- Direction Output
- Drive Enable Output
- Drive Fault Input

Stepper Output with SSI Input (-SSTn)

The RMC100 offers an SSI interface module with stepper output. It combines the features of the SSI module with the Stepper output.

Additional Digital Inputs and Outputs (-Dn)

 Index/ digital i/o /sensor

The RMC100 offers a Digital I/O module consisting of eighteen digital inputs and eight digital outputs. The outputs can be set using commands. The inputs on the Sensor Digital I/O can be used for the following:

- Triggering event sequences using the Input to Event table.
- Controlling transitions between Steps in the Event Step table.
- As an edge or quadrature counter (only inputs 16 and 17).

When used in combination with a Communication DI/O using Parallel Event mode, the inputs can be used as part of that mode. Refer to Parallel Event mode for details.

Transducer Compatibility with Common Manufacturers

Transducer Manufacturer	RMC100 Family Interface Option			
	-MDT	-SSI	-Q, -QST Quadrature	-H, -G Analog
Balluff 800-543-8390 www.balluff.com	Start-Stop and PWM supported (either edge)—specify external interrogation*	MDTs: Specify a BTL5-S1xx-Mxxx-x-SU040-xxx SSI synchronous transducer for motion control**	Quadrature encoders	0-10V, $\pm 10V$ (All) 0-5V, $\pm 5V$, 4-20mA (H only)
Baumer Electric Ltd. 800-937-9336 www.baumerelectric.com		Absolute rotary encoders	Quadrature encoders	
BEI Industrial Encoder 800-350-2727 www.beiied.com		Absolute rotary encoders	Quadrature encoders	
Heidenhain 847-490-1191 www.heidenhain.com		Absolute rotary encoders	Quadrature encoders	
MTS Systems Corp Sensors Division 800-633-7609 www.mtssensors.com	Start-Stop and PWM supported, specify external interrogation*	MDTs: Specify Synchronous Mode—output type Sxxx02— for motion control**		0-10V, $\pm 10V$, 0-5V, $\pm 5V$, 4- 20mA
Patriot Sensors & Control Corp 800-635-0289 www.patriotsensors.com	Start-Stop and PWM supported, specify external interrogation*			0-10V, $\pm 10V$, 0-5V, $\pm 5V$, 4- 20mA
Stegmann, Inc 800-811-9110 www.stegmann.com		Absolute rotary encoders	Quadrature encoders	

*For magnetostrictive displacement transducers (MDTs), the Start-Stop configuration is the native mode of operation, and typically gives the best price/performance when used with compatible motion controllers such as the RMC100 Series.

**Many MDTs are available with an optional synchronous serial interface (SSI). This extra-cost option offers several advantages including higher resolution and factory gain compensation while retaining the absolute position characteristics.

This is only partial list. The RMC100 motion controllers can interface with transducers from a wide range of manufacturers providing they meet the industry-standard interface specifications supported by the RMC100.

This list is provided for the convenience of our customers. Delta shall have no liability whatsoever for the use of this information, the accuracy or completeness of list or of the availability or suitability of any products referenced.

All registered or trademarked names are the property of their respective companies.

Appendix A: Wiring

This section describes how to wire the following RMC modules to feedback transducers and drives:

- Analog
- MDT
- SSI
- Quadrature
- Quadrature (with stepper output)

General Wiring Information.



[Index/wiring/general](#)

For CE compliance and to minimize electrical interference:

- Use twisted pairs for all wiring where possible.
- Use shielded cables for all wiring.
- Keep RMC wiring separate from AC mains or conductors carrying high currents. Especially high frequency switching power such as conductors between servo drives and motors or amplifiers and proportional valves.

For UL and C-UL compliance:

- Power supply must be Class 2.
- All RMC inputs and outputs must be connected to Class 2 circuits only.

RMC Drive Outputs

Four-Pin Plug-in Terminal Block

Pin	Function
1	Axis 0 Drive
2	Drive Common
3	Axis 1 Drive
4	Case

When positive voltage is sent to an axis's drive, the axis must extend. The extend direction is defined as the direction that causes the transducer to return increasing counts. The extend direction of a magnetostrictive transducer is away from the head.

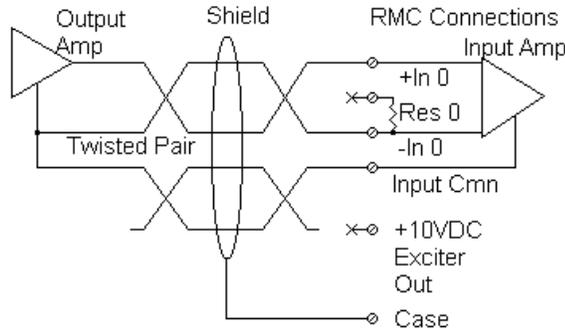
CAUTION: If the outputs from the RMC are reversed, the axis will be uncontrollable when power is connected. Confirm that your wiring is correct!

Wiring the Analog Feedback Module

Voltage Feedback Transducers

 [Index/wiring/analog](#)

Voltage feedback transducers can be connected directly to the +In and -In connections for the desired channel. The Res connection is unused for voltage transducers. The following configuration is recommended:

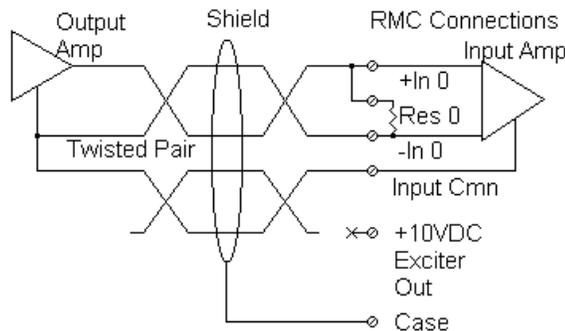


TIP: If you are using a 10V transducer output, but are only using values in the low 5V, it is recommended that you select a 5V setting to increase the resolution of the analog to digital conversion.

Current Feedback Transducers

 [Index/wiring/analog](#)

Current feedback transducers are connected in the same way as voltage transducers except that a jumper must be inserted between the +In and Res connections. This places a resistor internal to the RMC across the two inputs, thus converting the current to a voltage input. The following wiring diagram shows a suggested configuration:



Wiring the MDT Feedback Module

 Index/wiring/MDT

RMC MDT Six-Pin Plug-in Terminal Block Pin-out

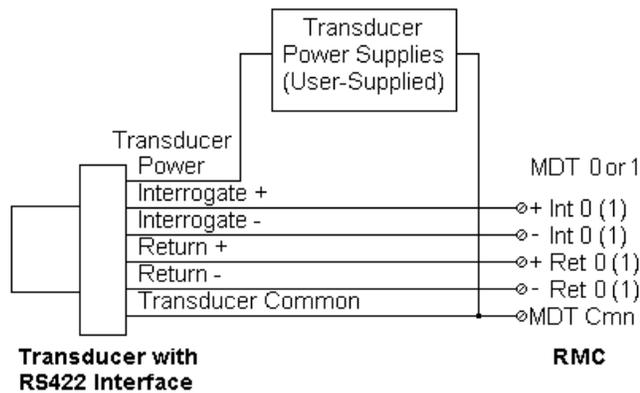
Pin	Function
1	MDT Axis + Interrogation
2	MDT Axis - Interrogation
3	MDT Axis Common
4	MDT Axis + Return
5	MDT Axis - Return
6	Case

The RMC can interface to Magnetostrictive Displacement Transducers with either single-ended (TTL) or Differential Line Driver (RS422) interrogation signals.

NOTE: The following example schematics do not include transducer pin numbers, color codes, or power supply requirements, since these vary between different transducers. To determine your power supply needs and connector pin-outs or cable color codes, consult your transducer manufacturers' documentation.

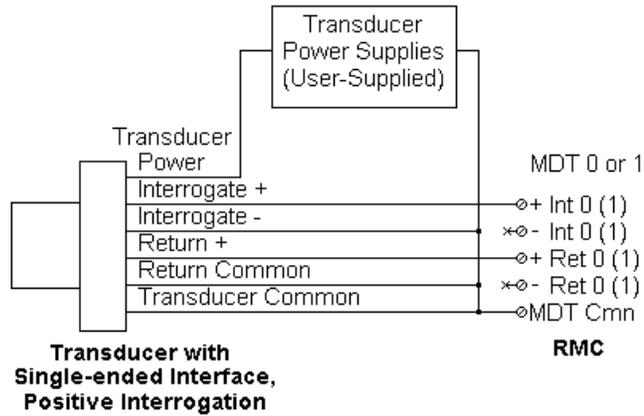
RS422 signals

- Connect both the '+Int' and '-Int' between the transducer and the RMC for the interrogation signal, and the '+Ret' and '-Ret' between the transducer and the RMC for the return signal.
- Connect the transducer DC ground to MDT Cmn.



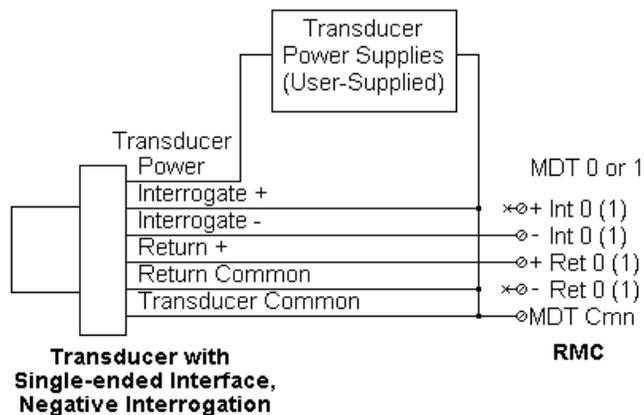
Single-ended (TTL) transducers with positive interrogation

- Connect the transducer '- interrogation in' wire to the 'MDT Cmn' pin and the transducer '+ interrogation in' wire to the '+ Int' pin.
- CONNECT NOTHING TO THE '-Int' PIN OF THE RMC.
- Connect the transducer return plus wire to the '+Ret' pin on the RMC and the transducer return common wire to 'MDT Cmn' on the RMC.
- CONNECT NOTHING TO THE '-Ret' PIN OF THE RMC.



