

P-400 DRO™ User's Guide



PRECISION GAGE & TOOL CO.



P-400 DRO

User's Guide

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Conventions & Terms

System refers to the P-400 DRO and the measuring devices connected to it.

Icons

This guide uses the following icons to highlight information:



WARNING

The raised hand icon warns of a situation or condition that can lead to personal injury or death. Do not proceed until the warning is read and thoroughly understood. Warning messages are shown in bold type.



DANGEROUS VOLTAGE

The lightning icon warns of the presence of a dangerous voltage within the product enclosure that might be of sufficient magnitude to cause serious shocks or death. Do not open the enclosure unless you are a qualified service person approved by Precision Gage & Tool Co., , and never open the enclosure while power is connected.



CAUTION

The exclamation point icon indicates a situation or condition that can lead to equipment malfunction or damage. Do not proceed until the caution message is read and thoroughly understood. Caution messages are shown in bold type.



NOTE

The note icon indicates additional or supplementary information about an activity or concept. Notes are shown in bold type.

Safety & Maintenance Considerations

General safety precautions must be followed when operating the system. Failure to observe these precautions could result in damage to the equipment, or injury to personnel.

It is understood that safety rules within individual companies vary. If a conflict exists between the material contained in this guide and the rules of a company using this system, the more stringent rules should take precedence.

Additional safety information is included in [Chapter 2: Installation](#).



WARNINGS

Disconnect the P-400 DRO from power before cleaning.

The P-400 DRO is equipped with a 3-wire power plug that includes a separate ground connection. Always connect the power plug to a 3-wire grounded outlet. The use of accessories that remove the third grounded connection such as a 2-wire power plug adapter create a safety hazard and should not be permitted. If a 3-wire grounded outlet is not available, ask your electrician to provide one.



DANGEROUS VOLTAGE

Do not open the enclosure unless you are a qualified service person approved by Precision Gage & Tool Co., and never open the enclosure while power is connected. There are no user-serviceable components or assemblies inside. Refer servicing to qualified service personnel.

General Maintenance

Unplug the P-400 DRO from the wall outlet and seek the assistance of a qualified service technician if:

- The power cord is frayed or damaged or the power plug is damaged
- Liquid is spilled or splashed onto the enclosure
- The P-400 DRO has been dropped or the exterior has been damaged
- The P-400 DRO exhibits degraded performance or indicates a need for service some other way

Cleaning

Use only a cloth dampened with water and a mild detergent for cleaning the exterior surfaces. Never use abrasive cleaners, and never use strong detergents or solvents. Only dampen the cloth, do not use a cleaning cloth that is dripping wet.

Accuracy & Precision

Measurement accuracy is determined by many factors, such as the resolution of the encoders or transducers connected to input channels. Generally, the display resolution of the P-400 DRO can exceed encoder or transducer resolutions. Setting the display resolution to exceed the encoder or transducer resolution does not increase measurement accuracy.

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Chapter 1: Overview

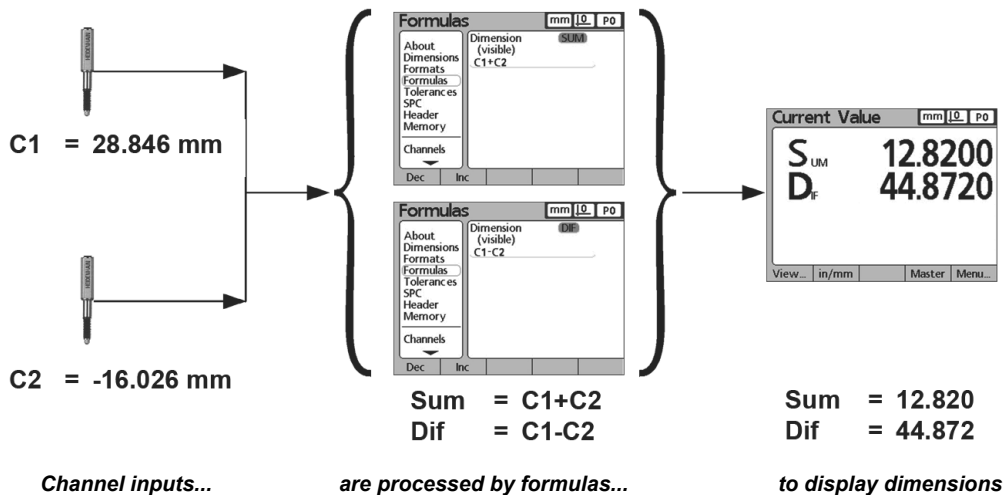


The P-400 DRO is an advanced digital readout system for performing single or multiple gage measurements at very high levels of precision and accuracy. Dimensional inspections of components are performed using encoders or transducers as part of in-line production activities, or final quality inspection. Measurements are conducted completely under operator control, or are semi-automated and conducted in conjunction with a fixtured gage system.

The P-400 DRO is configured at the factory to support

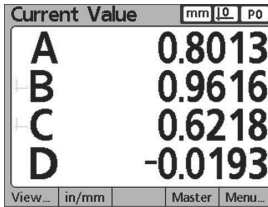
- 1, 4 or 8 single-input channels, or
- Up to 16 multiplexed RS-232 input channels, or
- Combinations of single-input channels and multiplexed RS-232 input channels for a total of up to 16 channels

Channel inputs can be algebraically combined or processed by powerful math and control formulas to display dimensions such as flatness, volume and runout. Formulas are created as part of the P-400 DRO setup using straightforward screen control and math functions.

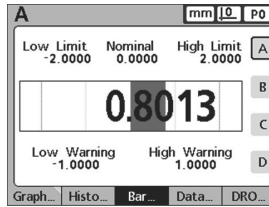


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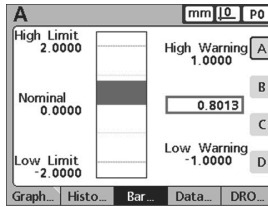
The intuitive user interface includes a large-character color LCD for fast and accurate measurement feedback. User interface screens include a digital readout of current values, bar and dial position value indicators, graphs of values, histograms of measurement statistics and tables of measurement and SPC data.



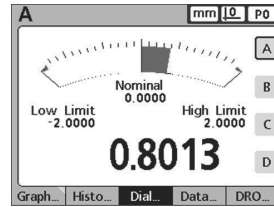
Digital readout (DRO)



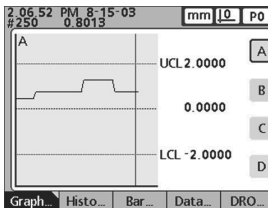
Horizontal bar



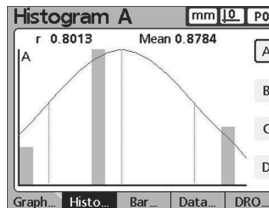
Vertical bar



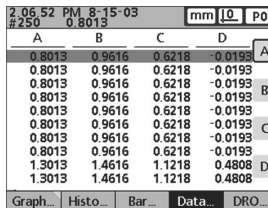
Dial



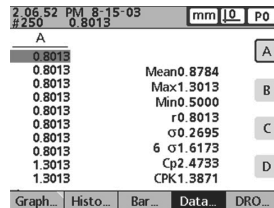
Graph of values



Histogram of values



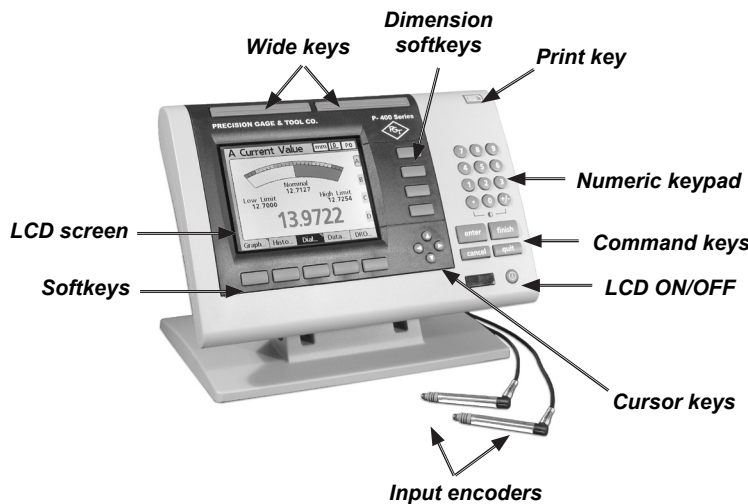
Measurement data



SPC data

Panel keys are provided for selecting measurement functions, changing display screens, entering numeric data, zeroing or presetting datums, and sending data to a USB printer, USB drive or a computer.

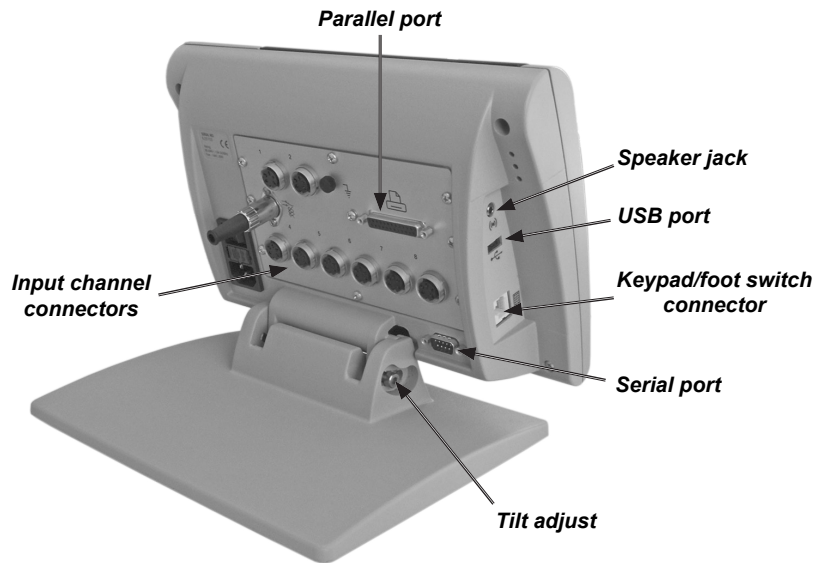
Softkeys control functions that change in support of screens selected by the user to control measurements or display measurement results.



Wide keys located over the LCD can be programmed as hotkeys that initiate frequently used system functions and can quickly be pressed without looking at the front panel. In addition, most keys on the front panel can also be programmed as hotkeys that initiate commonly used functions.

All front panel keys provide tactile sensory feedback, and many key-press operations can be configured to generate an audible sound.

Speaker and external speaker jack outputs can be adjusted for quiet or noisy environments. Earphones can be plugged into the external speaker jack to facilitate silent operation in quiet environments.



The compact ergonomic design and adjustable-tilt front panel of the P-400 DRO allow users to locate and mount the instrument in a wide variety of environments to accommodate nearly any viewing requirement. The tilt front panel can be adjusted and secured in any convenient position. Rubber feet on the bottom of the P-400 DRO prevent slipping when the system is not permanently bolted to a work surface.

Measurements viewed on the LCD and stored data can be transmitted to a PC over the standard RS-232 serial port, or to a printer over the USB port. The RS-232 and parallel I/O port can also be used to control the P-400 DRO from a remote PC or system controller using strings of standard ASCII characters or 5 Volt TTL logic signals.

A large selection of input encoder, transducer and general purpose interfaces can be configured at the factory to measure dimensional, physical or environmental characteristics. Inputs can be provided by individual sensing devices, or by multiplexed RS-232 or other hardware networks of sensing devices.

Chapter 2:

Installation

The P-400 DRO is easy to install in a variety of basic and advanced measurement applications. This chapter describes how to unpack, install and test the basic connections to the P-400 DRO. Repackaging instructions are also included for return shipments and for OEM customers that are configuring a P-400 DRO and shipping it to an end-user.

Unpacking the P-400 DRO

Carefully remove the contents of the P-400 DRO shipping carton.



NOTE

Save the carton and packaging materials in case future reshipment becomes necessary.

Inspect the components listed below for shipping damage and other abnormalities. The contents of the carton(s) includes:

- P-400 DRO instrument
- Relay output connector
(attached to the rear of the P-400 DRO)
- Power cord
- Warranty registration card
- Mounting stand
- Mounting hardware
(attached to the P-400 DRO)

Shipments of optional equipment in separate cartons can include:

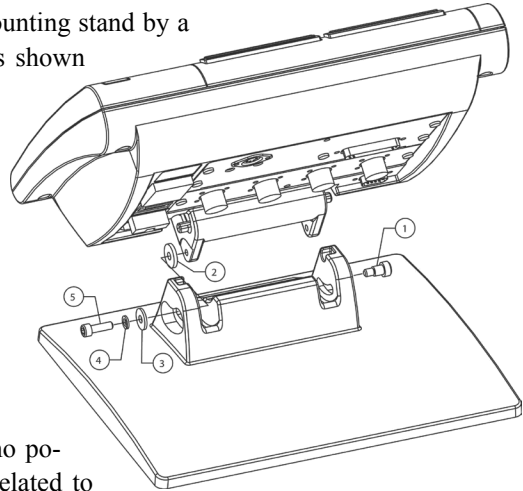
- Remote keypad
- Foot switch
- QC-Wedge software

If any components were damaged in shipment, save the packaging materials for inspection and contact your shipping agent for mediation. Contact PG&T Co. for replacement parts.

Assembling the mounting stand

The P-400 DRO is secured to the swivel slots of the mounting stand by a shoulder screw, a cap screw and associated washers as shown below.

Assemble the P-400 DRO to the mounting stand as shown. Tighten the shoulder screw (1), and then tighten the cap screw (5) and washers (3 & 4) so that the P-400 DRO can be adjusted to various tilt positions and will be secure in any position.



Safety considerations

The P-400 DRO is completely enclosed and provides no potentially hazardous outputs. Safety considerations are related to power connections and physical mounting.



WARNING

If the P-400 DRO falls from its mounting location, serious personal injury or damage to the equipment can result.

Power cord and plug

Do not locate the power cord where it can be walked on or will create a tripping hazard. Connect the 3-wire power plug to only a 3-wire grounded outlet. Never connect 2-wire to 3-wire adapters to the power cord or remove the third ground wire to fit the plug into a 2-wire electrical outlet. Modifying or overriding the third-wire ground creates a safety hazard and should not be permitted.



WARNING

Always disconnect the power cord from the source of AC power before unplugging it from the P-400 DRO power connector. The AC voltage available at electrical outlets is extremely dangerous and can cause serious injury or death.

Electrical wiring and connections

Perform regular inspections of all connections to the P-400 DRO. Keep connections clean and tight. Locate cables away from moving objects. Do not create tripping hazards with power cords, input cables and other electrical wiring.

Use shielded cables to connect to the parallel and serial RS-232 ports. Make certain that cables are properly terminated and firmly connected on both ends.

Location and mounting

Mount the P-400 DRO on a stable surface.

Power surge suppressor

Connect the P-400 DRO to power through a high-quality power surge suppressor. Surge suppressors limit the amplitude of potentially damaging power line transients caused by electrical machinery or lightning.



CAUTION

Industrial quality surge suppressors are recommended. Surge suppressors found in inexpensive power strips are sometimes insufficient to protect the P-400 DRO from damage.

Connecting channel inputs

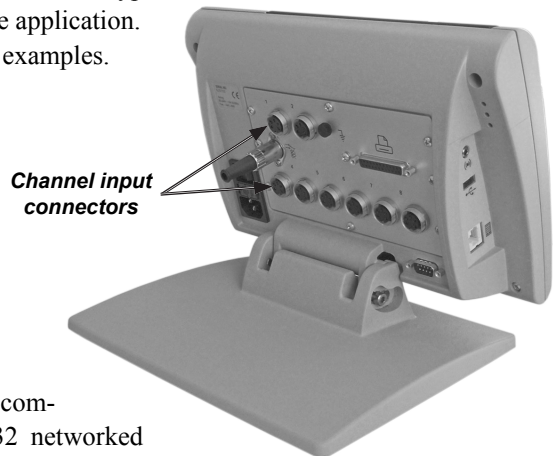
Channel input devices are attached to standard interface connectors or to the RS-232 port on the rear of the P-400 DRO. Many device interfaces are available to match the wide variety of encoder and transducer devices that can be used with the P-400 DRO. The number and type of channel input connectors will vary depending on the application. Eight standard interface connectors are shown here as examples.

Connect the channel input devices tightly to their connectors. A channel number is provided near each connector.

Channel input devices must be configured using the Channels setup screen. Please refer to [Chapter 3: Setup](#) for details regarding input channel setup.

Systems can be configured at the factory to support a combination of single-channel and multi-channel RS-232 networked input devices. These configurations can include:

- 1, 4 or 8 single-input channels, or
- Up to 16 networked RS-232 input channels, or
- Combinations of single-input channels and networked RS-232 input channels for a total of up to 16 channels



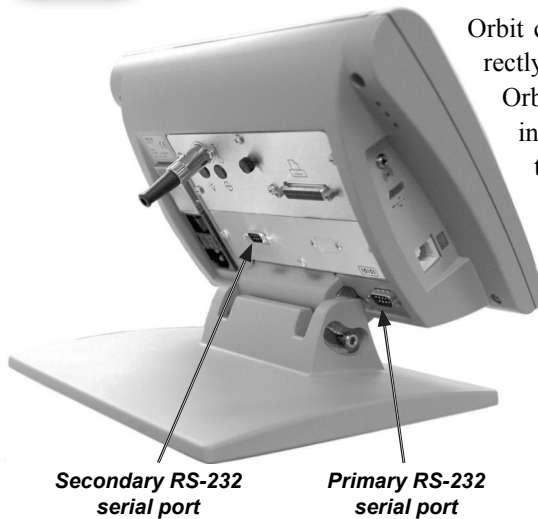
Connecting Solartron's Orbit network

An Orbit network of Solartron input devices can be attached to the primary or secondary RS-232 port on the rear of the P-400 DRO.

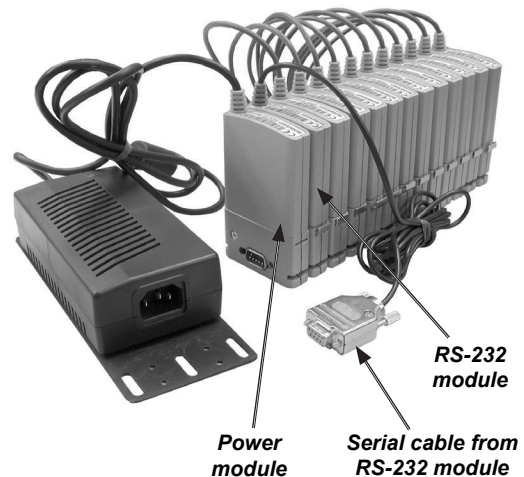


NOTE

While Solartron Orbit networks can be configured to communicate with either serial port, they should be connected to the secondary port whenever possible to preserve serial communication to computers or printers on the primary RS-232 port.