Temposonics I transducer users

- Connect the transducer '+ interrogation in' wire to the 'MDT Cmn' pin and the transducer '- interrogation in' wire to the '-Int' pin.
- CONNECT NOTHING TO THE '+Int' PIN OF THE RMC.
- Connect the transducer return plus wire to the '+Ret' pin on the RMC and the transducer return common wire to 'MDT Cmn' on the RMC.
- CONNECT NOTHING TO THE '-Ret' PIN OF THE RMC.
- Some Temposonics I transducers from MTS have 200 Ohm termination resistors installed between their interrogation pins and common. If yours do not, it may be necessary to install them as close to the transducers as possible to reduce electrical noise in the system.



Wiring the SSI Feedback Module

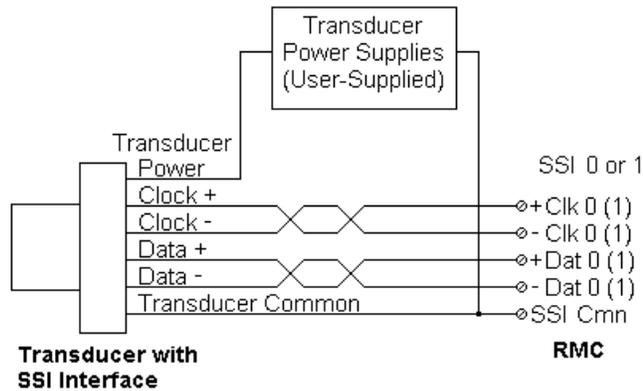
 [Index/wiring/SSI](#)

RMC SSI Input Six-Pin Plug-in Terminal Block Pin-out

Pin	Function
1	SSI Axis + Clock
2	SSI Axis - Clock
3	SSI Axis Common
4	SSI Axis + Data
5	SSI Axis - Data
6	Case

The SSI module uses differential line driver (RS422) clock and data signals.

- Connect both the +Clock and -Clock between the RMC and transducer for the clock signal, and both the +Data and -Data between the RMC and transducer for the data signal.
- The power (+24V) and ground is not provided by the RMC, and therefore must be provided externally to the transducer.
- Connect the transducer DC ground to SSI Cmn.



Wiring the QUAD Feedback Module

 [Index/wiring/quadrature](#)

Quadrature module DB25S Pin-out

Pin	Function	Wire Color	Pin	Function	Wire Color
1	A-	Enc: white/blue	14	Index (Z)-	Enc: white/green
2	A+	Enc: blue/white	15	Index (Z)+	Enc: green/white
3	B-	Enc: white/orange	16	Encoder Cmn	Enc: brown/white
4	B+	Enc: orange/white			Enc: white/brown
5	N/C		17	N/C	
6	Retract Lim-	Lim: white/orange	18	Home-	Lim: white/green
7	Retract Lim+	Lim: orange/white	19	Home+	Lim: green/white
8	Extend Lim-	Lim: white/blue	20	Fault-	Drv: white/green
9	Extend Lim+	Lim: blue/white	21	Fault+	Drv: green/white
10	N/C		22	N/C	

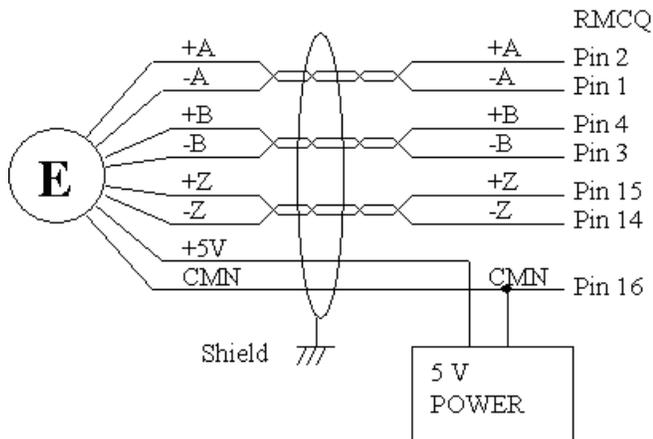
11	N/C		23	N/C	
12	Drive*	Drv: blue/white	24	Enable*-	Drv: white/orange
13	Drive Cmn*	Drv: white/blue	25	Enable*+	Drv: orange/white

Notes:

- "*" indicates outputs, all others are inputs
- Color codes are for cable part number RMC-CB-QUAD-01. This cable has three wire groups: encoder, limits, and drive. The wire color column lists the wire group and the individual wire color within that group.
- The encoder common should be connected to both wires listed.

Encoder Wiring

5 Volt differential driver:

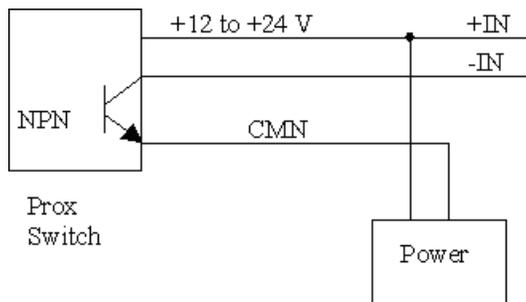


Input Wiring (Home and Limits)

NPN Proximity sensors

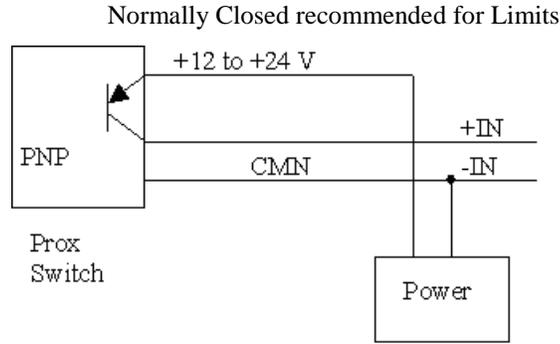
Normally Open recommended for Home

Normally Closed recommended for Limits

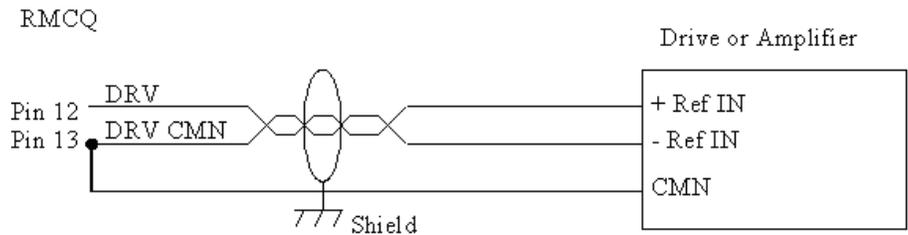


PNP Proximity sensors

Normally Open recommended for Home

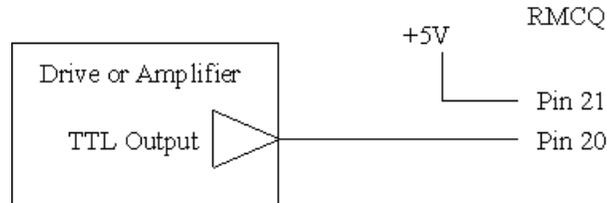


Drive Output Wiring

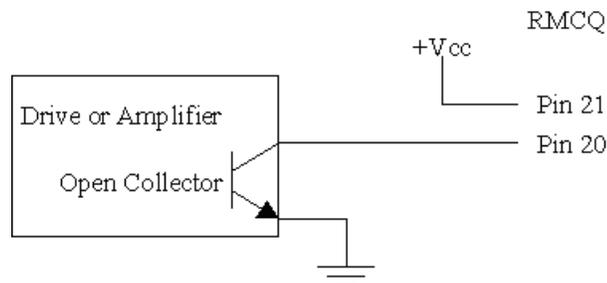


Fault Input Wiring

From TTL output:

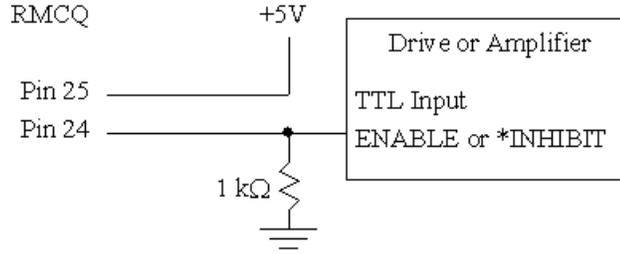


From Open Collector Output:

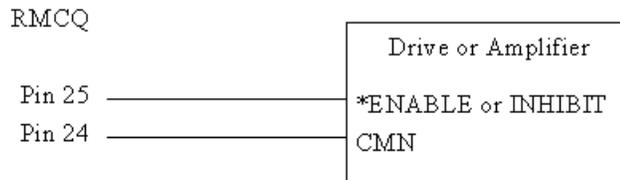


Enable Output Wiring

To TTL input (high = enable):



To active low Enable input:



Wiring the Stepper Module

 [Index/wiring/stepper](#)

Use shielded twisted pairs for all connections to inputs and outputs. Route the quadrature encoder wiring separate from other wiring. You must provide the power supplies needed by your quadrature encoders and drives, although the RMC can provide +5 VDC for the optoisolators on the drive module as shown in the Stepper Output Wiring section below.

DB25S Pin-out

Pin	Function	Pin	Function
1	A-	14	Index (Z)-
2	A+	15	Index (Z)+
3	B-	16	Encoder Common
4	B+	17	N/C
5	N/C	18	Home-
6	Retract Lim-	19	Home+
7	Retract Lim+	20	Fault-
8	Extend Lim-	21	Fault+
9	Extend Lim+	22*	Step-
10*	Vcc Out	23*	Step+
11*	Direction-	24*	Drive Enable-
12*	Direction+	25*	Drive Enable+
13*	Drive Common		

*Outputs, all others are inputs

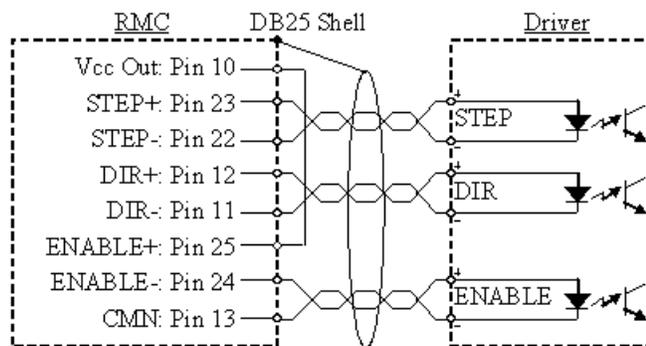
Stepper Output Wiring

NOTE: Do not use Vcc Out to power your encoder because:

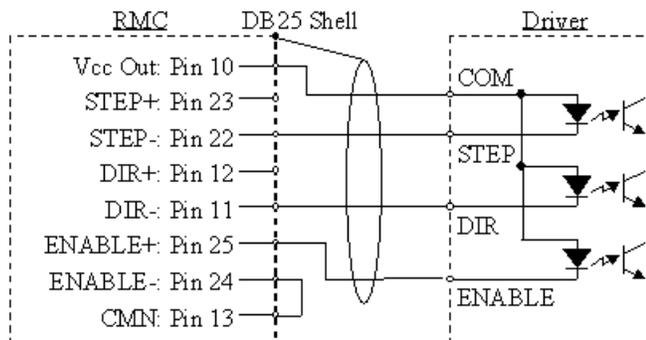
- This output's voltage is not regulated.
- 50 mA is not adequate current to power the encoder. Each of the encoder outputs (A, B, and Z) requires 20 to 25 mA in addition to the current used by the encoder's internal circuit.
- Using this output to power the encoder would violate the isolation that exists between the inputs and outputs.

NOTE: The Step and Dir outputs are generated by a differential driver, but the Enable output is a relay. Therefore, power must be provided through the Enable output, as shown in the diagrams below.

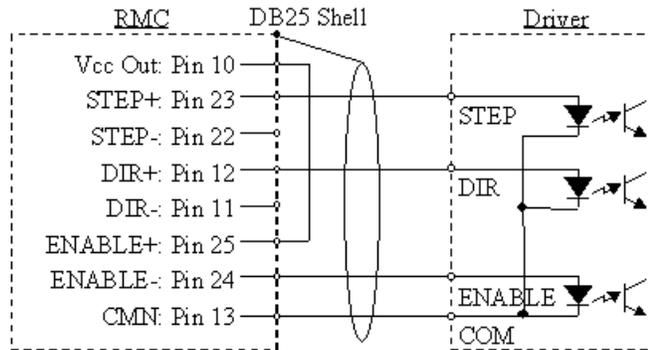
Drive with bipolar inputs:



Drive with common anode inputs:



Drive with common cathode inputs:



Input Wiring

The wiring for all inputs is identical to the wiring for the quadrature interface module with analog outputs. See the Quadrature wiring section for diagrams on these inputs.

Appendix B: Tuning

After setting up your system, it must be tuned in order to control it. The better tuned a system is, the better it follows the desired trajectory and holds position.

Tuning procedures differ depending on the type of system. This section contains procedures that may work for the following systems:

- A Hydraulic Position Axis or Motor in Velocity Mode
- A Motor in Torque Mode
- A Position/Pressure System

Please read the "General Tuning Guidelines" before continuing to any of the tuning procedures.

General Tuning Guidelines

 [Index/tuning/overview](#)

Keep these general guidelines in mind throughout the tuning procedure.

There is no substitute for experience when tuning an axis. The procedures offer some guidelines, tips, and suggestions for tuning your system. While the steps will work for many systems, they may not be the best for a particular system.

 [Index/go](#)

 [Index/plots/using](#)

 [Index/stored commands/using](#)

- The tuning procedure is a reiteration of the following general steps. Use these steps throughout the tuning procedure:
 - Make a move. Use the Go (G) command for making moves.
 - View the plotted move. See the Plots topic for more information. Viewing the plot will help you determine which parameters must be changed.
 - Change a parameter. To do this, edit the parameter in RMCWin and then click **P** to initialize the RMC100 with this value.
 - Repeat these steps using the same move until the parameter is at the desired value. See the Stored Commands topic for repeating moves.
- Use the Sum of Errors Squared in the RMCWin plotting utility to determine how the last parameter change affected the system. The Sum of Errors Squared indicates how closely the Actual Position is tracking the Target Position. If this number decreases significantly, the last parameter change was good. If this number increases significantly, the last parameter change was bad.
- Remember, that in order to use the Sum of Errors Squared to compare moves, the moves must be identical.
- Begin the tuning procedure with long, slow moves and low Accelerations. This will prevent you from losing control of and potentially damaging the system.
- To obtain the greatest tuning precision, use the shortest Plot Time possible. This will spread the move across the entire plot window and allow you to see precisely how the system is responding. See the Plot Time topic in the online help.
- You may want to turn off some of the Auto Stop bits. The Auto Stop turns off the Drive if an error occurs. In the initial stages of tuning, a Following Error or other error may occur, causing an undesired halt. Setting these bits to "Status

 [Index/plot time](#)

Only" will make the RMC ignore the errors so you can tune the axis. This may not be possible on some systems because of safety concerns. Remember to set these bits to either "Soft Stop" or "Hard Stop" when you have gained sufficient control of the axis.

- When changing the parameters, remember that they are not updated in the RMC until the Set Parameters (P) command  is issued. They are not stored into the RMC FLASH memory until the Update FLASH command  is issued.

Tuning a Position Axis



Index/tuning/position

The following procedure may be used to tune many hydraulic position axes and motors in velocity mode.

1. Set all Gains and Feed Forwards to zero

This is done by editing the values in the main RMCWin window. Then click the  to initialize the RMC100.

2. Set the Null Drive

The drive it takes to hold the axis in position is referred to as the Null drive. If the axis tends to drift significantly when you give it an Open Loop drive of 0, you should set the null drive. This drive is then always added to the total drive output and helps the RMC100 accurately follow the motion profile. To set the null drive, issue a P command to hold the axis in position in closed loop, then issue the N command.

3. Check Dead Band

If your system has a large dead band, you will need to set the Dead Band Eliminator value. To find your dead band, give increasing amounts of drive to the system with the Open Loop command. The value of drive at which the system starts to move is your dead band. If this value is approximately 400 or greater, the Dead Band Eliminator should probably be used. If it is less, it is left to the discretion of the designer.

4. Adjust the Proportional Gain

The Proportional Gain must be adjusted to gain some control over the system for continuing the tuning procedure. Adjust the Proportional Gain by slowly increasing it and making moves. When the system gets close to final position reasonably quickly, continue to the next step. If the system begins to oscillate, decrease the gain.

5. Adjust the Feed Forwards

In many hydraulic systems the feed forward parameters (Extend Feed Forward and Retract Feed Forward) are the most important parameters for position tracking during a move.

Make a long move without any oscillation or overdrive. Then issue the Set Feed Forward command. This command will automatically adjust the Feed Forward parameter for the direction of that move.

6. Adjust the Acceleration Feed Forwards

The Acceleration Feed Forward terms help eliminate following errors while accelerating. It is particularly useful for systems moving large masses with relatively small cylinders. Such systems often have a delay before the start of

movement. The Acceleration Feed Forward terms can help compensate for this delay.

Look for following errors during acceleration and deceleration. Increase the Extend and Retract Acceleration Feed Forward terms until the errors disappear.

For large masses the Acceleration Feed Forward may be in the tens of thousands.

7. **Readjust the Proportional Gain**

Proportional Gain affects the responsiveness of the system. Low gains make the system sluggish and unresponsive. Gains that are too high make the axis oscillate or vibrate.

Slowly increase the gain. When you see a tendency to oscillate as the axis moves or stops, reduce the gain by 10 to 30 percent.

At this point, if you have gained sufficient control of the system, you may want to increase the speed, accel and decel of your moves and further adjust the proportional gain. A value of proportional gain that may seem good at low speeds and accels, may not work at higher speeds.

8. **Adjust the Integral Gain**

The Integral Gain is helpful for getting into position and for tracking during long, slow moves. It will not significantly affect tracking during short, fast moves. Many hydraulic systems do not require a large Integral Gain. However, it is usually desirable to have some Integral Gain (5 to 50 units) to help compensate for valve null drift or changes in system dynamics. Some systems may require larger Integral Gain, in particular if they are moving a large mass or are nonlinear. Too much Integral Gain will cause oscillations and overshoot.

9. **Adjust the Differential Gain**

Differential Gain may greatly enhance performance on many hydraulic systems. It is used mainly on systems that have a tendency to oscillate. This happens when heavy loads are moved with relatively small cylinders. Differential Gain will tend to dampen out oscillations and help the axis track during acceleration and deceleration. This will positively affect short, fast moves.

Important: If you use Differential Gain, you may be able to increase the Proportional Gain somewhat without causing the system to oscillate.

If the drive output during the constant velocity portion of the move is smooth, the Differential Gain is perhaps not set high enough. The drive output may look "fuzzy." This indicates that the drive is responding to the minute errors of the axis. Note that not all systems allow the differential gain to be set high enough for the drive to be "fuzzy".

A disadvantage of Differential Gain is that it amplifies position measurement noise. If there is too much noise or the gain is too high, this can cause the system to chatter or oscillate.

10. **Increase System Speed**

Gradually increase the Speed and Acceleration values while making long moves. Look for following errors, overshoot, or oscillations.