Orbit connections to the secondary serial port are made directly using the serial cable from the Orbit RS-232 module. Orbit connections to the primary port must be made using a null-modem adapter that contains crossed receive/transmit wires. Null-modem adapters can be obtained at most retail electronic stores.



To install the Orbit network:

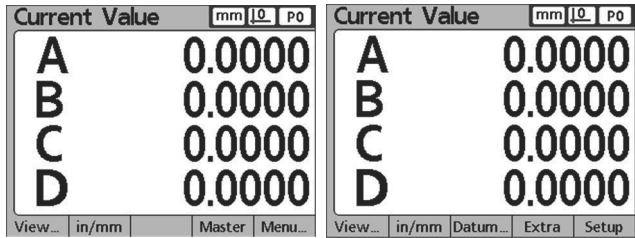
- 1 Verify that the network modules are connected in the order shown below:
 - A) Power module is first
 - B) RS-232 module to the female T-CON side of the power module
 - C) Up to 16 probe modules to the RS-232 module
- 2 Connect the serial cable from the RS-232 module to the P-400 DRO.
- 3 Connect power to the Orbit network and apply power to the P-400 DRO.



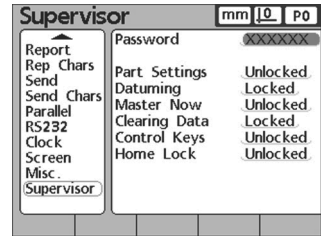
Null-modem adapter

Connecting input channels

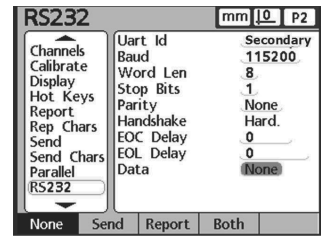
4 Press the P-400 DRO's Menu softkey then press the Setup softkey to display the P-400 DRO's setup menus.



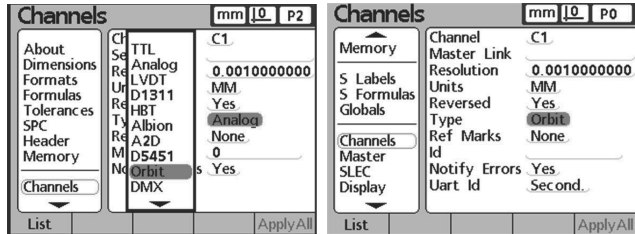
5 Scroll to the Supervisor menu item, highlight the Password field on the right side of the screen and enter the supervisor password.



6 Return to the left side of the screen and scroll to the RS-232 setup screen. Highlight the Uart Id field and press the Inc softkey to enter Secondary or Second.

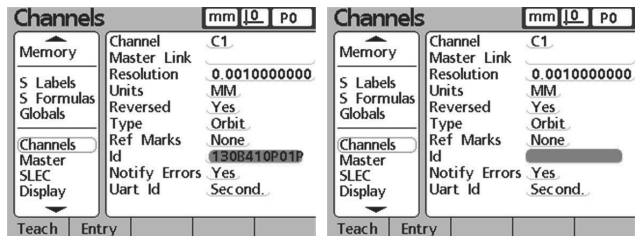


7 Return to the left side of the screen and scroll to the Channels setup screen. Highlight the Type field and press the List softkey to display the available input device types, select Orbit and press the Enter key.



8 The Current Value screen must be displayed to load the Orbit device driver. Press the Finish key twice to display the Current Value screen, then re-enter the setup menu by pressing the Menu then Setup softkeys.

9 Scroll to the Channels menu item, highlight the Id field on the right side of the screen and press the Teach softkey. You will be instructed to press OK and then move a probe to associate it with a channel and store its resolution. Alternatively, press the Entry softkey and enter the Id using the keypad.

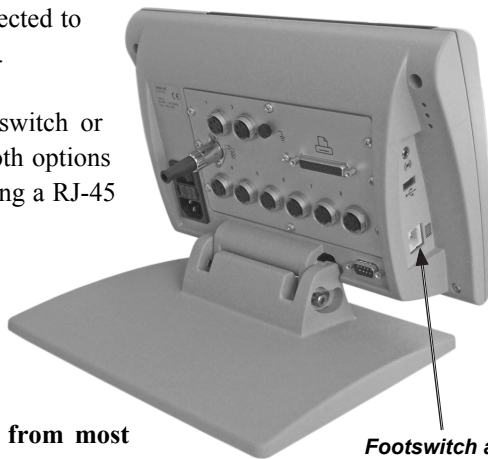


Connecting the optional footswitch and keypad

The optional foot switch and remote keypad are connected to the RJ-45 connector on the left side of the P-400 DRO.



Typically, either the optional foot switch or remote keypad is used. However, both options can be connected simultaneously using a RJ-45 splitter.



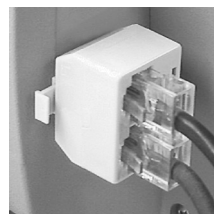
Footswitch and keypad connector



NOTES

RJ-45 splitters are readily available from most retail electronics stores.

When the foot switch and remote keypad are connected using the RJ-45 splitter, all operating functions of each device are retained. However, the foot switch shares Hot Key mapping with the number keys 7 and 8 of the remote keypad. As a result, functions assigned to the two foot switch contacts will also be mapped to remote keypad numbers 7 and 8.



Please refer to the Hot Keys portion of [Chapter 3: Setup](#) for details regarding the assignment of functions to the foot switch, remote keypad and P-400 DRO panel keys.

Connect the foot switch and/or remote keypad to the RJ-45 connector on the left side of the P-400 DRO body.

Testing the footswitch and keypad

The factory default P-400 DRO settings generate a beep sound when any key or foot switch is pressed.

- 1 Apply power to the P-400 DRO and press a foot switch or remote keypad Key. Listen for a beep each time a switch or Key is pressed. This audible beep indicates that the foot switch or keypad is working and connected properly.

**NOTE**

No default functions are assigned to the foot switch. Hot Key assignments must be made for each foot switch contact later using the Hot Keys Setup screen. Refer to **Chapter 3: Setup**. The remote keypad is always fully operational as a numeric keypad independent of Hot Key function assignments.

- 2 If a foot switch or remote keypad key is pressed and no audible beep is generated, turn the P-400 DRO off, disconnect the foot switch or remote keypad and examine the cable connector and RJ-45 jack in the P-400 DRO. The connector housings and pins should be clean and undamaged.
- 3 If the connector and jack appear to be clean and undamaged, reconnect the device, reapply power to the P-400 DRO and press the foot switch or keypad key again.
- 4 If pressing the foot switch or keypad key still doesn't generate an audible beep, consult PG&T Co. for assistance.

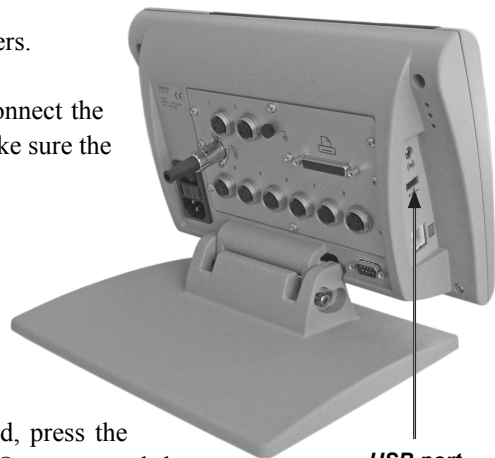
Connecting a printer

The P-400 DRO supports text and graphics for USB printers.

Verify that the P-400 DRO and printer power are off. Connect the printer to the USB port on the side of the P-400 DRO. Make sure the connection is tight.

Testing the printer connection

- 1 Apply power to the P-400 DRO, and then to the printer.
- 2 When the Power of Quadra-Chek screen is displayed, press the Finish or Quit key of the P-400 DRO to display the DRO screen, and then press the Printer key of the P-400 DRO. A small report should be printed.
- 3 If the printer doesn't respond, turn the P-400 DRO and printer power off and disconnect the cable from the P-400 DRO and the printer.
- 4 Examine the cable and cable connectors. The cable surface should be smooth and undamaged. The connectors should be clean and undamaged. The P-400 DRO USB port should be clean and undamaged.



**USB port
connector**

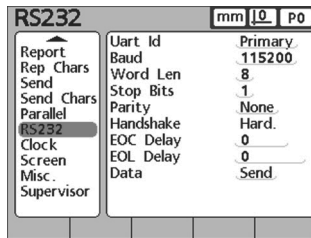
- 5 Reconnect the printer to the P-400 DRO. Make sure the connection is tight.
- 6 Apply power to the P-400 DRO, and then to the printer. Press the Finish or Quit key of the P-400 DRO to display the DRO screen, and then press the Printer key of the P-400 DRO.

If the printer still doesn't generate a report, consult PG&T Co. for assistance.

Connecting a computer

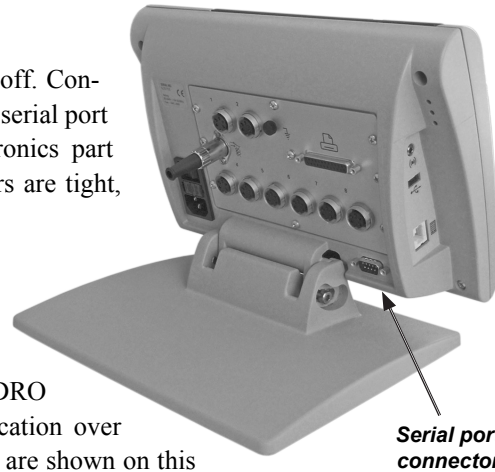
Verify that the P-400 DRO and computer power are off. Connect a computer COM port to the P-400 DRO RS-232 serial port using a standard straight-through serial cable (Metronics part number 11B12176). Make sure the cable connectors are tight, but do not overtighten the connector screws.

Apply power to the computer, and then the P-400 DRO.



The default P-400 DRO settings for communication over the RS-232 serial port are shown on this sample screen.

Launch the computer application that will be used to communicate with the P-400 DRO, and configure the communication properties of the COM port to match those of the P-400 DRO.



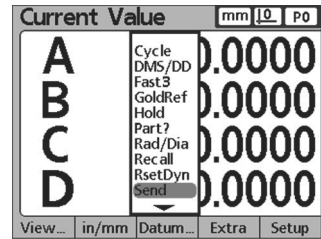
Serial port connector

Testing communication from P-400 DRO to computer

- 1 While displaying the DRO screen, press the Menu Softkey of the P-400 DRO to display the Extra menu softkey.

Current Value		mm | 10 | P0
A	0.0000	
B	0.0000	
C	0.0000	
D	0.0000	
View...	in/mm	Datum... Extra Setup

2 Press the Extra Softkey to display the Extra menu, and then scroll down to highlight the Send function.



3 Press the Enter key to transmit data to the computer over the serial port. The computer should display a short dimension data file. If it does, proceed to test communication from the computer to the P-400 DRO.

4 If no data file is displayed, make sure the serial port settings match those of the P-400 DRO. If the problem persists, turn the P-400 DRO and computer power off and disconnect the serial cable from the P-400 DRO and from the computer.

5 Examine the cable and cable connectors. The cable service should be smooth and undamaged. The connectors should be clean and undamaged. The P-400 DRO and computer cable connectors should be clean and undamaged.

6 Reconnect the computer and P-400 DRO. Make sure the connections are tight, but do not overtighten the connector screws.

7 Apply power to the computer, and then to the P-400 DRO. Press the Enter key of the P-400 DRO to display the DRO screen. Press the Menu Softkey, press the Extra Softkey and then scroll to highlight the Send function. Press the Enter key to transmit data.

If the computer still doesn't display a report, consult PG&T Co. for assistance.

Testing communication from computer to P-400 DRO

When communication from the P-400 DRO to the computer has been verified, communication from the computer to the P-400 DRO should be verified as well.

1 Transmit the following command line from the computer to the P-400 DRO in uppercase characters exactly as shown below, followed by a carriage return:

SEND A

2 The P-400 DRO should transmit back the current value of dimension A, shown on the LCD. If the value of dimension A is not displayed, transmit the command line again:

SEND A

If the computer still does not display the value of dimension A, consult PG&T Co. for assistance.

Wiring the relay output connector

The P-400 DRO is provided with a relay output connector and a cable strain relief on instruments that do not include an external edge option.



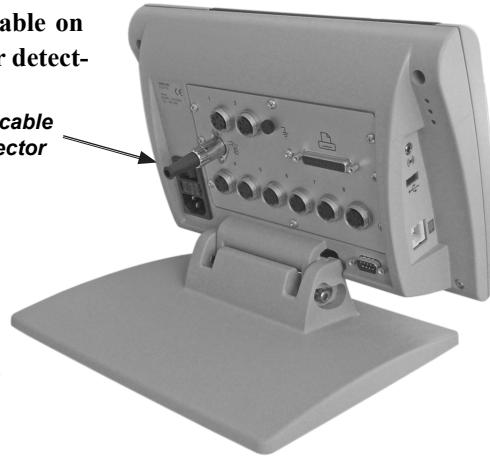
NOTE

Relay output functions are not available on instruments that include an option for detecting external edges.

1 Pull the relay output cable connector straight off the P-400 DRO rear panel.

2 Disassemble and wire the connector as shown in the table. Select an overall cable diameter that matches the strain relief. The strain relief inside diameter is 0.219 inches.

Relay cable connector



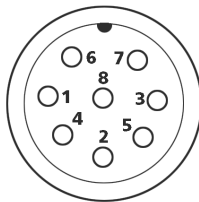
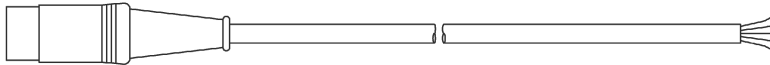
NOTE

Detailed specifications for the cable connector can be obtained from the Internet or directly from the manufacturer. The connector is a Switchcraft 15BL8M, male 8-pin DIN.

Electrical characteristics of the relay contacts are contained in [Chapter 8: Reference Material](#).

Relay operation is controlled by formulas created in the Formula setup screen. Testing the operation of the relay requires an understanding of formula creation in the P-400 DRO and is discussed in [Chapter 4: Formulas](#).

8 PIN DIN (Male)



8 Pin Conn.	Signal
1	Relay 1 Input
2	Relay 1 Normally Closed
3	Relay 2 Normally Open
4	Relay 1 Normally Open
5	Relay 2 Normally Closed
6	Relay 2 Input
7	-
8	-

External edge detector option connections

External edge detector options can be specified for the P-400 DRO at the time of purchase. When this option is included, touch probe connections are made through the connector that would alternately be used for relay output functions.



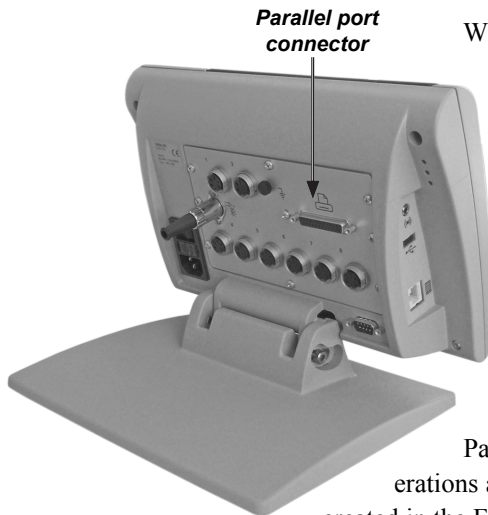
NOTE

Relay output functions are not available on instruments that include an option for detecting external edges.

External edge functions are controlled by formulas created in the Formula setup screen. Testing the operation of the external edge touch probe requires an understanding of formula creation in the P-400 DRO and is discussed in [Chapter 4: Formulas](#).

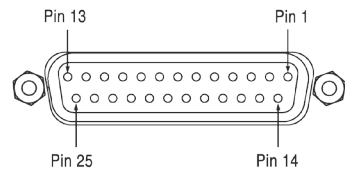
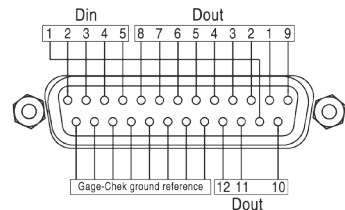
Wiring the parallel port data I/O connections

The parallel port can be configured in the Parallel setup screen as a standard printer port, or as a general-purpose data Input/Output (I/O) port.



When configured as a general-purpose data port, the P-400 DRO uses the parallel port connector as shown below.

Inputs and outputs support only 5 volt TTL logic levels. Pins 18 through 25 are connected to logic ground.



Parallel data input/output operations are controlled by formulas created in the Formula setup screen. Testing the operation of the data port requires an understanding of formula creation in the P-400 DRO and is discussed in [Chapter 4: Formulas](#).

ing the operation of the data port requires an understanding of formula creation in the P-400 DRO and is discussed in [Chapter 4: Formulas](#).

Warranty registration form

The warranty registration form included in the shipping carton should be completed and mailed as soon as possible. Also record the purchase and warranty information below so that it will be readily available later to support any necessary interactions with distributor or factory technical support personnel.

PG&T Co. model number _____

PG&T Co. serial number _____

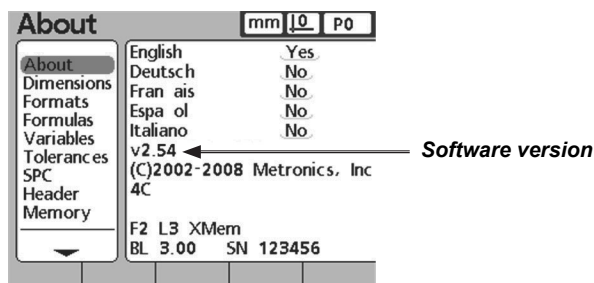
Purchased from _____

Date received _____

P-400 DRO software version _____

The software version is shown in the About setup screen.

Refer to [Chapter 3: Setup](#) for screen descriptions.



Repackaging for shipment

Repackage the P-400 DRO in the original packaging as received from the factory, or equivalent. It is not necessary to ship the base when shipping the P-400 DRO for repair.



CAUTION

The original packaging must be duplicated and the LCD must be inserted face-up to prevent damage to the LCD screen.

Pay special attention to the following instructions:

- 1 Connect any loose mounting hardware to the P-400 DRO instrument
- 2 Repackage the foam and cardboard carton inserts as originally shipped from the factory.
- 3 Place the P-400 DRO into shipping carton with the LCD facing up.
- 4 Replace the warranty card and slip sheets found at the top of the carton. The “Before you begin” slip sheet should be inserted last.

What’s next?

Proceed to [Chapter 3: Setup](#) and then to [Chapter 4: Formulas](#) to configure your P-400 DRO for use.

Chapter 3: Setup

The operating parameters of the P-400 DRO must be configured prior to using the system for the first time, and any time part measurement, reporting or communication requirements change. Day to day use of the P-400 DRO does not require reconfiguration of system settings.