- If an overdrive error occurs, there is not enough drive capacity to drive the axis at the requested Speed or Acceleration. Should this occur, reduce the Speed and/or Acceleration and Deceleration.

- If a following error occurs during acceleration and deceleration and adjusting the Gains and Acceleration Feed Forward does not help, the Acceleration and Deceleration ramps are too steep for the response of the system.
- If the actual position lags or leads the target position during the entire constant velocity section of the move, adjust the Feed Forwards.
- Should the system seem a little sloppy, try adjusting the Proportional Gain.
- If the Drive is not high, the gains can probably be increased for better control. If the Drive is too high, or an overdrive error occurs, the system is not capable of performing the requested move. The Speed, and/or Accelerations may need to be decreased.
- If the system vibrates while in position, the Dead Band value may need to be increased. However, if the oscillation is not caused by a deadband in the system then this will not help! A rule of thumb is to set the Dead Band Eliminator value to half of the peak-to-peak oscillation of the drive output while in position.

The final tuning of the system should be made at the speed of intended operation.

Tuning a Torque Motor

The following procedure may be used to tune motors running in torque mode.



Index/tuning/torque motor

1. Set all Gains and Feed Forwards to zero.

This is done by editing the values in the main RMCWin window. Then click the **P** to initialize the RMC100.

2. Set the Null Drive

The drive it takes to hold the axis in position is referred to as the Null drive. If the axis tends to drift significantly when you give it an Open Loop drive of 0, you should set the null drive. This drive is then always added to the total drive output and helps the RMC100 accurately follow the motion profile. To set the null drive, issue a P command to hold the axis in position in closed loop, then issue the N command.

3. Check Dead Band

If your system has a large dead band, you will need to set the Dead Band Eliminator value. To find your dead band, give increasing amounts of drive to the system with the Open Loop command. The value of drive at which the system starts to move is your dead band. If this value is approximately 400 or greater, the Dead Band Eliminator should probably be used. If it is less, it is left to the discretion of the designer.

4. Adjust the Differential Gain

Torque motors generally do not have much damping. Damping must be provided for the system, or it will be difficult to control. Providing some Differential Gain will effectively dampen the system. Do the following:

- Set all the gains to zero. Issue an Open Loop (O) command of zero.
- Increase the Differential Gain. Issue a Set Parameters (P) command to put the axis in closed loop control.

- c) Repeat b until sufficient damping is obtained. There are several methods to do this, depending on the system:
- For small motors, rotate the motor manually to get a feel for the resistance to movement (damping). Repeat step b until the damping is significant. If the motor chatters or oscillates, decrease the gain.
 - For systems that cannot be moved manually, repeat step b until the motor starts humming (or chattering or oscillating) and then back the Differential Gain off significantly, perhaps even 50%, to avoid oscillating later while making moves.
 - For finer adjustment on large systems, repeat step b, and then momentarily (e.g. 5 milliseconds) give a drive output to the motor. The Event Step table (see the Event Control help topic) can be used to do this with the Open Loop command. This jolt to the system will provide a clear indication of whether the Differential Gain is too high.



Index/event control/overview

Do not set the Differential Gain too high! Remember that the point here is only to provide some damping for continuing the tuning process. The Differential Gain will be fine-tuned later. Keep in mind that motors often require a very high Differential Gain.

5. Adjust the Proportional Gain

Adding Proportional Gain will now improve system performance. Adjust the Proportional Gain by slowly increasing it and making moves. If the system begins to oscillate, decrease the gain.

6. Adjust the Feed Forwards

In torque motor applications, feed forward parameters (Extend Feed Forward and Retract Feed Forward) often do not require high values. Adjust these parameters by making a long move without any oscillation or overdrive. Then issue the Set Feed Forward command. This command will automatically adjust the Feed Forward parameter for the direction of that move.

7. Adjust the Acceleration Feed Forwards

The Acceleration Feed Forward terms help minimize errors during acceleration and deceleration. Increase the Extend and Retract Acceleration Feed Forward terms until the errors disappear.

8. Adjust the Integral Gain

The Integral Gain is helpful for maintaining position. It will not significantly affect tracking during short, fast moves. Increase the Integral Gain until the system starts oscillating, then back it down some. Motors may require a high Integral Gain.

9. Readjust the Differential Gain

Differential Gain tends to dampen out oscillations and help the axis track during acceleration and deceleration. This will positively affect short, fast moves.

Important: If you increase the Differential Gain, you may be able to increase the Proportional Gain somewhat without causing the system to oscillate.

If the drive output during the constant velocity portion of the move is smooth, the Differential Gain is perhaps not set high enough. The drive output may look "fuzzy." This indicates that the drive is responding to the minute errors of

the axis. Note that not all systems allow the differential gain to be set high enough for the drive to be "fuzzy".

A disadvantage of Differential Gain is that it amplifies position measurement noise. If there is too much noise or the gain is too high, this can cause the system to chatter or oscillate.

10. Increase System Speed

Gradually increase the Speed and Acceleration values while making long moves. Look for following errors, overshoot, or oscillations.

- If an overdrive error occurs, there is not enough drive capacity to drive the axis at the requested Speed or Acceleration. Should this occur, reduce the Speed and/or Acceleration and Deceleration.
- If a following error occurs during acceleration and deceleration and adjusting the Gains and Feed Forwards does not help, the Acceleration and Deceleration ramps are too steep for the response of the system.
- Should the system seem a little sloppy, try adjusting the Proportional Gain.
- If the Drive is not high, the gains can probably be increased for better control. If the Drive is too high, or an overdrive error occurs, the system is not capable of performing the requested move. The Speed, and/or Accelerations may need to be decreased.
- If the system vibrates while in position, the Dead Band value may need to be increased.

The final tuning of the system should be made at the speed of intended operation.

Tuning a Position/Pressure System



Index/tuning/position-pressure

Tuning a position/pressure system is not a trivial task. In order to be successful, the system must be set up properly. Read the Position/Pressure Setup, the Position/Pressure Tuning Procedure, and the Position/Pressure Example in the online help before beginning the procedure.

Position/Pressure Setup



Index/position-pressure
transition/position-pressure setup

Steps for Setting Up Position/Pressure Control:

1. Configure the Axes

Once the RMC is correctly wired to the transducers, the modules must be correctly configured.

a) Configure the Position Axis

The following procedure is for configuring MDT modules. If you have a different module, look up its configuration procedure in the on-line help.

i. Set blanking period (if required)

- If you have a clevis-mounted transducer, see MDT configuration to change the blanking period from the default 21 ms to 5 ms, otherwise do nothing here.

ii. Configuration word

- Double-click the Config Word for the MDT axis.

- Select the transducer type you have. See MDT configuration for more details on the Configuration word.
- iii. Set scale and offset
- On the Tools menu, click MDT Scale/Offset Calibration.
 - In the Desired Position Units field, enter the desired measurement units. Many position/pressure applications use 1000 units per inch.
 - In the Transducer field, enter the transducer data. This information is available from the transducer specifications.
 - The Offset field allows you to set your zero point at any point along the transducer. Move the cylinder to where you want your zero point to be. Click the button in the Offset field to automatically enter the counts into the counts box.
 - If you wish your measurement to be in the opposite direction of the transducer counts, select decreasing position units in the Increasing counts equals field.
 - Set the desired extend and retract limits in the Extend/Retract Limits field.
 - Click Apply or Done when you are finished.
 - Issue a Set Parameters (P) **P** command to initialize the axis with these settings.
- b) Configure the Analog Axis
- The following procedure is for configuring the analog axis for pressure control.
- i. Module Configuration
- On the Tools menu, click Module Configuration.
 - In the Slots list, select an analog module.
 - Click Slot options.
 - Click the Channels 0-1 or Channels 2-3 tab depending on which channel your pressure transducer is connected to.
 - Click an option button to set the correct channels for either auxiliary pressure if you are using single-ended pressure, or auxiliary force if you are using double-ended (differential) pressure.
 - Click Update RMC.
 - The Update Module Configuration dialog box will be displayed to indicate the progress. If the RMC could not be reset automatically, you may be prompted to reset the RMC manually.
 - In the RMC Configuration dialog box, click Close.
- ii. Configuration word

- Double-click the Config Word (in the parameter area of the main screen) for the pressure axis.
 - In the Input type field, select the type of feedback of your pressure transducer.
- iii. Set scale and offset
- On the Tools menu, click Scale/Offset Calibration.
 - If the axis is pressure control:
Enter the desired Actual Pressure for two different pressure counts (the counts are the feedback from the transducer). The scale and offset will be automatically calculated.
 - If the axis is force (differential pressure) control:
Enter the following information:
 - Maximum gauge reading
 - Actuator Type
 - Cylinder Dimensions
 - Desired Force Units
 - Desired Force Direction

This information allows the Actual Pressure in the Status area of the main screen to display the net force on the cylinder.
 - Click Apply or Done when you are finished.

2. Assign the Pressure Axis to a Position Axis

The RMC performs pressure control using two or more inputs from transducers and one drive output to the hydraulic valve. Any position axis with analog drive output (not stepper output) can be used to provide the drive output and position input. To enable pressure control on this position axis, you must assign a pressure-enabled analog axis to the position axis. In this configuration, the analog inputs—whether using two transducers monitoring differential force, or a single transducer monitoring single-ended pressure—are then used together with the position axis to control both position and pressure.

To assign a pressure axis to a position axis:

- a) Double-click the Config Word for the position axis. This will open the Config Word dialog box.
- b) In the Pressure Axis field, click the desired Pressure Axis.
- c) Click **OK**.
- c) Issue a Set Parameters (P) command to cause these bits to take effect.
- d) If you want the axis assignment to be remembered after the RMC power is cycled, then issue an Update FLASH (U) command . This needs to be done only once.

3. Set Up the Event Step Table

Setting up and tuning position/pressure control requires issuing multiple

commands numerous times. Doing this from a PLC or by typing commands in RMCWin is very awkward. To simplify the process, Event Steps in RMCWin should be used for setting up and tuning position/pressure control.