The setup menu	20	S Labels	48
Accessing the setup menu	20	S Formulas	48
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Tolerances	35	USB	82
SPC	41	Hot keys	83
Header	45	Clock	94
Memory	47	External edge	95
		Misc	98
		Supervisor	101



CAUTION

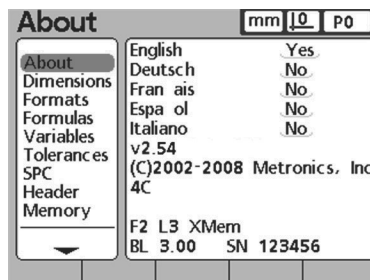
Parameter changes made in any of the setup screens can change the operation of the P-400 DRO. For this reason critical setup parameters are password-protected. Only qualified personnel should be given password access to setup screen parameters. The unlocking of password-protected setup functions is described later in this chapter.

The setup menu

P-400 DRO operating parameters are accessed and changed using a few screen navigation and menu keys located on the front panel and shown on the setup screens. Setup screens are selected from the setup menu located to the left of setup screens.

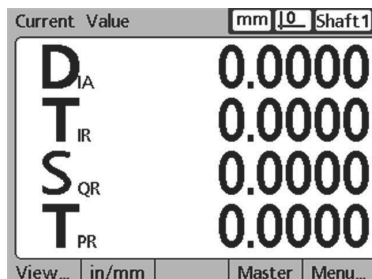
Setup parameters will be retained by the P-400 DRO until:

- The data-backup battery is changed
- The system data and settings are cleared by maintenance personnel
- They are changed using the setup menu screens

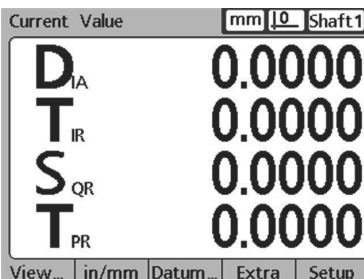


Accessing the setup menu

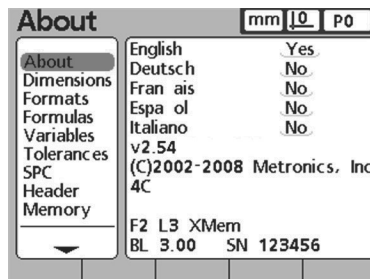
The Setup menu is accessed from the Home screen by pressing the Menu softkey, and then pressing the Setup softkey.



Press the Menu softkey...



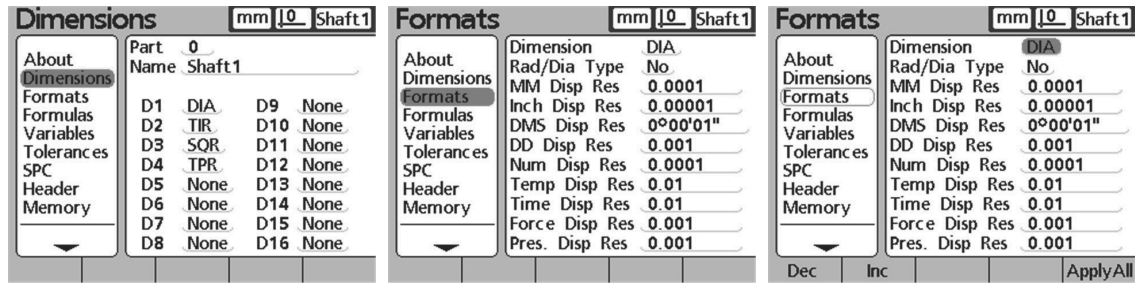
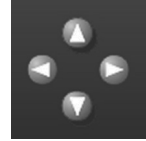
then press the Setup softkey...



to display the Setup menu

Navigating the setup menu

Scroll up and down through the list of setup screens using the up and down Cursor keys, then access setup screen functions using the right Cursor key. Menu items will become highlighted to indicate selections.



Pressing the down cursor ...

*highlights next menu item, then
pressing the right cursor ...*

highlights top screen parameter

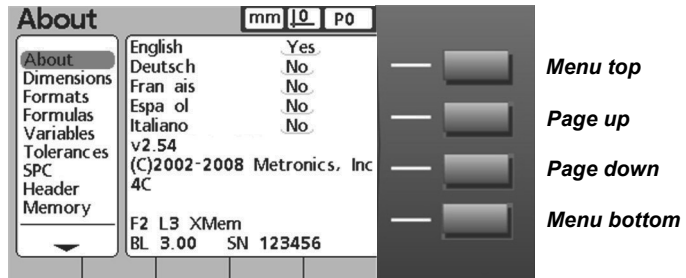


NOTE

It will be necessary to enter the Supervisor password into the Supervisor setup screen to gain access to setup screen parameter fields. Refer to the Supervisor setup screen discussion later in this chapter for details.

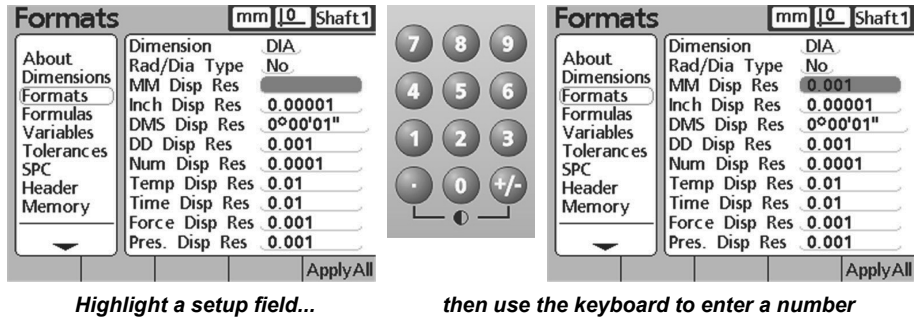
Using dimension keys in the setup mode

The functions of the dimension keys change to speed setup screen navigation when the setup menu is displayed. Dimension keys can be used to move to the top or bottom of the setup menu or to page up or down through the setup menu as shown here.

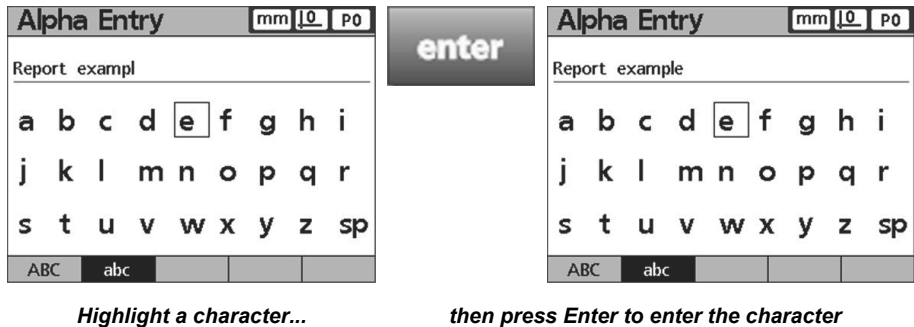


Entering data into setup fields

Enter numbers into the highlighted setup screen fields using the numeric keypad.

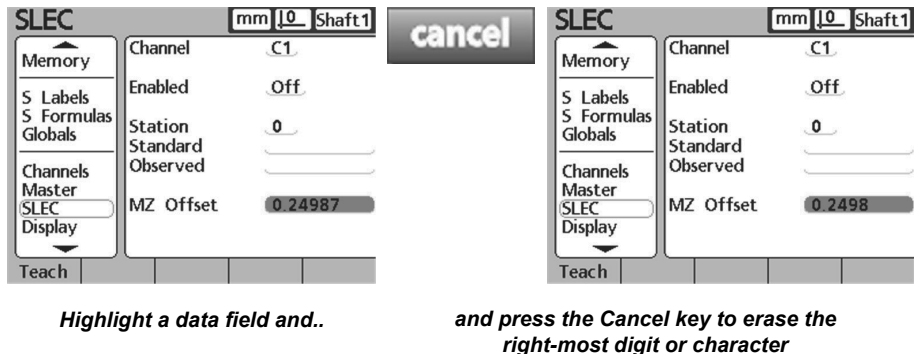


The Alpha Entry screen will be displayed when alpha character entry is required. Enter alpha characters into the Alpha Entry screen by highlighting a letter and then pressing the Enter key.



Deleting data entries

Press the Cancel key to erase the last (right-most) numeric digit or alpha character in the selected data field.

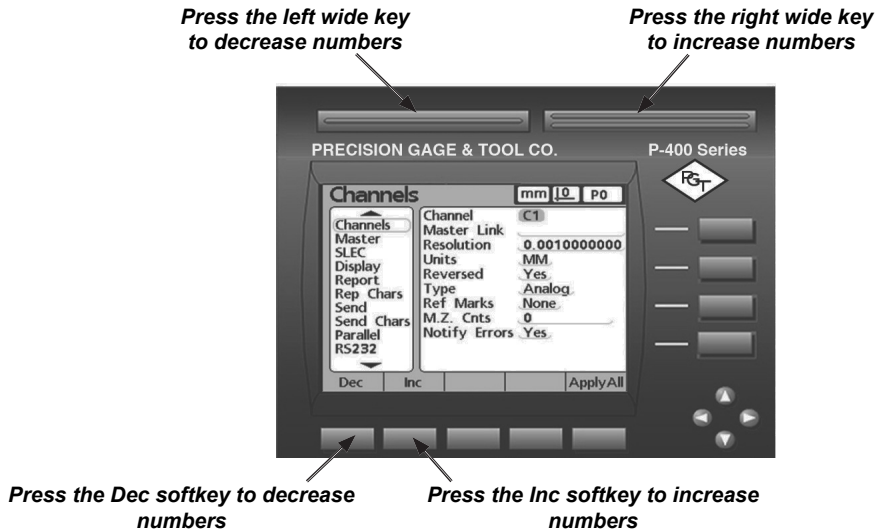


Entering setup parameters

Setup parameters and functions are displayed above the softkeys across the bottom of the screen.

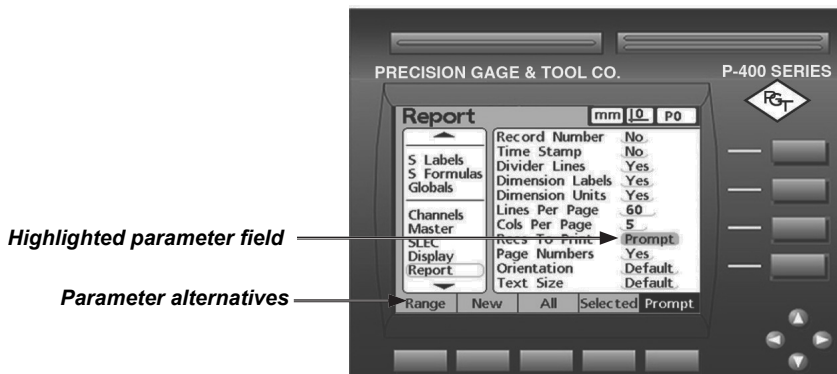
Changing the channel or dimension number

Often setup parameters and functions are related to specific channels or dimensions. When a channel or dimension is highlighted on the setup screen, the channel or dimension number can be increased or decreased by pressing the Inc or Dec softkey or by pressing the left or right wide key.



Entering parameters

When a setup parameter field is highlighted, setup alternatives are shown above the softkeys across the bottom of the screen. Press the softkey under the desired setup alternative to enter the parameter.



Copying parameters to other parts, dimensions or channels

A single highlighted parameter or all parameters of the current part, dimension or channel can be copied to all others by pressing the Apply All softkey.



If all part, dimension or channel parameters are already the same for the selected setup category, the Apply All softkey will be grayed-out.

Formats		mm	.0	Shaft1
About	Dimension	DIA		
Dimensions	Rad/Dia Type	No		
Formats	MIM Disp Res	0.001		
Formulas	Inch Disp Res	0.00001		
Variables	DMS Disp Res	0°00'01"		
Tolerances	DD Disp Res	0.001		
SPC	Num Disp Res	0.0001		
Header	Temp Disp Res	0.01		
Memory	Time Disp Res	0.01		
	Force Disp Res	0.001		
	Pres. Disp Res	0.001		
Dec	Inc			ApplyAll

Formats		mm	.0	Shaft1
About	Dimension	DIA		
Dimensions	Rad/Dia Type	No		
Formats	MIM Disp Res	0.001		
Formulas	Inch Disp Res	0.00001		
Variables	DMS Disp Res	0°00'01"		
Tolerances	DD Disp Res	0.001		
SPC	Num Disp Res	0.0001		
Header	Temp Disp Res	0.01		
Memory	Time Disp Res	0.01		
	Force Disp Res	0.001		
	Pres. Disp Res	0.001		
				ApplyAll

Copy all parameters by pressing the Apply All softkey when the part, dimension or channel name is highlighted.

Copy a single parameter by pressing the Apply All softkey when only a single parameter is highlighted.

Saving a parameter and advancing to the next

Press the Enter key to save the highlighted value and advance to the next parameter.



Channels		mm	.0	Shaft1
Channels	Channel	C1		
Master	Master Link			
SLEC	Resolution	0.005		
Display	Units	Linear		
Report	Reversed	Yes		
Rep Chars	Type	TTL		
Send	Ref Marks	None		
Send Chars	M.Z. Cnts	0		
Parallel	Notify Errors	Yes		
RS232				ApplyAll
Teach				

Channels		mm	.0	Shaft1
Channels	Channel	C1		
Master	Master Link			
SLEC	Resolution	0.005		
Display	Units	Linear		
Report	Reversed	Yes		
Rep Chars	Type	TTL		
Send	Ref Marks	None		
Send Chars	M.Z. Cnts	0		
Parallel	Notify Errors	Yes		
RS232				ApplyAll
List				

Press the Enter key...

to store the highlighted value and advance to the next parameter

Saving a parameter and returning to the setup menu

Press the Finish key to store the value and return to the setup menu.



Channels		mm	.0	Shaft1
Channels	Channel	C1		
Master	Master Link			
SLEC	Resolution	0.005		
Display	Units	Linear		
Report	Reversed	Yes		
Rep Chars	Type	TTL		
Send	Ref Marks	None		
Send Chars	M.Z. Cnts	0		
Parallel	Notify Errors	Yes		
RS232				ApplyAll
List				

Channels		mm	.0	Shaft1
Channels	Channel	C1		
Master	Master Link			
SLEC	Resolution	0.005		
Display	Units	Linear		
Report	Reversed	Yes		
Rep Chars	Type	TTL		
Send	Ref Marks	None		
Send Chars	M.Z. Cnts	0		
Parallel	Notify Errors	Yes		
RS232				ApplyAll

Press the Finish key...

to store the highlighted value and return to the setup menu

Discarding changes and returning to the setup menu

Press the Quit key to return to the setup menu on the left half of the screen without saving changes.



Formats		mm	I0	Shaft1
About	Dimension	DIA		
Dimensions	Rad/Dia Type	No		
Formats	MM Disp Res	0.005		
Formulas	Inch Disp Res	0.00001		
Variables	DMS Disp Res	0°00'01"		
Tolerances	DD Disp Res	0.001		
SPC	Nurn Disp Res	0.0001		
Header	Temp Disp Res	0.01		
Memory	Time Disp Res	0.01		
	Force Disp Res	0.001		
	Pres. Disp Res	0.001		
				ApplyAll

Press the Quit key...

Formats		mm	I0	Shaft1
About	Dimension	DIA		
Dimensions	Rad/Dia Type	No		
Formats	MM Disp Res	0.001		
Formulas	Inch Disp Res	0.00001		
Variables	DMS Disp Res	0°00'01"		
Tolerances	DD Disp Res	0.001		
SPC	Nurn Disp Res	0.0001		
Header	Temp Disp Res	0.01		
Memory	Time Disp Res	0.01		
	Force Disp Res	0.001		
	Pres. Disp Res	0.001		

to discard changes and return to the setup menu

Leaving the setup menu

Press the Finish key repeatedly to conclude the setup session and return to the DRO.



Formats		mm	I0	Shaft1
About	Dimension	DIA		
Dimensions	Rad/Dia Type	No		
Formats	MM Disp Res	0.001		
Formulas	Inch Disp Res	0.00001		
Variables	DMS Disp Res	0°00'01"		
Tolerances	DD Disp Res	0.001		
SPC	Nurn Disp Res	0.0001		
Header	Temp Disp Res	0.01		
Memory	Time Disp Res	0.01		
	Force Disp Res	0.001		
	Pres. Disp Res	0.001		

Press the Finish key repeatedly...

Current Value		mm	I0	Shaft1
D _{IA}		0.050		
T _{IR}		-0.0100		
S _{QR}		0.0040		
T _{PR}		0.0290		
View...	in/mm		Master	Menu...

to return to leave the setup menu and return to the DRO

Printing P-400 DRO setup configurations

Print all P-400 DRO configuration settings and formulas as a text file by pressing the Print key while displaying any setup screen.



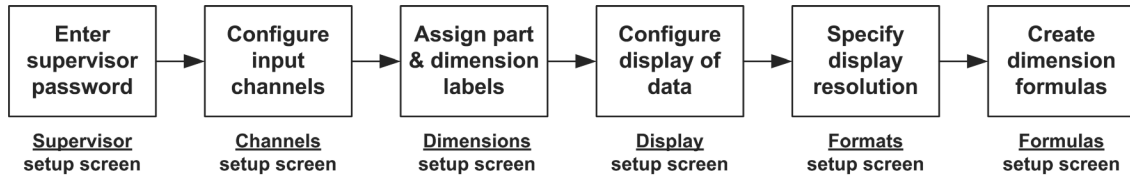
Saving or loading P-400 DRO configurations

Insert a USB drive into the USB port, navigate to the Supervisor screen, highlight the Password field and enter the password if necessary. Press the SaveX softkey to save the current configuration as an .xml file, or press the LoadX softkey to load a previously saved .xml configuration file from the USB drive.

Supervisor		mm	I0	P0
Rep Chars	Send	xxxxxxx		
Send Chars	Part Settings	Unlocked		
Parallel	Datuming	Locked		
RS232	Master Now	Unlocked		
USB	Clearing Data	Locked		
Hot Keys	Control Keys	Unlocked		
Clock	Home Lock	Unlocked		
Misc.	Delete 1 Record	Unlocked		
Supervisor	Lock Sys	Unlocked		
	Clr Scale Errors	Unlocked		
LoadX	SaveX			

Minimum setup requirements

The minimum setup steps required to begin conducting measurements are diagrammed below. Additional setup will be required to utilize the full SPC, reporting, data communication and other capabilities of the P-400 DRO system. The screens required for the initial setup are described in the remainder of this chapter.



Setup screens

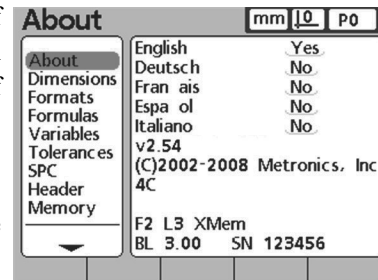
Setup screen descriptions are presented in the order of their appearance in the setup menu. However, the first time the P-400 DRO is configured the order of setup screen use should follow the essential setup requirements diagram, and then continue in the order that best satisfies the application or the user's preferences. The subsequent use of setup screens will probably be infrequent and will address application requirements or hardware changes.