To perform position/pressure control, the following steps must be set up in the Event Step Table:

1. Issue a P command so the axis will hold position.
2. Issue a Set Null Drive to Integral Drive (n) command. This updates the null drive (drive needed to hold position), which is critical for pressure control.
3. Move the axis to the correct starting position. Normally, the axis should be at a position where the pressure is below the desired entry pressure (Pressure Set A).
4. Set up the pressure control mode. This sets up the parameters that the pressure axis will use when it enters pressure regulating mode. This is done by issuing the Set Pressure (^) command.
Note: this step does not put the axis into pressure regulating mode.

This step sets up the following parameters:

Mode	Sets Ramp Type, Ramp Time and Integrator Mode
Pressure Set A	Pressure at which Pressure control begins.
Pressure Set B	Pressure at which Pressure control ends.
Ramp Time	Time to ramp to commanded pressure.
Command Pressure	The pressure the system will go to when regulating pressure.

5. Move in the direction of increasing pressure with the monitor pressure bit set (pressure monitoring mode). When the pressure reaches Pressure Set A, the axis enters pressure regulating mode. The axis enters pressure control according to the parameters previously set up by the Set Pressure command.
6. Control the pressure as desired.

The following sample Event Step Table illustrates these steps:

Parameter	0	1	2	3	4	5	6	7
Mode	0x0000	0x0000	0x0000	0x8001	0x0018	0x0101	0x0008	0x0008
Accel	0	0	0	100	1000	100	1000	1000
Decel	0	0	0	100	500	100	500	500
Speed	0	0	0	10000	200	5000	50	50
Command Value	0	0	0	36000	5000	40000	6000	5000
Command		P	n	G			G	
Commanded Axes	Default		Default					
Link Type	0 (End)	DelayMS	DelayMS	BitsON	DeleyMS	Bits2 ON	DelayMS	DelayMS
Link Value	0	500	0	0x0001	0	0x0001	1000	1000
Link Next	0	2	3	4	5	6	7	6

Explanation of each step in the Event Step table:

- Step 0: This step is normally linked to after finishing a sequence. If the event control is at step 0, it usually means the event control has stopped. This step does nothing.
- Step 1: Issues a P command so the axis will hold position. Waits for 1/2 sec so the drive output will stabilize for the next step.
- Step 2: Issues a Set Null Drive to Integral Drive. This updates the null drive (drive needed to hold position), which is critical for pressure control.
- Step 3: This step moves to 36.0 in. at 10 in./sec (assuming it is set up for a resolution of 0.001 in., then $36000 = 10$ in. and $10000 = 10$ in.) It then waits until bit 1 (the In Position bit) is on before continuing to the next step.
- Step 4: This step sets up the pressure parameters that will be used in step 5. The Mode word is set up to Calculate Ramp Time and Integrator Active Only at Pressure. Pressure Set A is 1000, Pressure Set B is 500, and the Command Pressure is 5000. This step waits 0 msec and goes to step 5. Note that the Ramp Time, set to 200, is not used since Calculate Ramp Time has been selected.
- Step 5: This step moves toward 40 in. with the Monitor Pressure bit set in the Mode word. Once the pressure reaches Pressure Set A (as set in step 4), it will begin controlling pressure. It will go to a pressure of 5000 (as set in step 4). This step waits until bit 0 (At Pressure) is on before continuing to step 6.
- Step 6: This step changes the Command Pressure to 6000, with the same Pressure Set A and B as in step 4 and a Ramp Time of 50. The pressure will ramp to 6000, and then the step waits 1000 msec before continuing to step 7.
- Step 7: This step changes the Command Pressure to 5000, with the same Pressure Set A and B and Ramp Time values as in step 6. The pressure will ramp to 5000, and then the step waits for 1000 msec before continuing to step 5. Steps 5 and 6 will repeat until a Quit Events (Q) command is issued. Ramping the pressure up and down in this manner is very useful when tuning the pressure. It is important that the Ramp Time be fairly short, because parameters suitable for slow changes (long Ramp Times) may make the system unstable for fast changes.

Notes on using event control for position/pressure:

- To begin an Event Step sequence, enter the desired event number in the Command Value field and issue a Start Events (E) command by typing "E" in the Command field on the main screen.
- Before any commands may be issued to an axis, a Set Parameters (P) command must be issued. This initializes the axis.
- Event control is only allowed on position axes. However, when a pressure command is entered in an Event Step on a position axis that has an assigned pressure axis, then the command is issued to the pressure axis instead of the position axis.
- For a list of pressure commands that will be sent to the pressure axis, refer to Command. Notice, however, that the Set Mode (M), Open Loop (O),

and Set Parameters (P) commands will not be sent to the pressure axis because they are also valid on the position axis.

- When editing the event table you will have to keep in mind that for pressure commands, you should enter values for Pressure Set A in the Acceleration field, values for Pressure Set B in the Deceleration field, and values for Ramp Time in the Speed field.

Once you have set up your Event Steps table, continue to Tuning a Position/Pressure System.

Position/Pressure Tuning Procedure

 Index/position-pressure transition/tuning a position-pressure system

The following procedure may be used to tune a system that transitions from position control to pressure control.

There is no substitute for experience when tuning an axis. This procedure offers some guidelines, tips, and suggestions for tuning your system. While these steps will work for some systems, they may not be the best for a particular system.

1. Tune the Position Gains

The position gains should be tuned before attempting to tune the axis for pressure. Obtaining control of the axis' position greatly simplifies the tuning of the pressure gains. If you have not yet tuned the position gains, follow the procedure outlined in Tuning a Position Axis before continuing.

2. Set Null Drive.

When the axis is holding position (stopped) in closed loop, issue a Set Null Drive to Integral Drive (n) command. For best accuracy, this should be done after the axis has been in position for a while, such as 1 second.

The null drive is the drive required to hold the axis in position. In some systems, such as hydraulics with servo valves, this value may change with time. Therefore, this step should be performed periodically.

For the remainder of the tuning procedure, use an Event Step sequence as described in the Position/Pressure Setup topic and illustrated in the Position/Pressure Example

3. Adjust the Proportional Gain

The Proportional Gain should be adjusted first to gain some control over the pressure before continuing the tuning procedure.

Note: If negative drive causes an increase in pressure, use negative values throughout the tuning procedure.

- Set the Proportional Gain to a small value, such as 2.
- Use an Event Step table that makes a position move with the Monitor Pressure bit set so the axis will transition to pressure control when the Pressure Set A threshold is crossed. Use a fairly long ramp time initially, such as 1000 msec.
- Once the axis is in pressure control, ramp the pressure between two pressures (this is best done in Event Steps). Gradually increase the proportional gain to minimize the following error. When you see a tendency to oscillate as the axis moves or stops, decrease the gain 10 to 30 percent.

4. Add Filter if Necessary

If the pressure feedback signal is excessively noisy, it may cause instability and will likely have been noticed already in the previous step. Adding a filter may help. This is done using the Filter TC parameter. See Filter TC for detailed information.

5. Adjust the Integral Gain

The Integral Gain helps get to the command pressure quickly.

- Use the same Event Step sequence as previously to ramp between two pressures. You may want to increase the delay between the steps to more clearly see the effect of this tuning step.
- Adjust the Integral Gain so that the pressure gets to commanded pressure quickly.
- Too much Integral Gain will cause oscillations and overshoot. If this happens, decrease the Integral Gain.

6. Adjust the Differential Gain

Differential Gain greatly enhances performance on many hydraulic systems. Differential Gain will tend to dampen out oscillations and help the axis track during acceleration and deceleration. This will positively affect short, fast moves.

- Continue ramping between two pressures.
- If the drive output is always smooth, the Differential Gain can probably be increased. The drive output should look "fuzzy." This indicates that the drive is correctly responding to the minute errors of the axis.
- A disadvantage of Differential Gain is that it amplifies measurement noise. If there is too much noise or the gain is too high, this can cause the system to chatter or oscillate. In this case, decrease the Differential Gain.

7. Readjust the Proportional Gain

Once the Differential Gain has been adjusted, the Proportional Gain may be readjusted. It affects the responsiveness of the system. Low gains make the system sluggish and unresponsive. Gains that are too high make the axis oscillate or vibrate.

- Continue ramping between two pressures.
- Slowly increase the gain. When you see a tendency to oscillate as the pressure changes or stops, reduce the gain by 10 to 30 percent.

8. Tune the Transition.

Now that both the position and pressure gains have been tuned, the transition may be tuned.

- Use the Event Step sequence to transition from position to pressure.
- If necessary, adjust the previously tuned pressure parameters for a smoother transition.
- If there is oscillation and overshoot or other undesirable behavior at the transition that cannot be avoided with tuning the gains, the Ramp Time may need to be changed, or the speed going into the transition may need to be slower.

- Selecting Calculate Ramp Time in the Mode word allows the RMC to automatically calculate the Ramp Time. This is useful if it is difficult to determine a Ramp Time.
- The following three steps also address parameters affecting the transition.

9. Adjust the Feed Forwards

The Extend and Retract Feed Forwards provide extra drive when extending or retracting.

- Adjust the Feed Forwards to help the actual pressure track the target pressure when it is changing.
- If the actual pressure leads the target pressure, decrease the Feed Forwards.
- The Feed Forwards may need to change for different rates of pressure change. See Feed Forwards for more information.

10. Integrator Preload

Upon transition from position control to pressure control, the drive normally goes immediately toward zero. In some cases, this is undesirable. The integrator preload can be set to some value (positive or negative) to provide some drive immediately upon the transition. If your system overshoots or undershoots when entering pressure control, you may want to adjust this value. See Integrator Preload for more information.

Using the Integrator Preload is useful for systems with predictable position-to-pressure transitions. It always provides the same amount of drive.

11. Drive Transfer Percent

The Drive Transfer Percent acts similarly to the Integrator Preload. The difference is that the Integrator Preload places a constant value into the integral drive term, while the Drive Transfer Percent places a certain percentage (positive or negative) of the current drive into the integral drive term. If your system overshoots or undershoots when entering pressure control, you may want to adjust this value. See Drive Transfer Percent for more information.

Using the Drive Transfer Percent is useful for systems with unpredictable position-to-pressure transitions, such as entering with different speeds. Because it is a percentage, the transferred drive will vary with the drive required immediately prior.

12. Fine-tune the System

The final tuning of the system should be made at the speed of intended operation.

Look for following errors, overshoot, or oscillations.

- Should the system seem a little sloppy, try adjusting the Proportional Gain.
- If the actual position lags or leads the target position during the entire constant velocity section of the move, adjust the Feed Forwards.
- If an overdrive error occurs, there is not enough drive capacity to drive the axis at the requested rate of pressure change. Should this occur, increase the Ramp Time or decrease the speed of the system.
- If the Drive is not high, the gains can probably be increased for better control, depending on system stability.

- Adding or changing the Filter TC value may help if noisy feedback is suspected.
- Note that tuning pressure is often very difficult because of the large change in pressure for a small change in position.

Appendix C: An Example

Example Setup & Tuning of a Hydraulic System

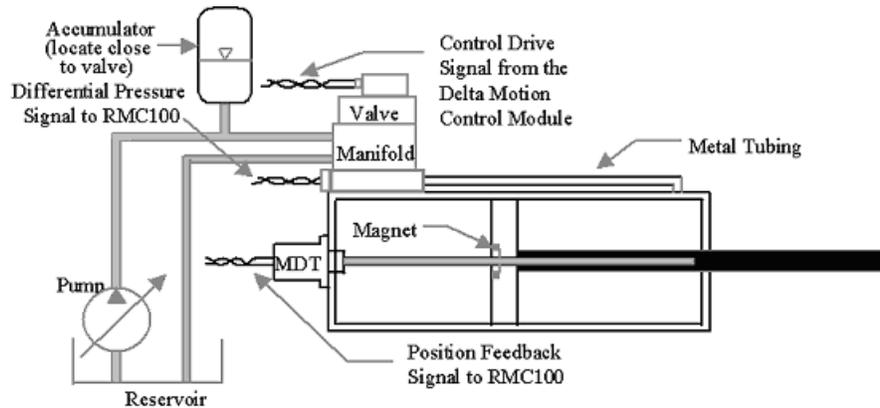
 Index/position-pressure transition/*position-pressure example*

This illustrated step-by-step example covers setting up and tuning a hydraulic position axis. This example uses a hydraulic system set up for position/pressure control, but will only treat the position portion. For a position/pressure example, see the online help.

This example uses an RMC101-M1-A1-ENET, a common configuration for position/pressure control. The system itself is a hydraulic cylinder with MDT feedback (start/stop rising edge).

1. System Design

A typical hydraulic system for position/pressure control looks like this:



Note the good design practices:

- Metal tubing between valve and cylinder.
- An accumulator close to valve.
- Use of a zero-overlap valve.

2. Wiring

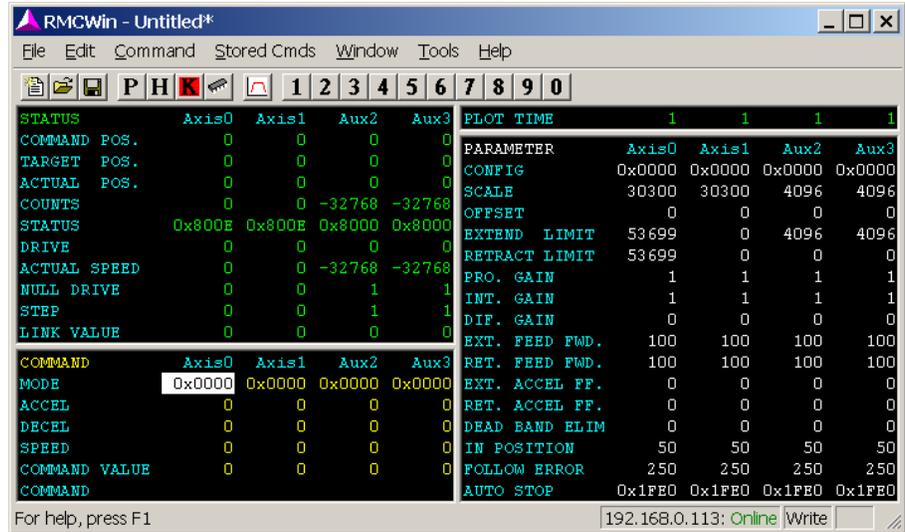
It is important to wire the transducer correctly. See the wiring section in this document for details.

For this example the system is wired as follows:

- The position feedback is wired to MDT channel 0.
- The MDT Drv 0 is wired to the valve.

3. RMCWin View

When connected to this RMC, the main RMCWin window looks as follows:

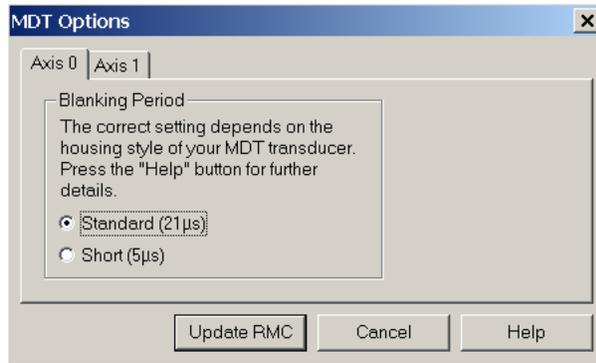


- Axes 0 and 1 are the two MDT axes.
- The other axes are for pressure and can be ignored for this example.

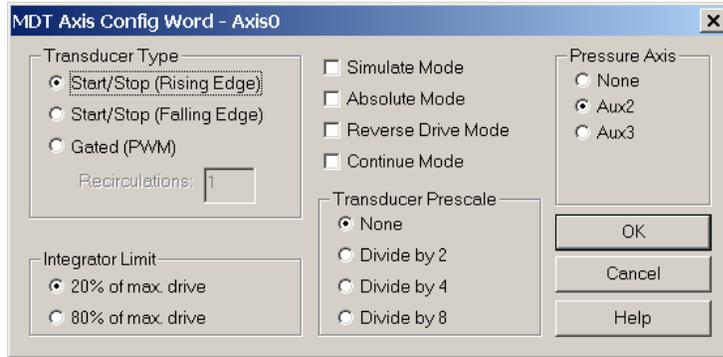
4. Configuring the MDT position axis.

To scale the MDT position axis, do the following:

- On the **Tools** menu, click **Module Configuration**.
- In the **Slots** field, click on MDT, which opens the following window:



- It is already set to 21 µs, which is correct. If the MDT transducer is a clevis-mount type, choose 5 µs.
- Click **Update RMC**.
- Double-click the Axis 0 Config Word, which opens the following window:

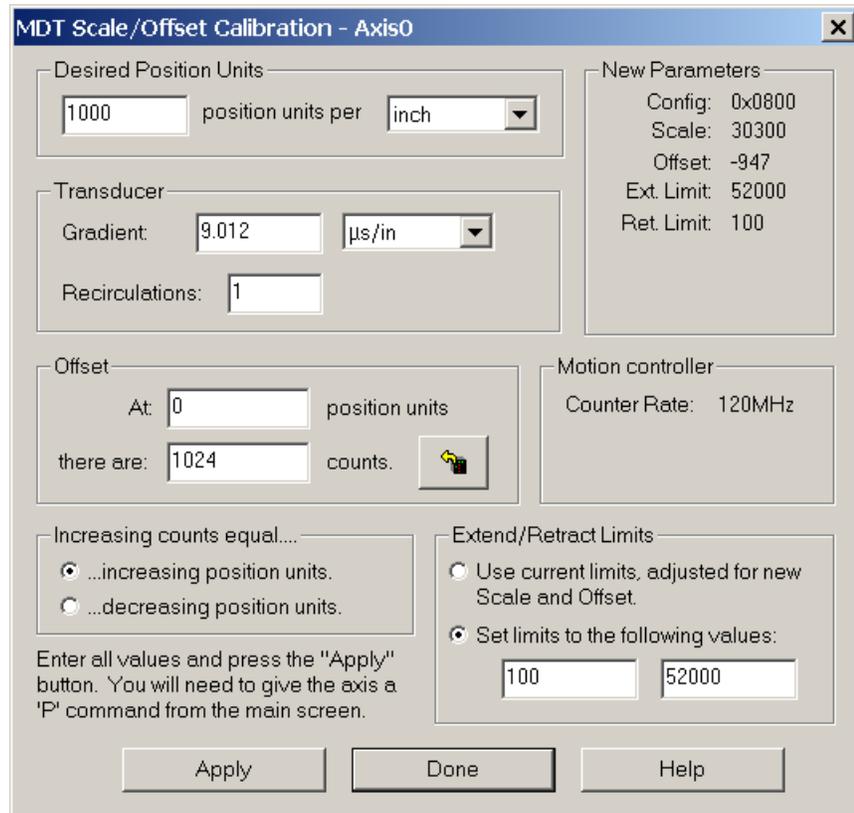


- In the **Transducer Type** field, select **Start/Stop (Rising Edge)**.
- Leave all the other settings as they are.
- Click **OK**.
- Issue a Set Parameters (P) command to Axis 0.