About screen

The About screen contains selections for changing the language of text displayed on the LCD, included in transmitted data and printed on reports. Software and hardware version information and the number of input channels are displayed on the bottom of the screen.

Specifying the displayed language

Highlight the desired language and then press the Yes key to select the language.



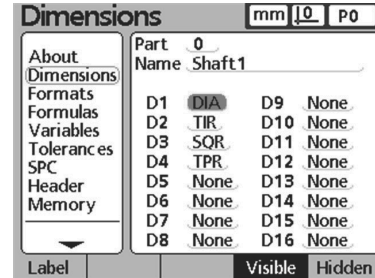
System information

The P-400 DRO software and hardware versions, number of input channels and unit serial number are displayed at the bottom of the About setup screen.

Dimensions screen

The Dimensions screen contains fields for defining the part and dimension labels displayed on the DRO, included in transmitted data, printed on reports and stored in the P-400 DRO database for up to 100 individual parts. Dimensions must be defined prior to other setup activities and conducting tests.

Part numbers consist of up to 2 numeric digits in the range from 0 to 99 entered by the system in sequence as new parts are added. Part and dimension labels consist of up to 8 alphanumeric characters entered from the character entry screen and the numeric keypad. Part names are shown in reports, but only part numbers are shown in formulas. Completed dimension labels of one part can be copied and applied to another.

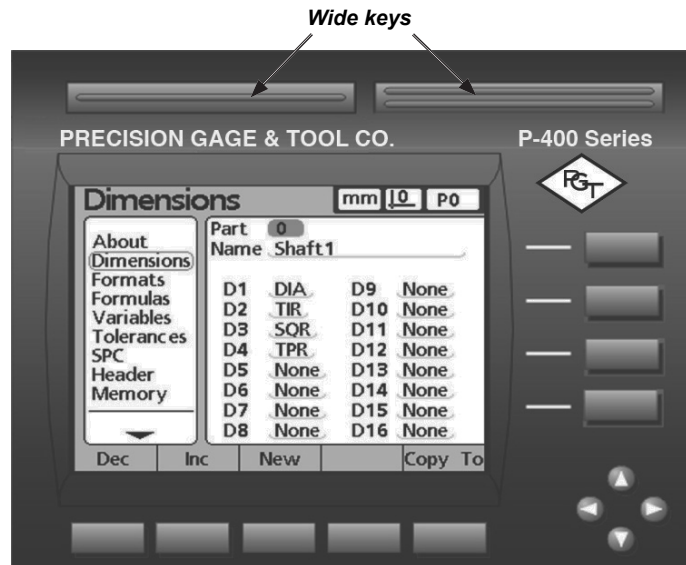


NOTE

Deleting part numbers will erase any data associated with the part's dimensions in the P-400 DRO database. Deleting a part number also decrements the part numbers of any higher-numbered parts, so that data for part numbers on previous reports might not agree with new data for the same part numbers.

Selecting part numbers

Use the Dec softkey or left wide key to decrement the part number, and the Inc softkey or right wide key to increment the part number to the desired value in the range from 0 to 99. The Dec, Inc and wide keys change the part number only when more than one part exists in the database.

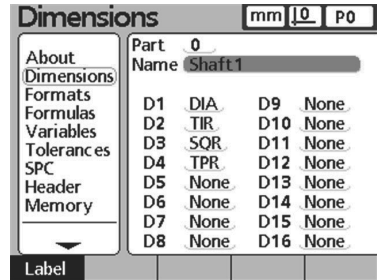


Decrement and increment keys

Labeling parts and dimensions

Part labels contain up to 8 alphanumeric characters. Dimension labels contain up to 3 alphanumeric characters. Alpha characters are in the range from A to Z and can be upper or lower case. Numeric characters are in the range from 0 to 9. The order of alpha and numeric characters in a label is defined by the user. The process of labeling a part or dimension is identical.

Highlight the part or dimension field, press the Label softkey to display the Alpha Entry screen, and then enter the desired alphanumeric characters. Press the Finish key to complete the process.



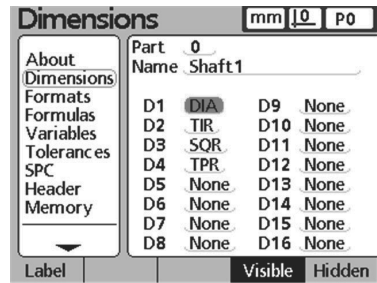
NOTE

Labels should be meaningful by reflecting the measurement application when possible.

Defining visible and hidden dimensions

Dimensions are defined as visible by default, displayed on the DRO and stored in the database. Dimensions can also be defined as hidden for use as variables in formulas and not displayed. Hidden dimensions are not printed on reports or sent to computers as data files. Visible and hidden dimensions use the same naming convention.

Press the Visible or Hidden softkey to define the dimension type.



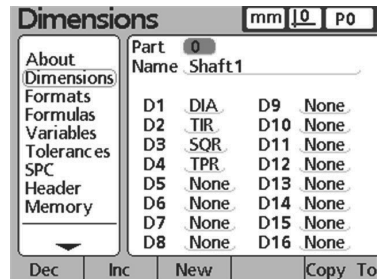
NOTE

More details regarding the use of hidden dimensions is contained in **Chapter 4: Formulas**.

Creating new parts

Up to 100 (software) parts can be created in the P-400 DRO. Multiple parts are useful when the number of measurements performed on one physical part is large and could be divided into categories, or when different physical parts must be measured.

Press the New softkey to create a new part.



Copying dimension parameters to other parts

Dimensions assigned to one part can be copied to another to save setup time when similar or identical measurements must be performed on new parts.

Highlight the Part field and press the Copy To softkey. The labels, formulas and all other parameters will be copied to the next new part. Database records will not be copied.

A pop-up screen will show the next part number. Press the OK softkey to copy the labels, and then press OK again to return to the Dimension setup screen.

Dimensions		mm	10	P0
Part 0				
Name Shaft 1				
D1	DIA	D9	None	
D2	TIR	D10	None	
D3	SQR	D11	None	
D4	TPR	D12	None	
D5	None	D13	None	
D6	None	D14	None	
D7	None	D15	None	
D8	None	D16	None	
Dec	Inc	New	Copy To	

Deleting parts

Parts can be deleted when it is no longer necessary to store old measurement results in the P-400 DRO. Deleting old part data makes more system memory available for new data and dimension formulas.

Highlight the Part field, use the Inc or Dec softkeys to select the desired part and press the Del softkey. You will be asked to confirm your intention of deleting the part. Press the Yes softkey to delete the part.

Dimensions		mm	10	P2
Part 2				
Name Shaft 2				
D1	A	D9	None	
D2	B	D10	None	
D3	C	D11	None	
D4	D	D12	None	
D5	None	D13	None	
D6	None	D14	None	
D7	None	D15	None	
D8	None	D16	None	
Dec	Inc	New	Del	Copy To

Formats screen

The Formats screen contains fields for specifying the display format and display resolution for dimensions of the currently selected part. Selections of radius and diameter measurement types are also provided.

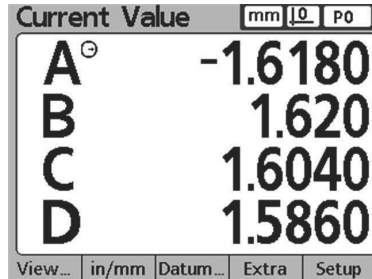
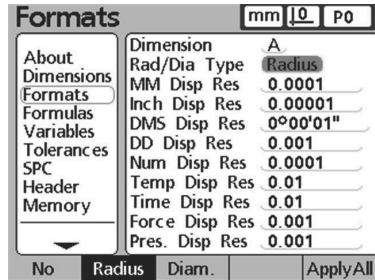
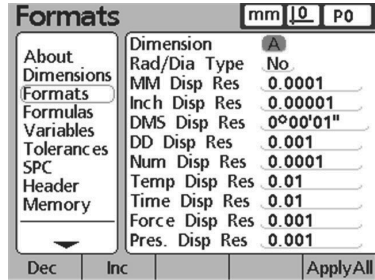
Specifying a dimension

Highlight the Dimension field and use the Dec or Inc softkey to specify the desired dimension.

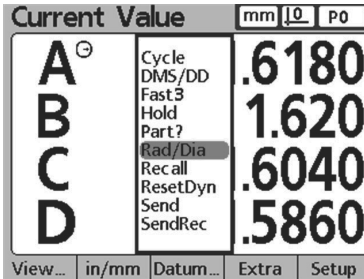
Specifying radius or diameter

Radius or diameter measurements can be specified for cylindrical and spherical parts or parts with curved surfaces. When radius or diameter measurements are specified, the corresponding symbol will be displayed near the associated dimension on the DRO screen.

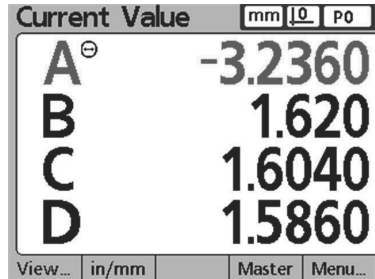
The display can be toggled between Radius and Diameter later from the Home screen using the Extra menu. Toggling the display mode changes it until the system power is cycled off and then on again. The default display mode upon powering the P-400 DRO is specified in the Formats screen. Use the Radius or Diam softkeys to specify the radius or diameter measurement type. Press the No softkey to specify measurements that do not require radius or diameter, such as linear or angular measurements.



The radius format...



is toggled in the Extra menu...



to show diameter

Display resolution

The display resolution fields are used to specify how numbers are shown on the DRO screen. Displayed numbers will be rounded as the display resolution is decreased. This table illustrates how the display of numbers is governed by the display resolution setting.

Channel input	Display resolution	Number displayed
1.567	0.0001	1.5670
1.567	0.001	1.567
1.567	0.01	1.57
1.567	0.1	1.6
1.567	1	2



NOTE

Measurement resolution can never be higher than the input channel resolution. Specifying display resolutions that are higher than the channel resolutions can lead to misleading displays of dimension values.

Specifying a display resolution

Highlight a display resolution (Disp Res) field, enter the desired display resolution and then press Enter.

In this example, the MM display resolution of dimension A is changed from a tenth of a micron to a micron.

The resulting change is shown on the DRO as one fewer digit to the right of the decimal point displayed for dimension A.

Formats mm | 0 | P0

- About
- Dimensions
- Formats
- Formulas
- Variables
- Tolerances
- SPC
- Header
- Memory

- Dimension A
- Rad/Dia Type No
- MM Disp Res **0.0001**
- Inch Disp Res 0.00001
- DMS Disp Res 0°00'01"
- DD Disp Res 0.001
- Num Disp Res 0.0001
- Temp Disp Res 0.01
- Time Disp Res 0.01
- Force Disp Res 0.001
- Pres. Disp Res 0.001

ApplyAll

Formats mm | 0 | P0

- About
- Dimensions
- Formats
- Formulas
- Variables
- Tolerances
- SPC
- Header
- Memory

- Dimension A
- Rad/Dia Type Radius
- MM Disp Res **0.001**
- Inch Disp Res 0.00001
- DMS Disp Res 0°00'01"
- DD Disp Res 0.001
- Num Disp Res 0.0001
- Temp Disp Res 0.01
- Time Disp Res 0.01
- Force Disp Res 0.001
- Pres. Disp Res 0.001

ApplyAll

Current Value mm | 0 | P0

A	0.0000
B	0.000
C	0.0000
D	0.0000

View... in/mm Master Menu...

Current Value mm | 0 | P0

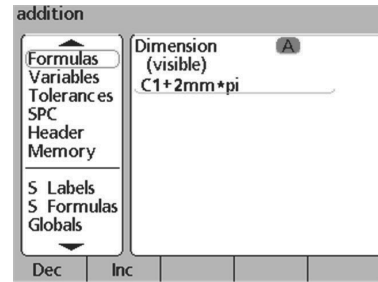
A [⊕]	0.000
B	0.000
C	0.0000
D	0.0000

View... in/mm Master Menu...

Formulas screen

The P-400 DRO uses formulas to define and display dimensions based on channel inputs. These formulas are constructed by the user to display:

- One dimension based on one channel
For example,
 $A = C1$
- One dimension based on multiple channels
For example,
 $A = C1 + C2$
- Multiple dimensions based on one channel
For example,
 $A = C1$
 $B = 2 * \pi * C1$
- Multiple dimensions based on multiple channels
For example,
 $A = C1$
 $B = C2$
 $C = C1 * C2$



Formulas can be constructed that simply display a channel as a dimension, or that calculate a dimension from one or more channels using powerful math, logic or other functions.

Dimension formulas are unique to the part they are created in. For example, a dimension formula created in part 0 cannot be used in part 2. However, system dimensions are described later in this chapter and can be used across all parts.



NOTE

Formulas are explained in [Chapter 4: Formulas](#).

Variables screen

Formulas use variables as symbols or names that represent values. For example, in the expression:

$$C1 + \text{Var1}()$$

Var1() is a variable, its value is flexible and is determined by operations on a different formula line for the current part. Variables can represent numeric constants, channel input values, dimension values or the results of a wide variety of math operations.

Variables are important in formula creation because they enable users to create flexible formulas. Rather than including data directly into a formula, a user can use variables to represent the data. Then, when the formula is executed, the variables are replaced with actual data. This makes it possible for the same formula to process different sets of data as conditions change.

The Variables setup screen allows the user to see the current value of any of the 20 possible variables. Variables that are not defined elsewhere by formulas can be set to constant values in this screen by highlighting a variable field and entering the value. Variables that are defined by formulas cannot be changed in the Variable screen.

Variables		mm	10	P0
About	V1	2.5891000	mm	
Dimensions	V2	1.0471000	mm	
Formats	V3	0.5663200	mm	
Formulas	V4	0.0000000		
Variables	V5	0.0000000		
Tolerances				
SPC				
Header				
Memory				

Values of 3 variables

Variables		mm	10	P0
Formulas	V1	5.0000000	mm	
Variables	V2	0.0000000		
Tolerances	V3	0.0000000		
SPC	V4	0.0000000		
Header	V5	0.0000000		
Memory				
S Labels				
S Formulas				
Globals				

Variable 1 set to a constant

Variables are unique to the part they were created in. For example, a variable created in part 0 cannot be used in part 2. Global variables, discussed later in this chapter, can be used across all parts.



NOTE

Variable functions are defined in the formula screen. Formulas are explained in Chapter 4: Formulas.

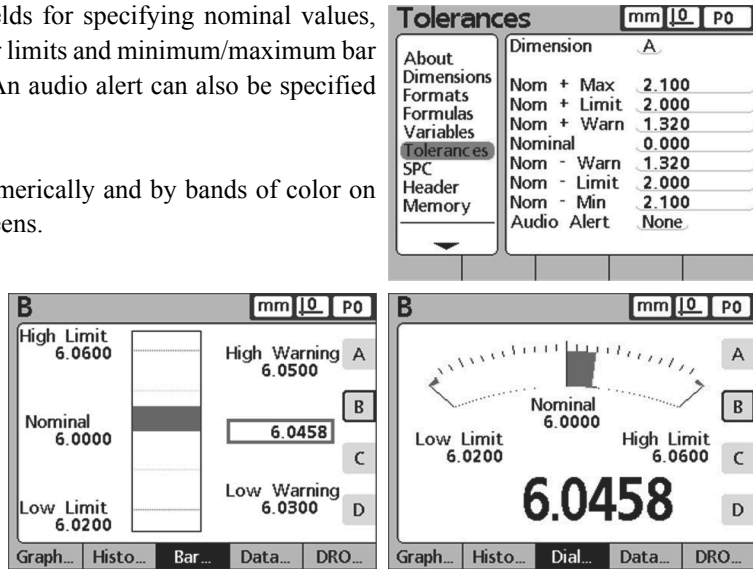
Tolerances screen

The tolerances screen contains fields for specifying nominal values, upper/lower warnings, upper/lower limits and minimum/maximum bar graph levels for each dimension. An audio alert can also be specified for warnings, limits, or both.

Tolerance ranges are indicated numerically and by bands of color on the Current Value bar and dial screens.

The default bar and dial displays show Pass values in green, Warning values in yellow, and Fail values in red.

These pass, warning and fail levels are shown clearly in the bar graph of current values above, and explained below:



- **Pass**
Above low warning and below high warning. Pass values fall within the specified range of acceptable values.
- **Warning**
Outside the range of pass values, but not at or beyond the specified acceptable limits. Warnings indicate the need to evaluate the process to prevent the future generation of unacceptable, or failed parts.
- **Fail**
Outside the specified range of acceptable limits specified.
- **Max/Min**
Highest and lowest graph scale values. These values determine the range of values plotted on the graph. This range should be greater than the range limits of acceptable limits.



NOTE

The colors used to indicate pass, warning and fail can be changed using the Display setup screen discussed later in this chapter.

Dimension

Press the Dec or Inc softkey to specify the desired dimension.

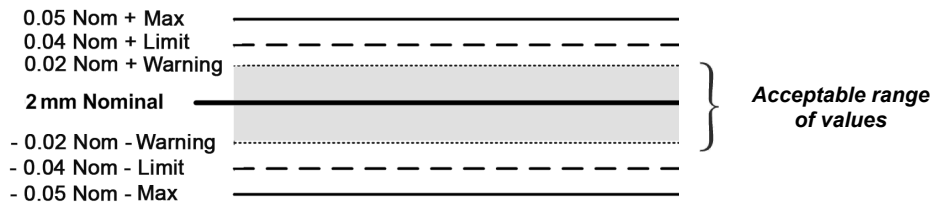
Nominal values with tolerances

Nominal values with tolerances can be specified as a nominal value between +/- tolerances, or as a nominal value with ++/-- tolerances distributed entirely on the plus side or entirely on the minus side of the nominal value.

Tolerances		mm	10	P0
About	Dimension	B		
Dimensions	Bar Gr. Max	2.005		
Formats	High Limit	2.004		
Formulas	High Warning	2.002		
Variables	Nominal	2.000		
Tolerances	Low Warning	1.998		
SPC	Low Limit	1.996		
Header	Bar Gr. Min	1.995		
Memory	Audio Alert	None		
Dec	Inc	Limits	+/-	ApplyAll

Nominal with +/- tolerances

A nominal value is displayed between plus and minus tolerances.



Press the +/--softkey to specify a nominal value with +/- tolerances, and then highlight the desired fields, and then enter the desired values.

This example screen contains the nominal value and tolerances listed below:

Tolerances		mm	10	P0
About	Dimension	B		
Dimensions	Nom + Max	0.005		
Formats	Nom + Limit	0.004		
Formulas	Nom + Warn	0.002		
Variables	Nominal	2.000		
Tolerances	Nom - Warn	0.002		
SPC	Nom - Limit	0.004		
Header	Nom - Min	0.005		
Memory	Audio Alert	None		
Dec	Inc	Limits	+/-	ApplyAll

- Nominal = 2.0000 mm
- Warning tolerance = ± 0.0020 mm
- Limit tolerance = ± 0.0040 mm
- Max tolerance = ± 0.0050 mm

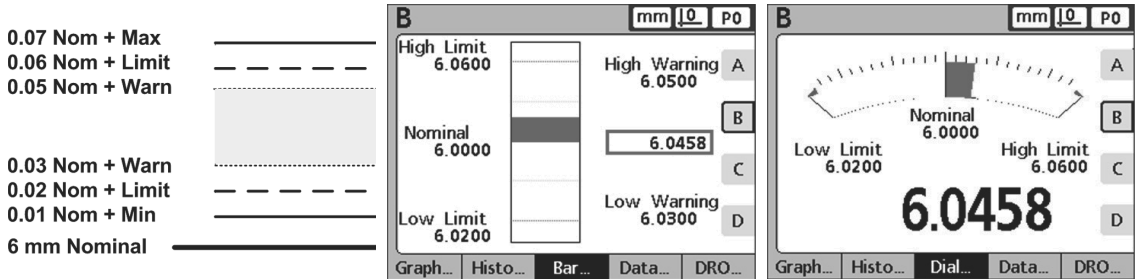


NOTE

Values specified using the +/- Tolerances screen will also be converted to fixed limits if the Limits softkey is pressed.

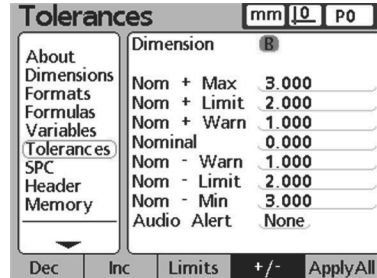
Nominal with ++ tolerances

A nominal value is displayed with tolerances entirely on the plus side of nominal.

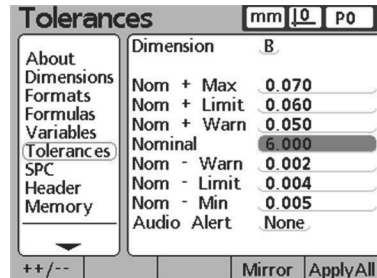


To specify a range of tolerances above the nominal value (+ Tolerance):

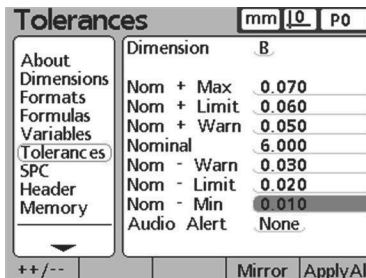
- 1 Press the +/- softkey



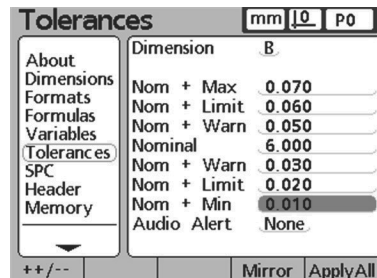
- 2 Enter the high end of the positive tolerance range into the + Max, + Limit and + Warn fields, and then enter the Nominal value.



- 3 Enter the low end of the positive tolerance range into the -Warn, and press the ++/-- softkey to change the fields to + Warn.



Repeat this procedure for the - Limit and - Min fields. This establishes the lower end of the positive range of tolerances.



Nominal with - - tolerances

A nominal value is displayed with tolerances entirely on the minus side of nominal.

6 mm Nominal

- 0.01 Nom - Max

- 0.02 Nom - Limit

- 0.03 Nom - Warn

- 0.05 Nom - Warn

- 0.06 Nom - Limit

- 0.07 Nom - Min

B mm 10 P0

High Limit 5.9800

Nominal 6.0000

Low Limit 5.9400

High Warning 5.9700

Low Warning 5.9500

5.9677

Graph... Histo... Bar... Data... DRO...

B mm 10 P0

Nominal 6.0000

Low Limit 5.9400

High Limit 5.9800

5.9677

Graph... Histo... Dial... Data... DRO...

To specify a range of tolerances below the nominal value (- Tolerance):

1 Press the +/- softkey.

Tolerances mm 10 P0

Dimension B

Nom + Max 3.000

Nom + Limit 2.000

Nom + Warn 1.000

Nominal 0.000

Nom - Warn 1.000

Nom - Limit 2.000

Nom - Min 3.000

Audio Alert None

Dec Inc Limits +/- ApplyAll

2 Enter the low end of the negative tolerance range into the - Max, - Limit and -Warn fields, and then enter the Nominal value.

Tolerances mm 10 P0

Dimension B

Nom + Max 3.000

Nom + Limit 2.000

Nom + Warn 1.000

Nominal 6.000

Nom - Warn 0.050

Nom - Limit 0.060

Nom - Min 0.070

Audio Alert None

++/-- Mirror ApplyAll

3 Enter the high end of the negative tolerance range into the + Warn, and press the ++ /-- softkey to change the field to - Warn.

Tolerances mm 10 P0

Dimension B

Nom + Max 0.010

Nom + Limit 0.020

Nom + Warn 0.030

Nominal 6.000

Nom - Warn 0.050

Nom - Limit 0.060

Nom - Min 0.070

Audio Alert None

++/-- Mirror ApplyAll

Tolerances mm 10 P0

Dimension B

Nom - Max 0.010

Nom - Limit 0.020

Nom - Warn 0.030

Nominal 6.000

Nom - Warn 0.050

Nom - Limit 0.060

Nom - Min 0.070

Audio Alert None

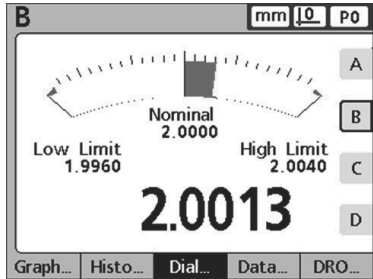
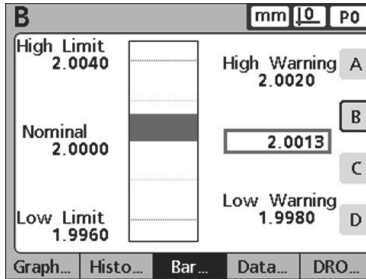
++/-- Mirror ApplyAll

Repeat this procedure for the + Limit and + Max fields. This establishes the upper end of the negative range of acceptable tolerances.

Nominal with fixed limits

A nominal value is displayed between plus and minus fixed limits.

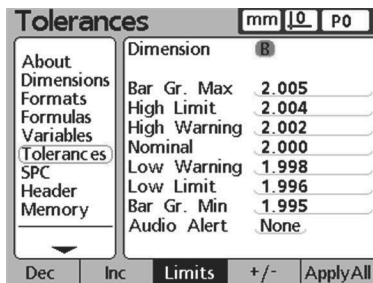
To specify fixed limits above and below a nominal value:



- 1 Press the Limits softkey to specify a nominal value with fixed limits.
- 2 Highlight the desired fields, and then enter the desired values.

The example below of 2 mm ± 0.005 mm is used to show a nominal value with fixed limits.

- Nominal = 2.0000 mm
- High warning = 2.0020
- Low warning = 1.9980
- High limit = 2.0040
- Low limit = 1.9960
- Bar graph max = 2.0050
- Bar graph min = 1.9950



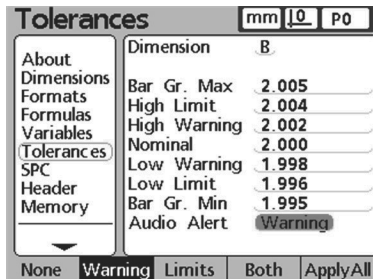
Specifying an audio alert

Audio alerts can be specified that sound when a dimension reaches warning and limit values.

The audio alert sounds when a warning or limit threshold is crossed, and will not sound again until the alert is reset by crossing the threshold again in the opposite direction.

Press the appropriate softkey to specify:

- No audio alerts
- Audio alerts for tolerance or limit warnings
- Audio alerts for limit failures
- Audio alerts for both; warnings and limit failures



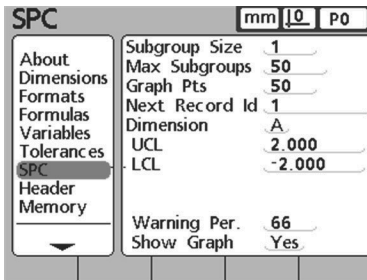
Mirror values

The positive and negative Max and Warn values can be changed automatically by entering either a positive or negative Limit value and pressing the Mirror softkey. The UCL and -LCL values in the SPC screen will also be changed. New values will be:

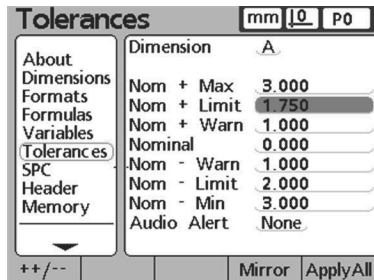
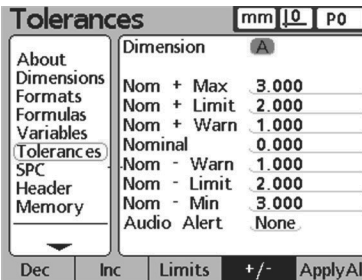
- Max = Limit + 5%
- Warn = SPC screen Warning Per (%) of Limit
- SPC screen ULC & -LCL = Limit

In this example, the Limit is changed to 1.750. The resulting changes are:

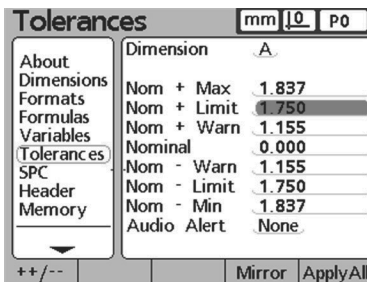
- Max = Limit + 5% = 1.837
- Warn = SPC screen Warning Per (%) of Limit = 66% of Limit = 1.155
- SPC screen ULC & -LCL = Limit = 1.750



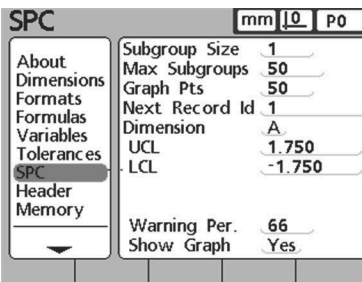
Initial values in the SPC and Tolerances screen are changed when...



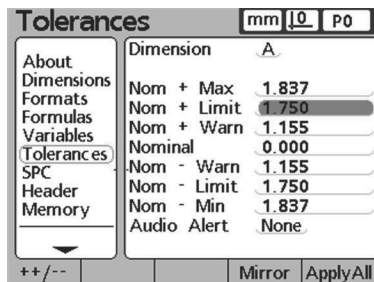
the Limit value is changed and...



the Mirror key is pressed



resulting in new SPC UCL & LCL and Tolerance Max & Warn values



SPC screen

The SPC screen contains fields for specifying statistical process control parameters including the Subgroup (sample) Size and Max (number of) subgroups stored, upper and lower mean control limits, and upper and lower range control limits. Record ID numbers can also be viewed or changed.

Subgroup size

Enter the desired subgroup size from 1 to 10 samples.

SPC parameters in the lower half of the screen and graphs of data displayed on the screen are different for subgroup sizes of 1 and subgroup sizes greater than 1.

The differences between subgroups of 1 and subgroups greater than 1 are described later in this SPC screen discussion.

SPC		mm	10	po
About	Subgroup Size	1		
Dimensions	Max Subgroups	50		
Formats	Graph Pts	50		
Formulas	Next Record Id	1		
Variables	Dimension	A		
Tolerances	UCL	2.0000		
SPC	LCL	-2.0000		
Header	Warning Per.	66		
Memory	Show Graph	Yes		

Subgroup size = 1

SPC		mm	10	po
About	Subgroup Size	3		
Dimensions	Max Subgroups	50		
Formats	Graph Pts	50		
Formulas	Next Record Id	1		
Variables	Dimension	A		
Tolerances	UCL	2.0000		
SPC	LCL	-2.0000		
Header	r UCL	1.0000		
Memory	r LCL	0.0000		
	Warning Per.	66		
	Show Graph	Yes		

Subgroup size > 1

Max Subgroups

Enter the maximum number of subgroups to be stored for the specified dimension. Each dimension can store samples in from 2 to 1000 subgroups.

SPC		mm	10	po
About	Subgroup Size	3		
Dimensions	Max Subgroups	50		
Formats	Graph Pts	50		
Formulas	Next Record Id	1		
Variables	Dimension	A		
Tolerances	UCL	2.0000		
SPC	LCL	-2.0000		
Header	r UCL	1.0000		
Memory	r LCL	0.0000		
	Warning Per.	66		
	Show Graph	Yes		

Graph Points

Enter the maximum number of points that will be plotted on graphs of subgroups for the specified part.

SPC		mm	10	po
About	Subgroup Size	3		
Dimensions	Max Subgroups	50		
Formats	Graph Pts	50		
Formulas	Next Record Id	1		
Variables	Dimension	A		
Tolerances	UCL	2.0000		
SPC	LCL	-2.0000		
Header	r UCL	1.0000		
Memory	r LCL	0.0000		
	Warning Per.	66		
	Show Graph	Yes		



NOTE

When there are fewer graph points specified than subgroups, the resulting dimension graphs might need to be scrolled to view all the subgroup data.

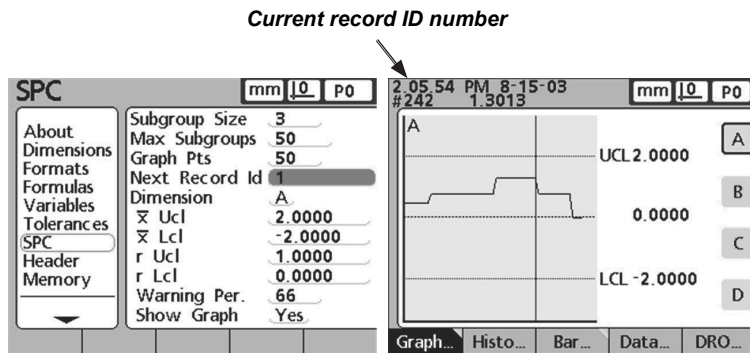
Refer to [Chapter 5: Operation](#) for details regarding viewing and scrolling graphs.

Next Record ID

Record ID numbers are displayed on graphs and can be included in printed reports and transmitted data.

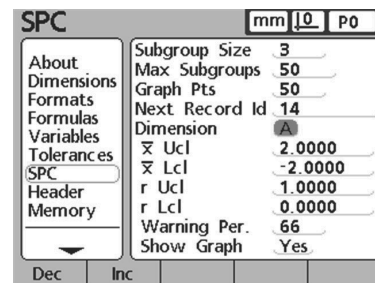
Normally, the Next Record ID field starts at 1 and is automatically incremented by the system each time a new record is stored. However, the Next Record ID

field can be set to any value by the user to restart a new database at a specified record number, or for a variety of other reasons. Enter the Next Record ID to restart the database at a new number. Entering 999,999,999 will prevent any data from being recorded in the database



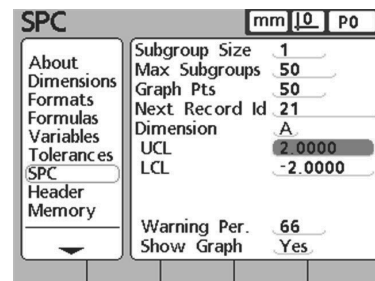
Dimension

Use the Dec or Inc softkey to select the dimension.



UCL and LCL

The UCL and LCL fields are displayed when the subgroup size is 1. Subgroup sizes greater than 1 change the lower half of the SPC screen to display mean and range control limits that are described later in this discussion. By default, the UCL and LCL fields display the upper and lower (acceptance) limits specified earlier on the Tolerance setup screen. The limits are used by the P-400 DRO graphing software to scale the value axis of SPC graphs.



CAUTION

The UCL and LCL values shown on the SPC setup screen should not be altered after initial setup. Change them only if you are certain that your application requires different values.

Xbar and r Ucl and Lcl

The Xbar and r Ucl and Lcl fields are displayed when the subgroup size is greater than 1.

Ucl and Lcl

The Xbar Ucl and Xbar Lcl are the likely limits of the values of Xbar in future subgroups. These limits are either entered manually or calculated (Recalc softkey) on the basis of existing subgroup data. The Xbar Ucl and Xbar Lcl values are displayed as horizontal lines on the Xbar chart and used to generate SPC limit alarms.

Recalculating or specifying Xbar Ucl and Lcl

The Xbar chart above shows upper and lower control limits that were entered into the Tolerance setup screen as upper and lower acceptance limits prior to the collection of subgroup measurement data. Once subgroup data has been collected, the upper and lower control limits can be simultaneously recalculated by highlighting either of the Xbar control limit fields and pressing the Recalc softkey. Alternatively, the x upper and lower control limits can be entered directly into the Xbar Ucl and Xbar Lcl fields.

r Ucl and Lcl

The r Ucl and r Lcl are the likely limits of the values of the r of future subgroups calculated on the basis of existing subgroup data. These limits are either entered manually or calculated (Recalc softkey) on the basis of existing subgroup data. The r Ucl and r Lcl values are displayed as horizontal lines on the chart and used to generate SPC limit alarms.

Recalculating or Specifying r Ucl and r Lcl

The chart shown earlier indicates upper and lower control limits that were included as upper and lower acceptance limits prior to the collection of subgroup measurement data. Once subgroup data has been collected, the upper and lower control limits can be simultaneously recalculated by highlighting either of the r control limit fields and pressing the Recalc softkey. Alternatively, the r upper and lower control limits can be entered directly into the Ucl and Lcl fields.