5. Scaling the MDT position axis.

To scale the MDT position axis, do the following:

- Click on any Axis 0 field.
- On the **Tools** menu, click **MDT Scale/Offset Calibration**. The following window opens:



- The position feedback is to be measured in thousandths of inches, so 1000 position units per inch is entered in the **Desired Position Units** field.
- The transducer gradient information in the **Transducer** field is found on the transducer.
- To set the offset, the following steps are performed
 - Retract the cylinder all the way. This can be done by issuing an Open Loop (O) command with a small amount of drive.
 - When the cylinder is all the way retracted, the transducer shows 1024 counts in this example.
 - If this is the desired zero point, click the button in the **Offset** field and it automatically enters 1024 into the counts field.
 - **...increasing counts** is selected in the **Increasing counts equal...** field.
- Set the desired extend and retract limits to 0.100 and 52 inches. This system can extend 52.700 inches, but it is undesirable to ever reach either end.
- Click **Apply** and **Done**.
- Issue a Set Parameters (P) command.

The main RMCWin window looks now like this:

STATUS	Axis0	Axis1	Axis2	Axis3	PLOT TIME	1	1	1	1
COMMAND POS.	79	0	-26	0	PARAMETER	Axis0	Axis1	Axis2	Axis3
TARGET POS.	79	0	-26	0	CONFIG	0x0800	0x0000	0x0000	0x0000
ACTUAL POS.	79	0	-26	0	SCALE	30300	30300	29695	4096
COUNTS	1110	0	-18	-32768	OFFSET	-947	0	0	0
STATUS	0x0008	0x800E	0x0000	0x8000	EXTEND LIMIT	52000	0	20712	4096
DRIVE	0	0	0	0	RETRACT LIMIT	100	0	0	0
ACTUAL SPEED	59	0	15	-32768	PRO. GAIN	1	1	1	1
NULL DRIVE	0	0	-16	1	INT. GAIN	1	1	1	1
STEP	0	0	9	1	DIP. GAIN	0	0	0	0
LINK VALUE	0	0	0	0	EXT. FEED FWD.	100	100	100	100
COMMAND	Axis0	Axis1	Axis2	Axis3	RET. FEED FWD.	100	100	100	100
MODE	0x0000	0x0000	0x0000	0x0000	EXT. ACCEL FF.	0	0	0	0
ACCEL	0	0	0	0	RET. ACCEL FF.	0	0	0	0
DECEL	0	0	0	0	DEAD BAND ELIM	0	0	0	0
SPEED	0	0	0	0	IN POSITION	50	50	50	50
COMMAND VALUE	0	0	0	0	FOLLOW ERROR	250	250	250	250
COMMAND					AUTO STOP	0x0CE0	0x1FE0	0x0080	0x1FE0

6. Tuning position.

Now the system is set up and ready to tune for position. The procedure in Tuning a Position Axis is followed:

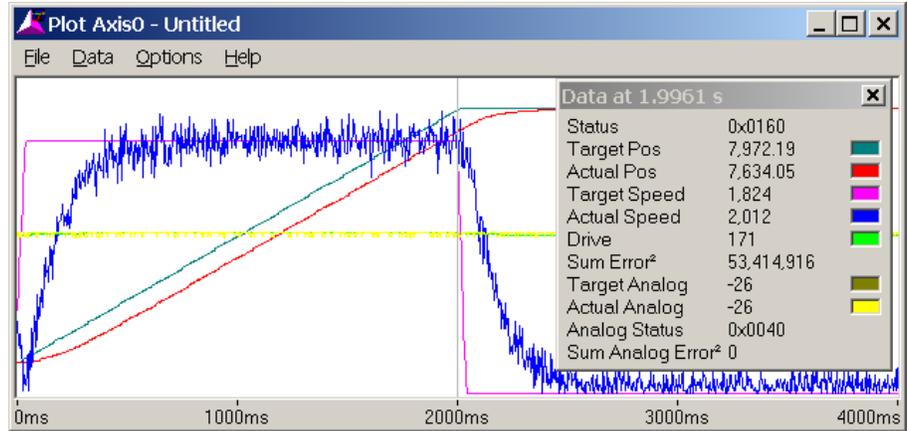
- Issue Open Loop (O) commands with small positive and negative drives to see if the cylinder goes in the right direction.
- If the cylinder moves in the wrong direction, the wiring to the drive may be swapped, or Reverse Drive mode can be selected in the Config word.

- Check the deadband. This system has a very small deadband, approx 5 millivolts, so we will not worry about it.
- Set the gains and feed forwards to zero and issue a Set Parameters (P) command.
- Double-click the Axis 0 Auto Stop word (in the Parameters field).
 - Set the Overdrive, Integrator Windup and Overdrive bits to Status only.
- Set the proportional gain to a small value, such as 5. Issue a Set Parameters (P) command.
- Set the Plot Time for Axis 0 to 4.
- Now make a move. The tuning process will consist of repeatedly making moves. To easily make repeated moves, use Stored Commands:
 - To edit and view the Stored Commands, click **Stored Command Editor** on the **Stored Commands** menu. The following window appears:

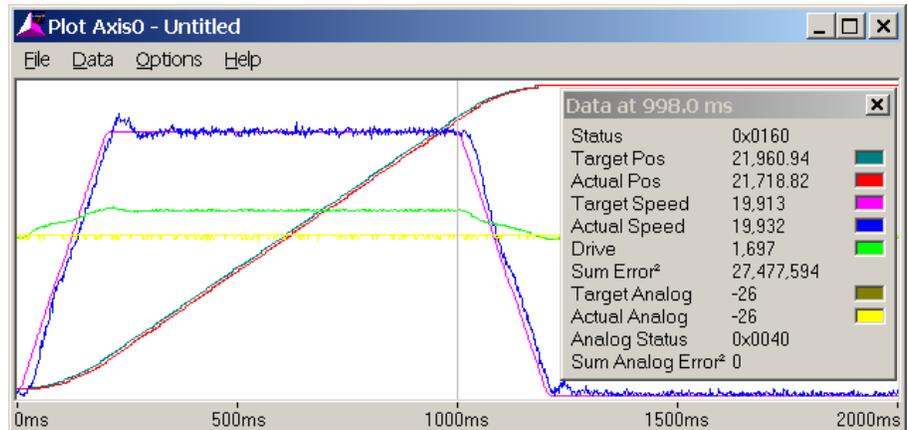
Parameter	Alt+1	Alt+2	Alt+3	Alt+4	Alt+5	Alt+6
Axis0 Mode	0x0001	0x0001	0x0001	0x0001	0x0001	0x0001
Axis0 Accel	100	100	100	100	100	100
Axis0 Decel	100	100	100	100	100	100
Axis0 Speed	10000	10000	10000	10000	10000	10000
Axis0 Command Value	4000	8000	12000	16000	20000	24000
Axis0 Command	G	G	G	G	G	G
Axis1 Mode	0x0001	0x0001	0x0001	0x0001	0x0001	0x0001
Axis1 Accel	100	100	100	100	100	100
Axis1 Decel	100	100	100	100	100	100
Axis1 Speed	10000	10000	10000	10000	10000	10000
Axis1 Command Value	4000	8000	12000	16000	20000	24000
Axis1 Command	G	G	G	G	G	G

For help, press F1

- For example, **ALT-1** on axis 1 will issue a Go cmd to 4000 at a speed of 10 in/sec, with acceleration rates of 100 in/(sec*sec). These are common values for moving hydraulic systems. These values are editable from this window.
- To use the stored commands, click on any Axis 0 field, then press e.g. ALT-1 to move to 4 in. and ALT-5 to move to 20 in. The command will be issued to the axis where the cursor is located.
- Using the Stored Commands, a move is made in this example from 2 in. to 8 in. The move will take less time than what the Plot Time is set to so that the entire move can be viewed.
- Press the Insert key. This opens the Plot window with the last move. It looks like this:

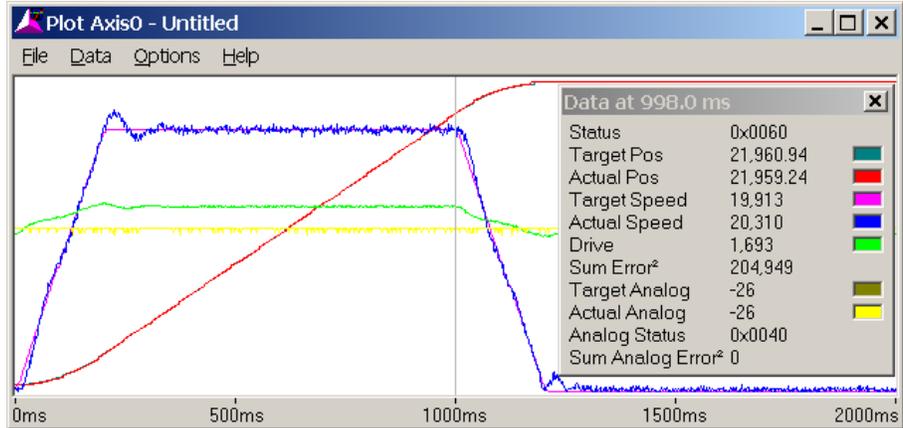


- The detail window in the plot may be opened by clicking **Show Detail Window** on the **Data** menu. The detail window provides much useful information.
- In this plot, the colored lines represent:
 - Red.....Actual Position
 - Dark Blue-Green.....Target Position (Desired Position)
 - Blue.....Actual Speed
 - Pink.....Target Speed
 - Green.....Drive Output (volts)
 - Yellow.....Pressure
- Note the Sum Error². This number gives an indication of the position error throughout the entire move. If the same move is repeated, this value can be compared to previous moves to determine whether the control has improved or worsened. If the number decreases, the control has improved.
- If the system controls fairly well, which this one does, increase the speed. Here it is increased to 20.000 in/sec. The plot time can also be reduced to 2.
- Increase the proportional gain until some oscillation appears, then back off 10-20%. On this system that point is about 70. The plot looks like this:

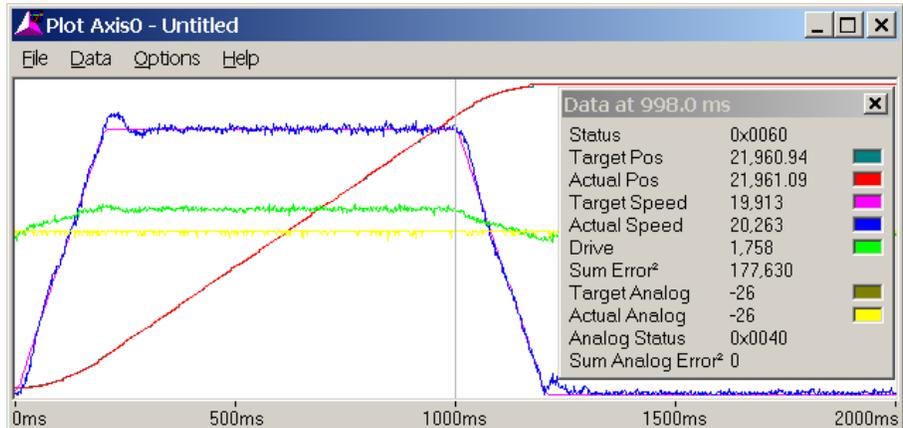


- The Sum Error² decreased from 53 million to 27 million.

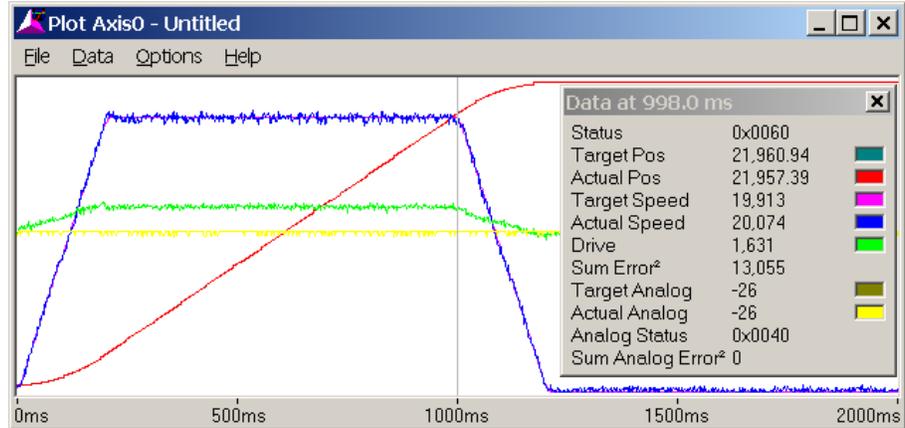
- The position lags during the constant speed portion of the move, which the next step will address.
- Make a fairly long move without any oscillations. Issue a Feed Forward Adjust (F) command. The Retract Feed Forward value is automatically updated to 84 in this case.
- Make a move in the opposite direction. Issue a Feed Forward Adjust (F) command. The Extend Feed Forward value is automatically updated to 84 in this case.
- Make a move. The axis should track much better now:



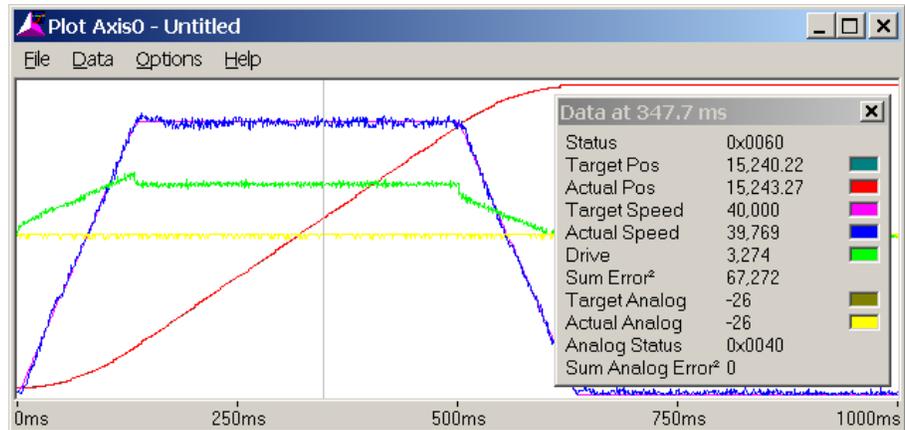
- The Sum Error² decreased from 27 million to 204,000!
- The next step is the integral gain. Gradually increase it as long as it does not adversely affect the system. Generally, the Integral gain does not need to be extremely high. In this example, 150 was deemed enough. The plot (not shown) did not change much from the previous one. This does not mean the integral gain won't help! It is important for dynamic changes that may be encountered during system operation and may not be present during the tuning.
- Increase the Differential Gain. In this example, it was increased to 250. When the Differential gain is high enough, the drive output may look fuzzy:



- If the system starts oscillating or chattering, decrease the Differential Gain.
- The Sum Error² decreased to 177,000.
- Increase the Acceleration Feed Forwards to get rid of the following errors during acceleration and deceleration.
- After increasing the Acceleration Feed Forwards to 200, the plot looks like this:

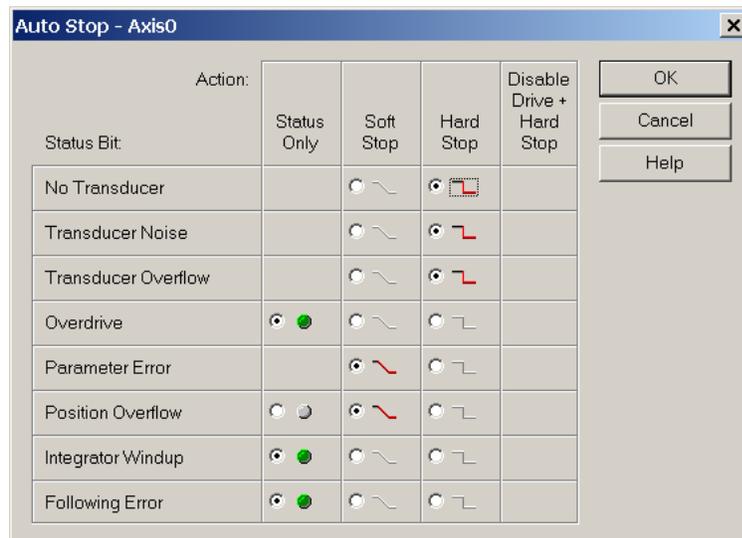


- The Sum Error² decreased to 13,000!
- The overshoot disappeared.
- The Extend and Retract Feed Forwards are generally not the same for hydraulic systems.
- The position is now fairly well tuned. To check that this will work at higher speeds, increase the Accel and Decel to 300 and the speed to 40000. The plot (plot time = 1 sec) looks like this:



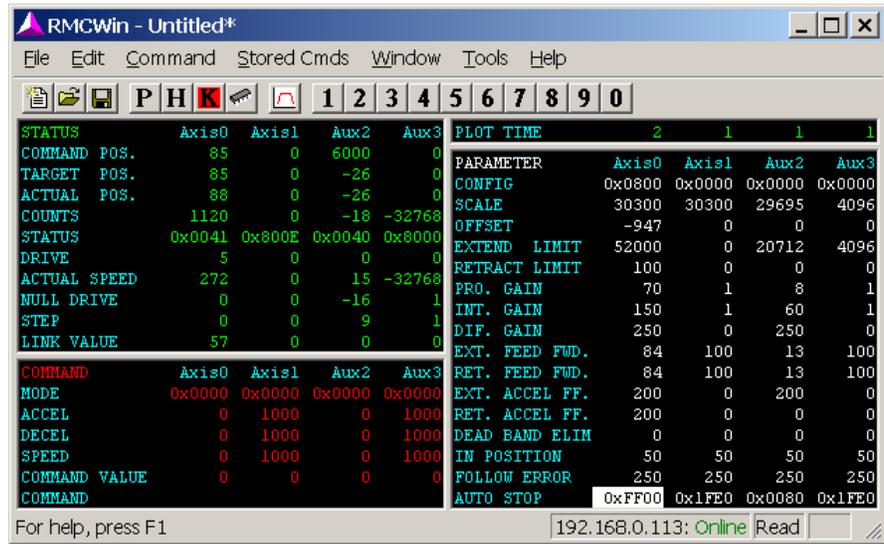
- The parameters work well for the higher speed (no lagging, overshoot or oscillation) and will be left unchanged.
- The Sum Error² increased, but that is only because of the higher speed, which inherently results in greater position errors.

- Now that the system is tuned, it is important to enable any Auto Stops that were set to Status Only. Double-click the Axis 0 Auto Stop field. The following window appears:



- On most systems, it is preferable to have any axis errors cause a Soft or Hard Stop for safety. Additionally, Soft Stops are often desirable because they slowly stop the axis. A Hard Stop immediately puts the drive output to 0 volts, which in some cases can cause a sudden (and potentially dangerous) jerk in the system. Carefully consider your system requirements before determining how to set the Auto Stop bits. In this case, it was decided to set all the Auto Stops are set to Soft Stop. This is done by clicking the Soft Stop button for each Status Bit. Clicking **OK** exits the window and issuing a P command initializes the axis with these parameters.
- The In Position, At Pressure, and Following Error parameters should also be set properly.
 - The In Position parameter specifies the size of the window in which the axis is considered to be in position. Once the axis is in this window, the In Position bit is turned on. This is useful for determining whether the axis has reached the commanded position. In this example, the axis is considered to be in position when it is within 0.050 inches, so the In Position parameter is set to 50.
 - The At Pressure parameter is similar to the In Position parameter, but is for the differential pressure axis. In this example, it is set to 50, which is 50 lbs.
 - The Following Error parameter determines how large the difference between the Target Position and Actual Position can get before the Following Error bit is set in the Status word. Normally, this parameter is set to greater than the worst-case following error to avoid unnecessarily causing an error. In this example, the Following Error parameter is set to 250 (0.25 in.).

- The RMCWin window now looks like this:



- The system is now ready to be used for more complicated commands, such as speed control, gearing, splines, synchronized moves, etc.