SPC		mm	0	P0
About	Subgroup Size	3		
Dimensions	Max Subgroups	50		
Formats	Graph Pts	50		
Formulas	Next Record Id	14		
Variables	Dimension	A		
Tolerances	X̄ Ucl	2.0000		
SPC	X̄ Lcl	-2.0000		
Header	r Ucl	1.0000		
Memory	r Lcl	0.0000		
	Warning Per.	66		
	Show Graph	Yes		
Recalc				

SPC		mm	0	P0
About	Subgroup Size	3		
Dimensions	Max Subgroups	50		
Formats	Graph Pts	50		
Formulas	Next Record Id	21		
Variables	Dimension	A		
Tolerances	X̄ Ucl	0.2765		
SPC	X̄ Lcl	0.1235		
Header	r Ucl	1.0000		
Memory	r Lcl	0.0000		
	Warning Per.	66		
	Show Graph	Yes		
Recalc				

SPC		mm	0	P0
About	Subgroup Size	3		
Dimensions	Max Subgroups	50		
Formats	Graph Pts	50		
Formulas	Next Record Id	21		
Variables	Dimension	A		
Tolerances	X̄ Ucl	0.2765		
SPC	X̄ Lcl	0.1235		
Header	r Ucl	1.0000		
Memory	r Lcl	0.0000		
	Warning Per.	66		
	Show Graph	Yes		
Recalc				

SPC		mm	0	P0
About	Subgroup Size	3		
Dimensions	Max Subgroups	50		
Formats	Graph Pts	50		
Formulas	Next Record Id	21		
Variables	Dimension	A		
Tolerances	X̄ Ucl	0.2765		
SPC	X̄ Lcl	0.1235		
Header	r Ucl	0.1928		
Memory	r Lcl	0.0000		
	Warning Per.	66		
	Show Graph	Yes		
Recalc				

Warning limits

The Warning Per field is used to specify the upper and lower warning limits on the Xbar and r SPC charts as a percentage of upper and lower control limits. For example:

When the Warning Per = 66

and:

Xbar Ucl = 2.0000

Xbar Lcl = -2.0000

r Ucl = 1.0000

r Lcl = 0.0000

then:

Xbar upper warning = 1.3200

Xbar lower warning = -1.3200

r upper warning = 0.6600

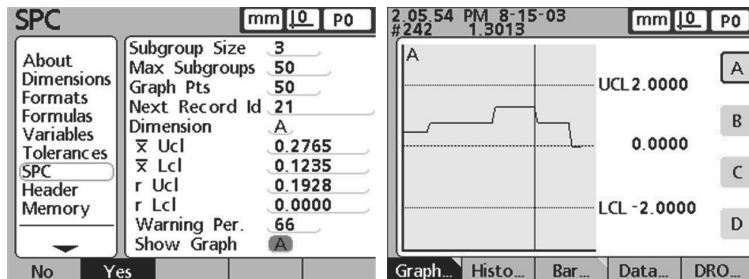
r lower warning = 0.0000

SPC		mm	10	p0
About	Subgroup Size	3		
Dimensions	Max Subgroups	50		
Formats	Graph Pts	50		
Formulas	Next Record Id	21		
Variables	Dimension	A		
Tolerances	X̄ Ucl	0.2765		
SPC	X̄ Lcl	0.1235		
Header	r Ucl	0.1928		
Memory	r Lcl	0.0000		
	Warning Per.	66		
	Show Graph	Yes		

Warnings and over-limits are indicated on Xbar and r SPC charts by color changes to yellow for warnings, and red for over-limits. These colors can be changed in the Display setup screen.

Showing and hiding SPC graphs

The SPC graph for each dimension can be shown or hidden by choosing Yes or No when the Show Graph setup selection is highlighted. Hiding SPC graphs for dimensions reduces system resource consumption and increases throughput speed.



Header screen

The Header screen contains fields for creating header labels and user prompts for text that will be included on printed reports. Header information will be printed in text fields at the top of all reports oriented as shown on the Header setup screen.

Each header text field can be defined as a Label or a Prompt. Labels are created in the header setup screen and printed on reports. Prompts are also created in the Header setup screen and printed on reports, but prompts elicit additional information from the user when the Print key is pressed. The user text response to the prompt will be printed next to the prompt on the report. The example report at the right shows label and prompt fields.

Labels

Highlight the desired header field and press the Label softkey to define the field as a label, and then press the Change softkey to display the Alpha Entry screen.

Label text	Prompt text
Mean:	1.3050
Max:	1.3780
Min:	1.2180
Range:	0.1600
Sigma:	0.0547
6 Sigma:	0.3280
Cp:	0.1220
CPK:	-28.2627

A
1.2820 mm
1.2820 mm
1.2820 mm

Page 1

Upper/lower case

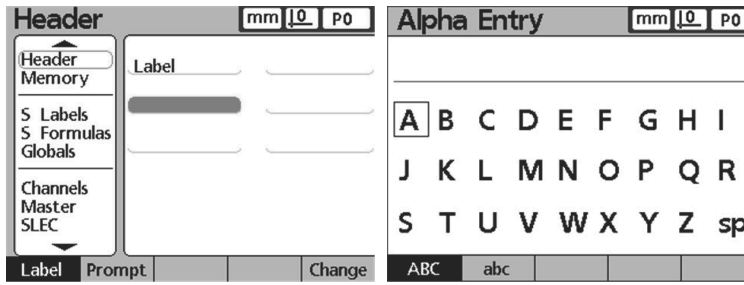
Alpha characters are entered in upper or lower case. Press the ABC softkey for uppercase, or the abc softkey for lower case.

Entering label characters

Use the Cursor keys to select the desired character, then press the Enter key to append the selected character to the message line. Use the SP character to include spaces. Press the Finish key to return to the Header setup screen.

Prompts

Highlight the desired header field and press the Prompt softkey to define the field as a prompt, and then press the Change softkey to display the Alpha Entry screen.



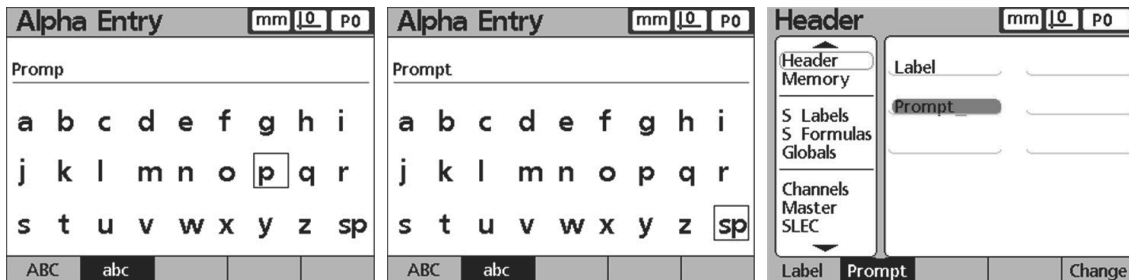
Label text	Prompt text
Mean:	1.3050
Max:	1.3780
Min:	1.2180
Range:	0.1600
Sigma:	0.0547
6 Sigma:	0.3280
Cp:	0.1220
CPK:	-28.2627
+-----+	
| A |	
+-----+	
| 1.2820 mm |	
+-----+	
| 1.2820 mm |	
+-----+	
| 1.2820 mm |	
+-----+	
Page 1	

Upper/lower case

Alpha characters can be entered in upper or lower case. Press the ABC softkey for uppercase, or the abc softkey for lowercase.

Entering prompt characters

Use the Cursor keys to select the desired character, and then press the Enter key to append the selected character to the message line. Use the SP character to include one space after the prompt, so that the prompt message is separated from the user's text response. Press the Finish key to return to the Header setup screen.



The Alpha Entry screen will be displayed with the prompt when the user presses the Print key in the graph, histogram, data and detailed data views.

Press the Finish key to return to the Setup menu.

Memory screen

The memory screen contains fields that describe memory allocations and use for the total system and the current part.

Memory allocations are changed by the system when the user changes:

- The number of parts
- The number of measurements performed
- Formula complexity
- Parameters in the SPC setup screen.

Memory		mm	0	PO
Total Available		975886		
Total Allocated		4820		
Part		0		
Amt Available		2400		
Amount Used		0		
Percent Used		0		
Num Records		0		
Max Records		50		



NOTE

The memory screen is provided only as a convenience for determining the memory usage in your system. The user cannot change memory allocations, beyond reducing the number of parts used or database records stored.

S Labels screen

The S Labels screen provides fields for labeling up to 16 system dimension formulas. Labels contain up to 3 alphanumeric characters. Alpha characters are in the range from A to Z and can be upper or lower case. Numeric characters are in the range from 0 to 9. The order of alpha and numeric characters in a label is defined by the user.

Highlight the system dimension field, press the Label softkey to display the Alpha Entry screen, and then enter the desired alphanumeric characters. Press the Finish key to complete the process.

The S Labels screen displays a grid of 16 labels (L1-L16) with a navigation menu on the left. The menu includes SPC Header Memory, S Labels (selected), S Formulas, Globals, and Channels Master. The grid shows the following labels:

L1	S1	L9	None
L2	None	L10	None
L3	None	L11	None
L4	None	L12	None
L5	None	L13	None
L6	None	L14	None
L7	None	L15	None
L8	None	L16	None



NOTE

Labels should be meaningful by reflecting the measurement application when possible.

S Formulas screen

System dimensions are created in the S Formulas screen and are used like the dimension formulas discussed earlier in this chapter, except that, unlike dimension formulas, System dimensions can be used by any part.

The S Formulas screen displays a channel with a label name and a formula. The channel is labeled 'channel' and the label name is 'S1'. The formula is 'C1+C2'. The screen also shows a navigation menu on the left and a bottom bar with buttons for Chan..., Dim..., +-*/..., Math..., and Other....



NOTE

Formulas are explained in [Chapter 4: Formulas](#).

Globals screen

The Globals screen shows the current state of global variables and is used like the Variables screen discussed earlier in this chapter. Global variables are used like variables except that, unlike variables, globals can be used by any part.

The Globals screen displays five global variables (G1-G5) with numerical values. The screen also shows a navigation menu on the left and a bottom bar with buttons for Chan..., Dim..., +-*/..., Math..., and Other....

G1	0.0000000
G2	0.0000000
G3	0.0000000
G4	0.0000000
G5	0.0000000

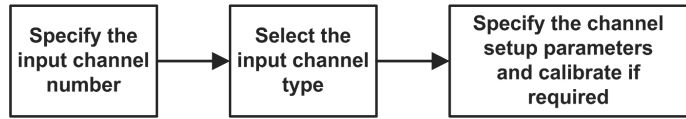


NOTE

Global variable functions are defined in the formula screen. Formulas are explained in [Chapter 4: Formulas](#).

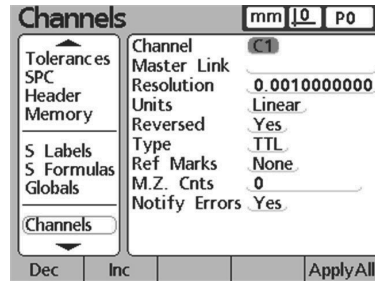
Channels screen

The Channels screen contains fields for selecting, configuring and calibrating input channel devices. The input channel setup process is diagrammed here.



Specifying the input channel

Highlight the Channel field and use the Dec or Inc softkey to specify the desired input channel.



Selecting the channel input type

Channel input devices are attached to standard interface connectors or to an RS-232 serial port on the rear of the P-400 DRO. The number and type of channel inputs are specified when the P-400 DRO is purchased, but might need to be specified again in the field. Channel types include:

- TTL
TTL square wave encoder
- Analog
Sinusoidal analog encoder
- D1311
RS-232 thermocouple
- HBT
Analog input from half-bridge transducers
- LVDT
Analog input from full-bridge transducers
- Albion
RS-232 temperature compensation for gage materials
- A2D
Analog input from a wide variety of analog to digital devices
- A2E
Analog input from air gage devices.
- AEK
Analog input from AEK air gage devices.
- SerAxis
RS-232 Single probe input to primary or secondary RS-232 port
- MTISer
Data byte inputs from single MTI probes
- D5451
RS-232 serial thermocouple probe network
- Orbit
RS-232 Solartron Orbit probe network
- Marposh
RS-232 serial probe network
- SonyMG
RS-232 Sony probe network
- DMX
RS-232 multiplexer
- MPLX
RS-232 multiplexer

To select the channel input device to match your P-400 DRO interface configuration:

1 Highlight the Type field and then press the List softkey to display the list of channel input types.

Channels		mm	10	P0
Tolerances	Channel	C1		
SPC	Master Link			
Header	Resolution	0.0010000000		
Memory	Units	Linear		
	Reversed	Yes		
S Labels	Type	TTL		
S Formulas	Ref Marks	None		
Globals	M.Z. Cnts	0		
	Notify Errors	Yes		
Channels				
List				ApplyAll

2 Highlight the desired type and then press the Enter key. In this example, the Analog type was selected.

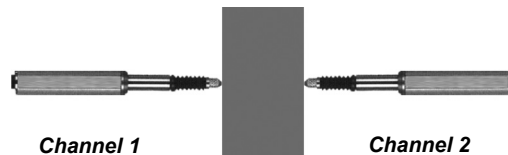
Channels		mm	10	P0
Tolerances	Channel	C1		
SPC	Master Link			
Header	Resolution	0.0010000000		
Memory	Units	Linear		
	Reversed	Yes		
S Labels	Type	Analog		
S Formulas	Ref Marks	None		
Globals	M.Z. Cnts	0		
	Notify Errors	Yes		
Channels				
List				ApplyAll

Specifying input channel setup parameters

Input channel setup parameters change to support the selected input channel type. Some input devices share common parameters, and others require unique setup parameters. Setup parameters for all input types are described in this section, but only a portion of these setup parameters will apply to your system.

Master Link probe balancing

The Master Link function masters two opposing probes for balanced-probe measurements, as shown in this example of thickness measurement.



Material thickness is measured by two balanced probes

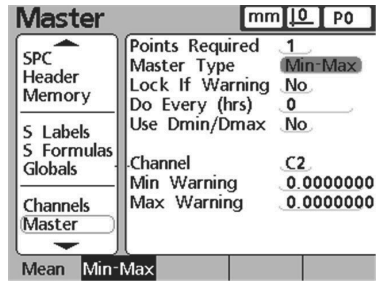
To balance two opposing probes:

1 Confirm that the Reversed settings of the two probe setup screens are the same. Change the setting of one if necessary. In this example, the reversed settings of channels 1 and 2 are identical.

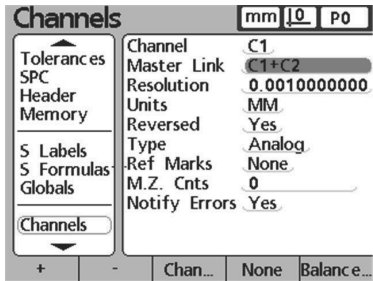
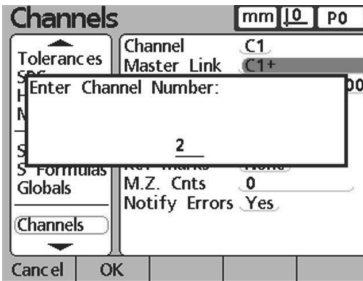
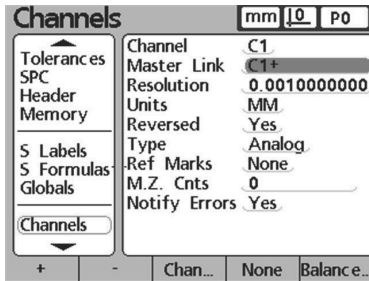
Channels		mm	10	P0
Tolerances	Channel	C1		
SPC	Master Link			
Header	Resolution	0.0010000000		
Memory	Units	Linear		
	Reversed	Yes		
S Labels	Type	Analog		
S Formulas	Ref Marks	None		
Globals	M.Z. Cnts	0		
	Notify Errors	Yes		
Channels				
No	Yes			ApplyAll

Channels		mm	10	P0
Tolerances	Channel	C2		
SPC	Master Link			
Header	Resolution	0.0010000000		
Memory	Units	MM		
	Reversed	Yes		
S Labels	Type	Analog		
S Formulas	Ref Marks	None		
Globals	M.Z. Cnts	0		
	Notify Errors	Yes		
Channels				
No	Yes			ApplyAll

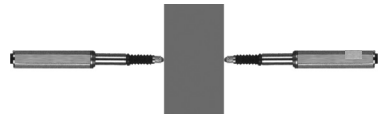
2 Confirm that the Master Type setting of the Master setup screen is set to Min-Max. Change the setting if necessary.



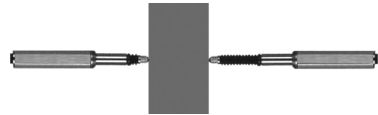
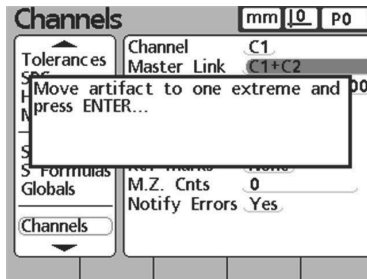
3 Highlight the Master Link field of the first channels screen, press the + softkey and then the Chan softkey. Enter the number of the second linked channel and press the OK softkey to update the Master Link field.



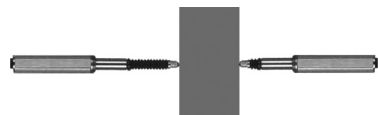
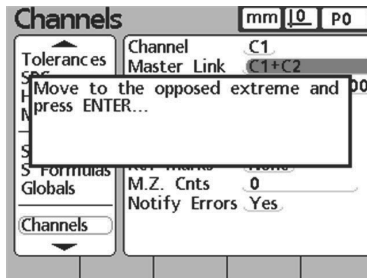
4 Place the desired artifact between the two probes and press the Balance softkey.



5 You will then be instructed to move the artifact to one extreme of the measurement range. Move the artifact and then press Enter.



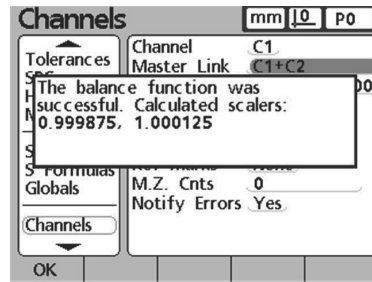
You will then be instructed to move the artifact of the opposite extreme of the measurement range. Move the artifact and then press Enter.



6 The balance scalars will be displayed. Press the OK softkey to save the balance scalars.

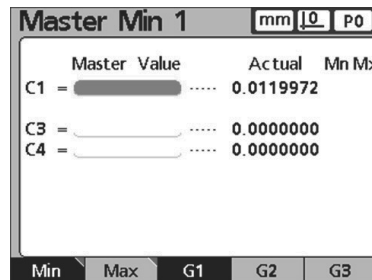
**NOTE**

In the Channel screen of the linked (second) probe will now show the first probe number in the Master Link field. Do not change this field.

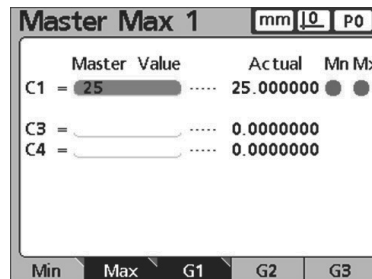
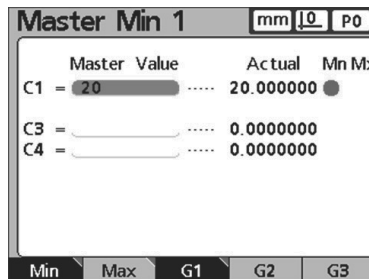


7 Press the Finish softkey twice, then press the Master softkey to display the Master screen.

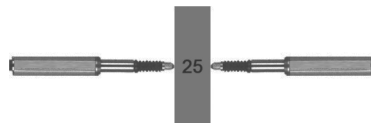
8 Highlight the Master Value field of the first balanced channel.



9 Master the Min and Max values using calibration artifacts as described in [Chapter 5: Operation](#) and shown in this example of 20 mm Min and 25 mm Max.

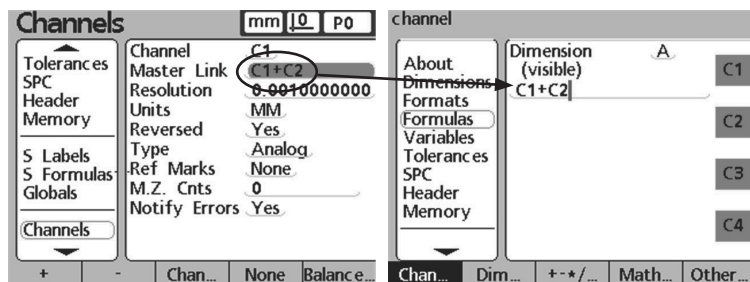


The Min is mastered



The Max is mastered

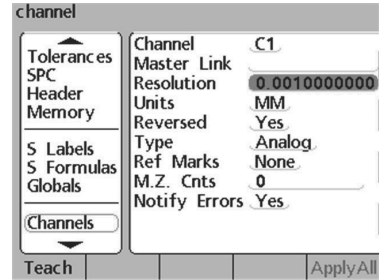
10 Press the Finish key to return to the home screen and then display the Formula setup screen for the balanced probes. Enter the formula as it is shown in the channel screen of the first balanced channel.



The two probes are now balanced and mastered. Press to Finish key to return to the setup menu.

Specifying channel input resolution

The resolution field defines the input resolution for encoder, transducer, thermocouple, RS-232 probe network and other channel inputs. The channel input resolution must be specified by the user for all input devices except transducer and the Solartron Orbit RS-232 network. To specify a resolution, highlight the Resolution field and enter the resolution using the numeric keypad.



Transducers

Transducer gain must be calibrated before mastering the transducer resolution. The instructions for gain calibration are provided later in this chapter. After transducer gain is calibrated, LVDT and HBT transducer resolution is determined by performing a full calibration using the Master function. Refer to [Chapter 5: Operation](#) for detailed instructions.

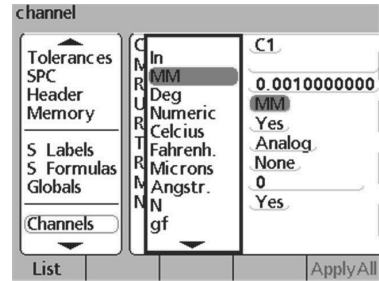
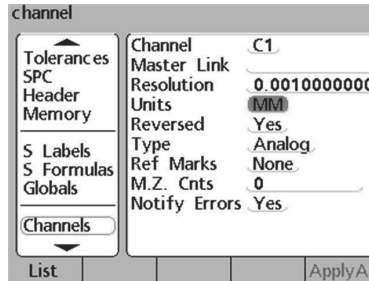
Solartron orbit probes

The resolution of Solartron Orbit probes must be determined by *Teaching* the or manually entering ID numbers in the Channels setup screen. Refer to [Chapter 2: Installation](#) for detailed instructions.

Specifying units of measure

The Units field is used to specify channel input units of measure. Displacement units of measure can be inches, millimeters, angular or simply numeric. Thermocouple units of measure can be Celsius, Fahrenheit or numeric.

Press the List softkey to display a list of units of measure. Highlight the desired unit, and then press the Enter key to select the unit.

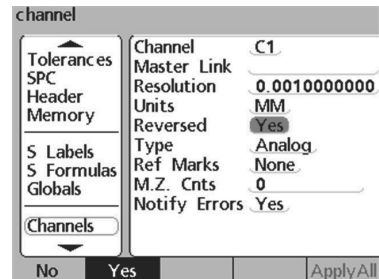


Reversing channel input polarity

The Reversed field is used to reverse the direction of all specify channel input counts, and will reverse the polarity of serial inputs.

Normally, displacement counts increase as the device is compressed or rotated clockwise. Serial input polarity can be reversed to suit the requirements of the application.

Press the Yes softkey to reverse input channel polarity.



Specifying encoder reference marks

Encoder reference marks can be used to home the system when it is started. The P-400 DRO can be configured to prompt the user to cross reference marks or to perform a hard stop machine zero prior to measurements.

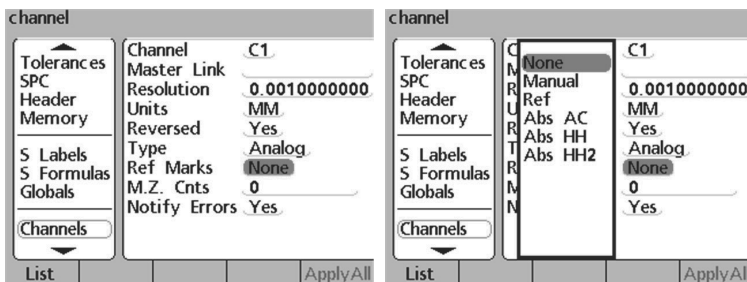


NOTE

The Reference Marks setup parameter has no meaning when an RS-232 device is specified as the channel input.

Press the List softkey to display a list of reference mark types. Highlight the desired reference, and then press the Enter key.

When Manual is selected, the operator will be prompted when powering the system to move to the desired zero point and press the Enter key. When Ref, Abs AC, or Abs HH is selected, the operator will be prompted to move the encoder to cross a reference mark. Abs AC specifies Acu-Rite C-scales, Abs HH specifies Heidenhain C-scales.



NOTE

If a reference has been specified, a password is required to skip the reference initialization when power is applied to the system.

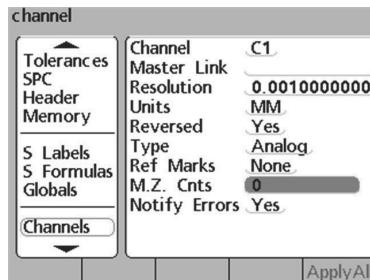
Changing the machine zero position

The M.Z.Cnts field can be used to specify an offset count value for repositioning machine zero.



NOTE

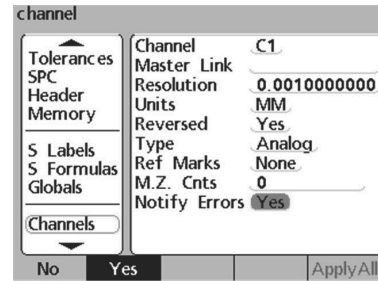
The Machine Zero Count setup parameter has no meaning when an RS-232 device is specified as the channel input device.



If it becomes necessary to change the position of machine zero, highlight the M.Z.Cnts field and use the number keypad to enter the required offset counts into the M.Z.Cnts field, then cycle the P-400 DRO power and cross reference marks.

Enabling scale error notification

The Notify Errors field is used to enable the reporting of scale errors for the specified channel on the DRO screen. Use the Yes or No softkeys to activate or deactivate error reporting.



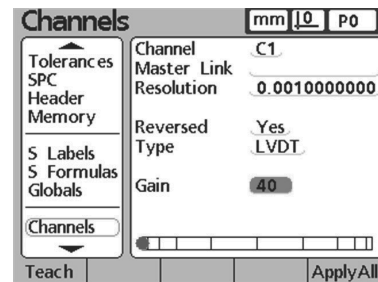
Calibrating LVDT and HBT transducer gain

The P-400 DRO includes hardware and software for automatically calibrating the system to accommodate variations in transducer output level.

Highlight the Gain field, press the Teach softkey, and follow instructions that appear on the P-400 DRO screen for calibrating the system to accommodate the output level of the transducer connected to this channel.

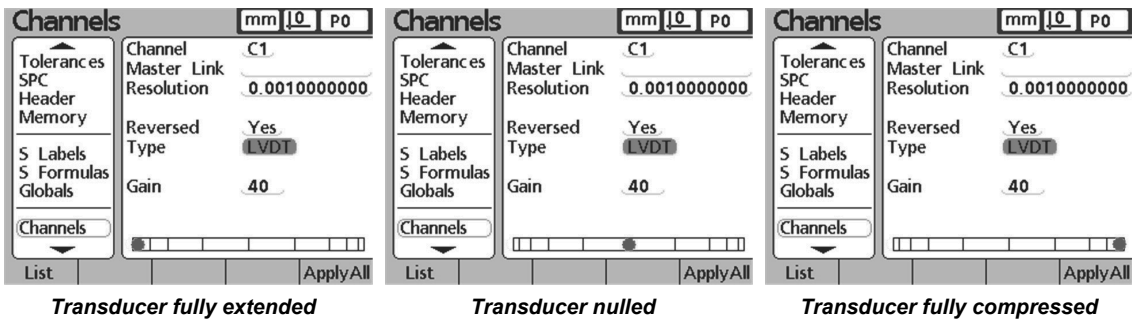
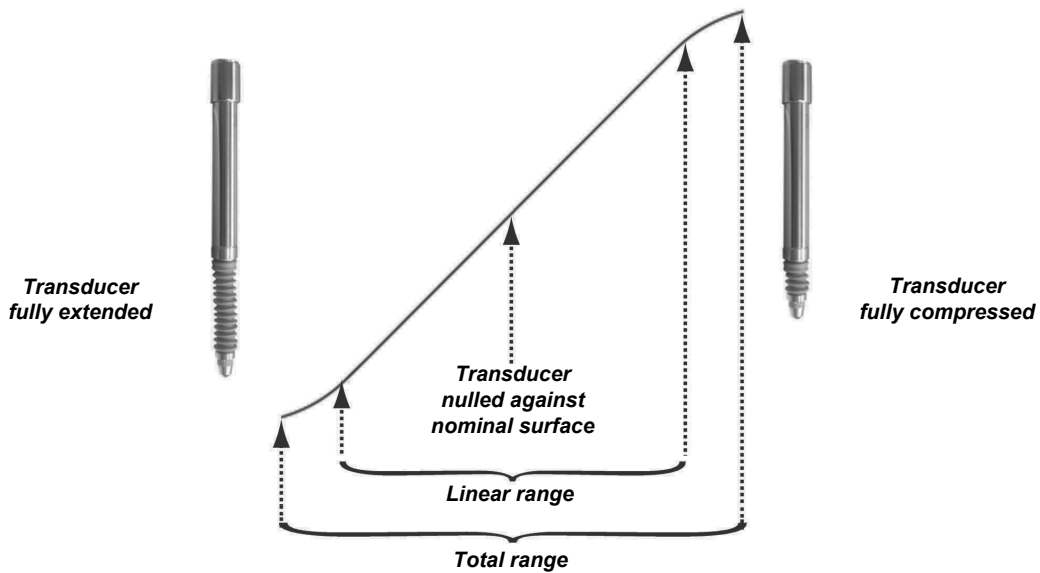
Centering (Nulling) LVDT and HBT transducers

Transducer outputs are most linear in the central portion of their total range of movement. Each LVDT and HTB transducer must be positioned at the center of its range of movement (nulled) in the gage and against a nominal reference surface to provide the most accurate measurements. The bar graph at the bottom of the transducer Channel setup screens display the relative position of the transducer tips from one extreme of movement to the other and is used to null transducers as shown on the next page.



Prior to conducting measurements, the transducer gain must be calibrated as described above, and then the transducer must be:

- Secured in the gage
- Positioned against the nominal reference surface
- Adjusted in the gage to null against the nominal reference surface
- Locked in place



When the transducer gain is calibrated and the transducer has been nulled against the nominal reference surface, the transducer resolution can be calibrated using the Master function and measurements can be conducted.

Transducer resolution is usually calibrated periodically on a schedule determined by the application and the measurement environment. Refer to [Chapter 5: Operation](#) for detailed instructions regarding the use of the Master function to calibrate transducer resolution.

Selecting an external RS-232 channel

RS-232 input networks include multiple channel inputs that are numbered to reflect the manufacturers' channel module identification system. These numbers must be entered into the Ext Num field of all Channels setup screens. Consult the documentation that accompanied the RS-232 network for a description of the module numbering system.

Specifying an RS-232 input port

Multiple RS-232 serial ports are provided on P-400 DROs that include RS-232 input channels. In most instances the secondary port should be used for channel inputs. However, the primary port can be specified if desired. To specify an RS-232 serial port for input channel connection, highlight the Uart id field and press the Dec or Inc softkey.



NOTE

Communication with computers and other serial devices takes place over the primary serial port. Use of the primary serial port for the connection of serial input channel devices will make serial communication with other devices impossible.

Selecting and calibrating a Solartron Orbit channel

Solartron Orbit networks can include from 1 to 16 input channel probes. Any of the available probes can be selected for use on the current P-400 DRO channel by entering the Orbit probe ID number into the current channel setup screen. Consult the documentation that accompanied the Orbit network for a description of the probe ID numbers.

Channels		mm	10	P0
Tolerances	Channel	C1		
SPC	Master Link			
Header	Resolution	0.0010000000		
Memory	Units	Linear		
S Labels	Reversed	Yes		
S Formulas	Type	D5451		
Globals	Ext Num	0		
Channels	Uart Id	Primary		

Channels		mm	10	P0
Tolerances	Channel	C1		
SPC	Master Link			
Header	Resolution	0.0010000000		
Memory	Units	Linear		
S Labels	Reversed	Yes		
S Formulas	Type	DMX		
Globals	Ext Num	0		
Channels	Uart Id	Primary		
Dec	Inc	ApplyAll		

Channels		mm	10	P0
Tolerances	Channel	C1		
SPC	Master Link			
Header	Resolution	0.0010000000		
Memory	Units	Linear		
S Labels	Reversed	Yes		
S Formulas	Type	Orbit		
Globals	Ref Marks	None		
Channels	Id			
Teach	Notify Errors	Yes		
Entry	Uart Id	Primary		

Master screen

The Master screen contains fields for setting up and calibrating encoders and transducers.

Specifying the number of calibration points

The calibration of the input encoders and transducers is performed using the Master function described in [Chapter 5: Operation](#). Calibrations can be based on a single data point, or on an average of up to 10 data points. Averaging data points is useful when calibrations are performed in the presence of vibration, surface irregularities or electrical noise. Enter the desired number of calibration data points into the Points Required field.

Master		mm	10	P0
SPC	Points Required		10	
Header	Master Type		Min-Max	
Memory	Lock If Warning		No	
	Do Every (hrs)		0	
	Use Dmin/Dmax		No	
S Labels	Channel		C1	
S Formulas	Min Warning		0.0000000	
Globals	Max Warning		0.0000000	
Channels				
Master				

Selecting calibration type

Input channel calibrations are Min-Max or Mean. Min-Max calibrations use data points on the low and high ends of the measurement range to define channel input resolution. LVDT, half-bridge transducers and inputs with initially undefined measurement resolutions require Min-Max calibrations. Mean calibrations are used to preset input channels that are calibrated or have defined resolutions to specific values. Encoders, scales and other input devices with defined resolutions can be preset at any device state the user wishes using the Mean calibration type. After Min-Max calibration, transducer input values can also be preset using the Mean calibration type. The channel input calibration process is discussed in detail in [Chapter 5: Operation](#).

Master		mm	10	P0
SPC	Points Required		1	
Header	Master Type		Min-Max	
Memory	Lock If Warning		No	
	Do Every (hrs)		0	
	Use Dmin/Dmax		No	
S Labels	Channel		C1	
S Formulas	Min Warning		0.0000000	
Globals	Max Warning		0.0000000	
Channels				
Master				
	Mean		Min-Max	

Locking the calibration process if warnings occur

The calibration process can automatically be locked when a calibration fails and a warning is displayed. Once locked, the calibration process can only be completed by performing a new calibration that is successful or by entering the supervisor password to abort the calibration process. Enter Yes to lock the calibration when a warning is displayed.

Master		mm	10	P0
SPC	Points Required		1	
Header	Master Type		Min-Max	
Memory	Lock If Warning		No	
	Do Every (hrs)		0	
	Use Dmin/Dmax		No	
S Labels	Channel		C1	
S Formulas	Min Warning		0.0000000	
Globals	Max Warning		0.0000000	
Channels				
Master				
	No		Yes	

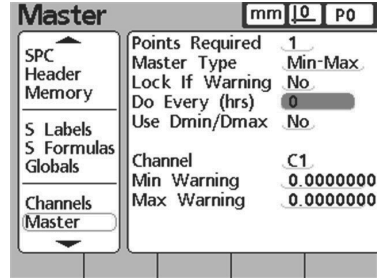
Specifying a calibration interval

The Master calibration screen can automatically be displayed at regular intervals to support a schedule of periodic input device calibrations. The Master screen will be displayed at the specified intervals unless a setup screen is being displayed to configure the P-400 DRO. To specify a calibration interval, enter the interval in the hours.



NOTE

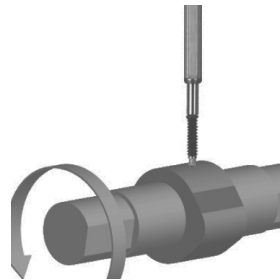
The user will be unable to skip a calibration without the supervisor password when the Lock If Warning field is set to Yes.



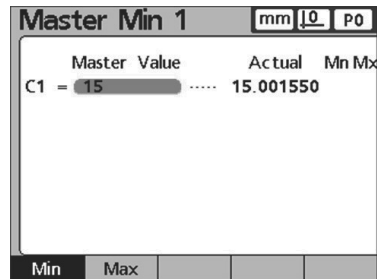
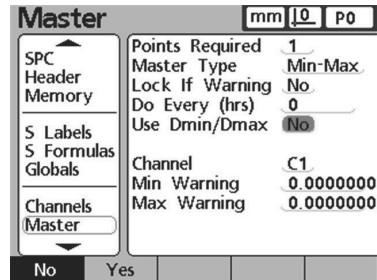
Using dynamic Min/Max values for calibration

Dynamic minimum and maximum measurements can be used in place of static artifact measurements for calibration when the calibrations must be performed in a gage system using rotary standard parts or rock step masters. To specify the use of dynamic minimum and maximum values for calibration, press the Yes SoftKey.

When dynamic minimum or maximum measurements are used for calibration, the Actual value on the Master screen changes as a standard part is rotated until the minimum or maximum values are found. Once the minimum or maximum values are displayed, the user simply enters the value for the calibration and presses the Enter key.

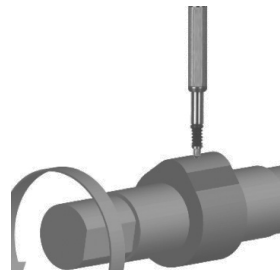


1.5 cm Dmin is measured and mastered as Min 1

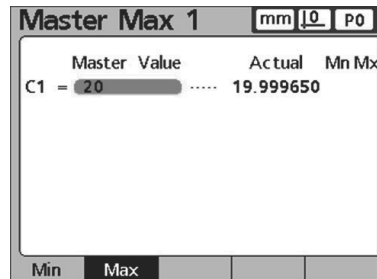


When Mean calibrations are performed, the calibration of the minimum value establishes a channel preset.

When Min-Max calibrations are performed, the minimum value establishes a preset and the combination of the minimum and maximum values is used to define channel resolution.



2.0 cm Dmax is measured and mastered as Max 1



Specifying Min and max calibration warnings

Periodic calibrations of input devices are sometimes performed on a regular schedule using the same calibration artifacts for each calibration. The Min and Max calibration warnings support these activities by validating each calibration. Warnings apply only to user-specified linear channels, not to angular or time-oriented channels. Specify the channel by decrementing or incrementing to the desired channel number.

The screenshot shows the 'Master' dialog box with the following settings:

mm | 0 | P0	
SPC	Points Required: 1
Header	Master Type: Mean
Memory	Lock If Warning: No
	Do Every (hrs): 0
	Use Dmin/Dmax: No
S Labels	Channel: C1
S Formulas	Min Warning: 0.000000
Globals	Max Warning: 0.000000
Channels	
Master	
Dec	Inc

Calibrations are validated by comparing each new set of calibration values to the original calibration values. Significant differences between the new and original values indicate artifact errors, equipment malfunctions or measurement errors. The acceptable difference between the new and original calibration values is specified by entering the acceptable difference into the Min Warning and Max Warning fields.

During calibration, if new calibration values fall outside the acceptable range, the calibration is invalidated and a warning is displayed. When a new calibration is invalidated, the user can correct the problem and attempt another new calibration, except the value as a preset or conduct measurements using the original (unchanged) calibration values.

The screenshot shows the 'Master Min 1' dialog box with a warning message:

mm | 0 | P0		
Master Value	Actual	Mn Mx
One or more of your channels has failed because it was not close enough to the last calibration.		
OK		

To specify the acceptable range of new calibration values:

- 1 Highlight the Min Warning field and enter the acceptable deviation from the original minimum master calibration value. When Mean calibrations are performed, only the Min Warning value is required.
- 2 When Min-Max calibrations are performed, Min and Max Warning values are required. Highlight the Max Warning field and enter the acceptable deviation from the original maximum master calibration value.

The screenshot shows the 'Master' dialog box with the following settings:

mm | 0 | P0	
SPC	Points Required: 1
Header	Master Type: Min-Max
Memory	Lock If Warning: No
	Do Every (hrs): 0
	Use Dmin/Dmax: No
S Labels	Channel: C1
S Formulas	Min Warning: 0.000000
Globals	Max Warning: 0.000000
Channels	
Master	



NOTE

The Min/Max warnings will be applied to the next set of calibration values obtained using the Master function described in [Chapter 5: Operation](#).

SLEC screen

The SLEC screen contains fields for configuring and enabling segmented linear error correction (SLEC), or linear error correction (LEC) for each input channel.

SLEC		mm	0.	P0
Header Memory	Channel	C1		
S Labels	Enabled	Off		
S Formulas	Station	0		
Globals	Standard			
Channels	Observed			
Master	MZ Offset	0.0000000		
SLEC				
Dec	Inc			

SLEC or LEC, which is right for my application?

Any channel input device can include slight nonlinearities over its measurement range. LEC compensates for nonlinearities by applying a single linear correction coefficient to the entire range of measurement. SLEC compensates for nonlinearities by applying multiple correction coefficients to individual nonlinear segments within the measurement range.

LEC is easy to set up, but does not provide correction for local nonlinearities that could be present over only small portions of the measurement range. SLEC correction requires a greater investment of time to set up, but results in more accurate measurements.

If an overall nonlinearity exists without significant local errors, LEC can be applied as a correction method. However, if input devices are found to have significant local nonlinearities, SLEC should be applied as a correction method.



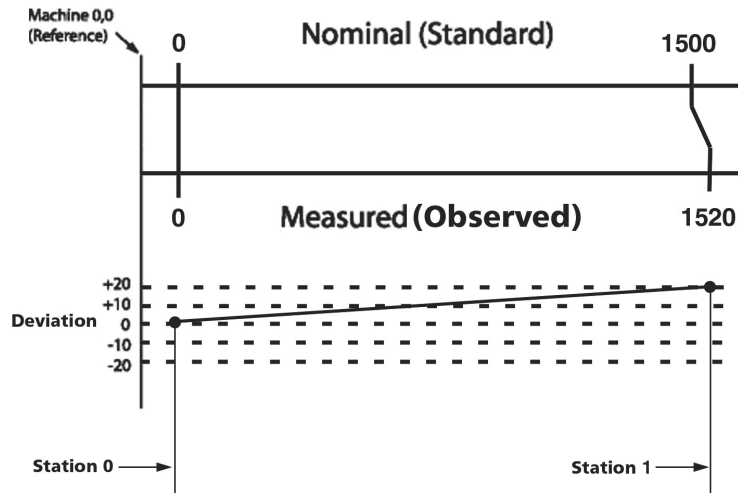
NOTE

SLEC and LEC require a repeatable machine zero.

LEC (Linear error correction)

The LEC correction coefficient is created by the P-400 DRO system using data provided by the user in the SLEC Setup screen. The LEC setup data provided by the user consists of nominal and measured values of a standard at the two extreme ends of the entire measurement range.

This diagram shows nominal (standard) values and measured (observed) values of a standard and shows that a small overall error exists across the entire measurement range.



The standard and observed values at the two ends of the measurement range are entered as data for stations 0 and 1 in the SLEC Setup screen. The standard and observed values at the beginning of the range are 0 because this end of the standard is the measurement reference. These zero values are entered into Station 0. The standard and observed values at the end of the range are 1500 and 1520 respectively in our example, indicating a linearity error of 20 over the entire range of measurement. These values are entered into Station 1.

SLEC		mm	.10	P0	SLEC		mm	.10	P0
Header Memory	Channel	C1			Header Memory	Channel	C1		
	Enabled	Off				Enabled	Off		
S Labels	Station	0			S Labels	Station	1		
S Formulas	Standard	0.0000000			S Formulas	Standard	1500.0000		
Globals	Observed	0.0000000			Globals	Observed	1520.0000		
Channels Master	MZ Offset	0.3552400			Channels Master	MZ Offset	0.3552400		
SLEC					SLEC				
Teach					Teach				

When the procedure is complete and setup data are entered, a correction coefficient will be calculated for the input device .



NOTE

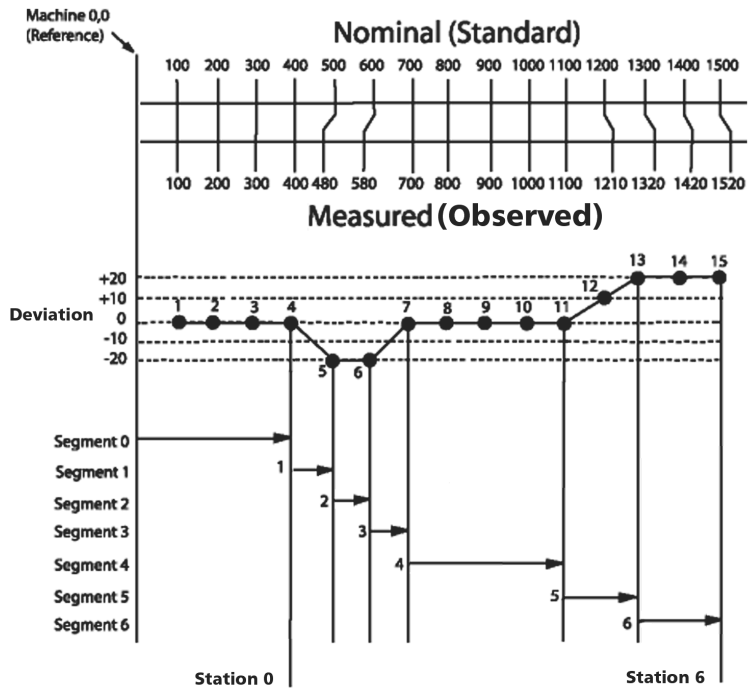
The LEC setup procedure is a subset of steps required for SLEC setup and requires a repeatable machine zero and only the first and last station entries.

SLEC (Segmented linear error correction)

SLEC compensates for channel input nonlinearities by applying correction coefficients only to the segments that require them. These SLEC correction coefficients are created by the P-400 DRO system using data provided by the user in the SLEC Setup screen. The SLEC setup data provided by the user consists of nominal and measured values of a standard, or standards that cover the entire channel input range.

The measurements divide the channel input range into as many as 60 user-defined segments. This diagram shows nominal (standard) values compared to measured (observed) values. The deviation (difference between standard and observed) is shown as a graph. Segments are defined here as any straight line on the graph, beginning with segment zero.

The standard and observed values at the end of each segment are entered as data into a station in the SLEC Setup screen. For example, the standard and observed values at the end of segment 0 on the diagram are 400 and 400, and are entered in this screen for station 0.



3 Setup

The screenshot shows the SLEC Setup screen. The title is 'SLEC' and the units are 'mm | 0 | P0'. The screen is divided into sections: 'Header Memory', 'S Labels', 'S Formulas', 'Globals', 'Channels Master', and 'SLEC'. The 'SLEC' section contains the following fields: 'Channel' (C1), 'Enabled' (Off), 'Station' (0), 'Standard' (400.00000), 'Observed' (400.00000), and 'MZ Offset' (0.0000000). Arrows point to the 'Station' field with the label 'Station number' and to the 'Standard' and 'Observed' fields with the label 'Data'.

When the procedure is complete and setup data are entered, correction coefficients will be calculated for the input based on the standard and observed values at the end of each segment.

SLEC setup procedure

The procedure for configuring the SLEC error correction is diagrammed and explained below.



CAUTION

Make sure that all encoder channel resolutions and machine zero references are properly configured, and that any required channel Master operations have been completed prior to configuring the SLEC feature. Refer to the description of Channel setup earlier in this chapter, and to the description of the Master function in [Chapter 5: Operation](#).

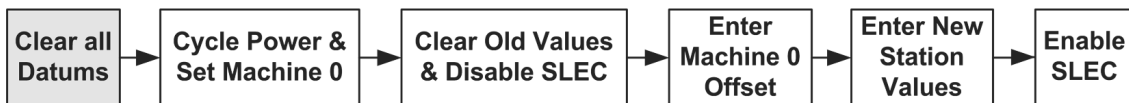
The SLEC setup procedure includes the following steps:

- Clear all datums
- Cycle the power and set a repeatable machine zero
- Clear all old SLEC values and disable SLEC
- Enter the offset from the machine zero to the standard's zero
- Enter new SLEC station nominal and observed values
- Enable SLEC

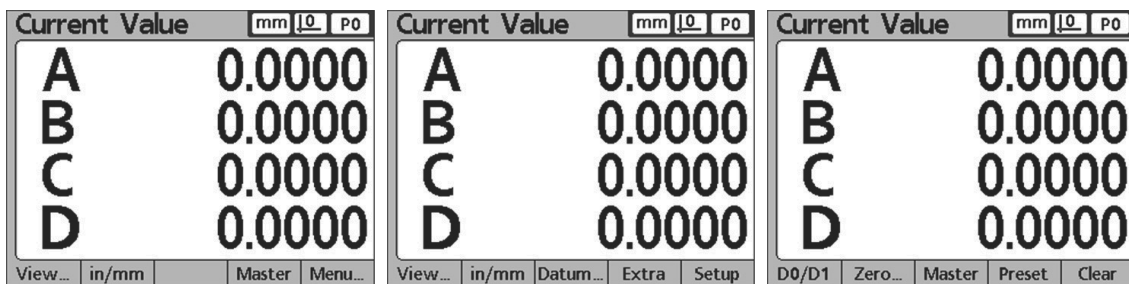
A diagram of the SLEC setup process is shown for each step with the current step highlighted.

Clear all datums

The following steps clear datums in preparation for SLEC standard measurements. To clear datums:

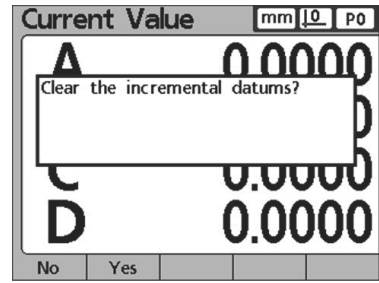


1 From the DRO screen, press the Menu softkey, press the Datum softkey, and then press the Clear softkey.



You will be asked to confirm your Clear datums request.

- 2 Press the Yes softkey to clear datums.



Press Yes to clear datums

Cycle power & set machine zero

The following steps cycle power to reestablish fresh machine zeros for all input channels. To cycle power and set machine zeros:

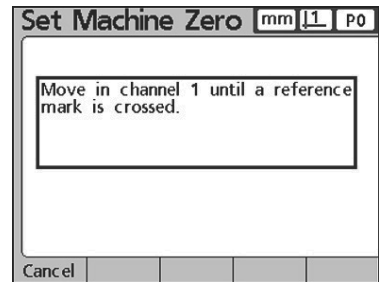


- 3 Turn the P-400 DRO power switch off, wait for a few seconds and turn the power switch on again.
- 4 Press the Finish or Quit key to initiate the P-400 DRO display.

You will be prompted to move the encoder to cross reference marks or perform hard stop zeroing on all input channels.



NOTE
Reference marks must be specified in the Channels setup screen to establish a machine zero on startup.



- 5 Perform machine zero operations on all channels.



NOTE
If a hard stop zero is performed, the same stop will be required each time the P-400 DRO is started.

Clear old values & disable SLEC

The following steps disable the SLEC feature to isolate the SLEC data fields during the data entry process, and clear old SLEC values. To clear old SLEC values:



6 Return to the setup menu.

7 Navigate to the Supervisor setup screen, enter the supervisor password and unlock the Datuming and Clearing Data.

Return to the Setup menu.

8 Navigate to the SLEC Setup screen and highlight the Channel field.

Supervisor		mm	10	P0
Rep Chars	Send	Send Chars	Parallel	RS232
USB	Hot Keys	Clock	Misc.	Supervisor
LoadX	SaveX			

If this is the first time that SLEC compensation is being configured, or if new SLEC values are being created for all encoders, then SLEC for all channels must be disabled. Any existing SLEC values must also be cleared. However, if only a fraction of channels require new SLEC values, only those channels must be disabled and cleared of old values.

9 Use the Dec or Inc softkey to select a channel that will be configured, highlight the Enabled field and then press the Off key to disable SLEC for the selected channel.

SLEC		mm	10	P0
Header Memory	Channel	C1		
S Labels	Enabled	Off		
S Formulas	Station	0		
Globals	Standard			
Channels	Observed			
Master	MZ Offset	0.000000		
SLEC				
Off	On			

11 Highlight the Station field and use the Dec or Inc key if necessary to display Station 0.

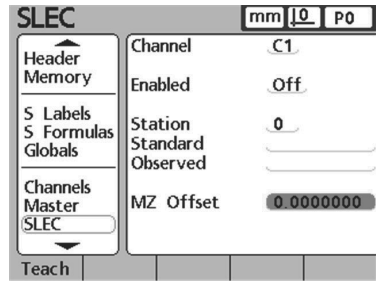
12 If the Standard and Observed fields contain data, press the remove softkey to clear the data. The old station 0 data will be replaced by data from station 1.

Continue pressing the remove key until the Standard and Observed fields are empty.

SLEC		mm	10	P0
Header Memory	Channel	C1		
S Labels	Enabled	Off		
S Formulas	Station	0		
Globals	Standard			
Channels	Observed			
Master	MZ Offset	0.000000		
SLEC				
Dec	Inc	Remove		

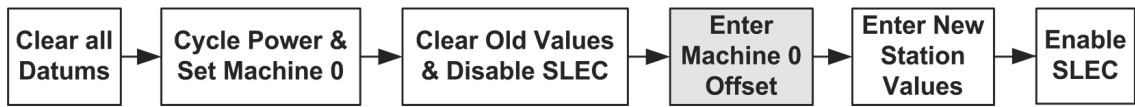
13 Highlight the MZ Offset field and use the numeric keypad to enter 0.

14 Repeat steps 9 through 13 for each encoder channel to be configured for SLEC.



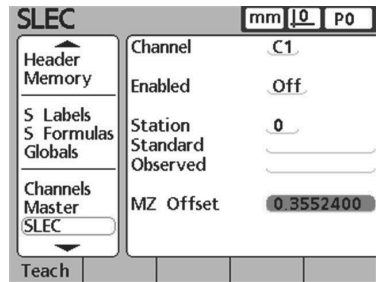
Enter machine zero offset

The following steps enter the offset count value from machine zero to the standard's zero.



15 Highlight the MZ Offset field of the channel being configured and position the Channel's probe at the standard's zero reference.

16 Press the Teach softkey, then press the Enter key to enter the machine zero offset.



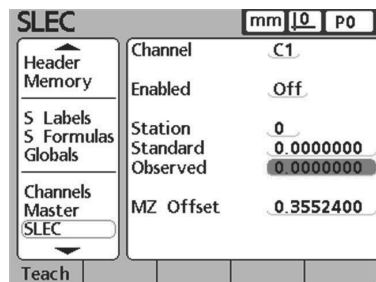
Enter New Station Values

The following steps enter standard and observed values across the entire range of measurement.



The Station 0 data is used as the reference for all subsequent SLEC segment measurements and is derived from the standard's zero reference. Station 0 Standard and Observed field data must be identical or entered as zeros to initiate the standard's reference position.

17 Highlight the Standard field, enter 0, and then press the Enter key. Highlight the observed field, enter 0, and then press the Enter key.



Now that the Station 0 reference data is entered into Standard and Observed fields, subsequent observed values can be measured and entered.

18 Highlight the Station field and use the Inc softkey to enter the next station number. Highlight the Standard field and use the numeric keypad to enter the value marked on the standard part. Press the Enter key to enter the value and highlight the Observed field.

SLEC		mm	10	P0
Header Memory	Channel	C1		
	Enabled	Off		
S Labels	Station	1		
S Formulas	Standard	1.0000000		
Globals	Observed			
Channels Master	MZ Offset	0.3552400		
SLEC				
Dec	Inc	Remove		

19 Position the probe against the surface of the standard and press the Teach softkey. The appropriate measured value will be displayed in the Observed field. Press the Enter key to enter the value.

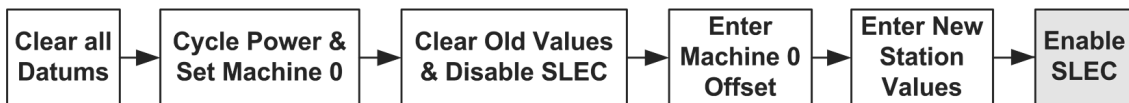
SLEC		mm	10	P0
Header Memory	Channel	C1		
	Enabled	Off		
S Labels	Station	1		
S Formulas	Standard	1.0000000		
Globals	Observed	1.0076		
Channels Master	MZ Offset	0.3552400		
SLEC				
Teach				

20 Repeat steps 18 and 19 to enter Standard and Observed values across the entire encoder range.

21 Repeat this process for each channel until SLEC data is entered for all channels.

Enable SLEC/LEC

When all station data for the encoder has been entered, the SLEC function must be enabled.



Highlight the Enabled field for any channel and use the On softkey to enable SLEC or LEC for that channel.

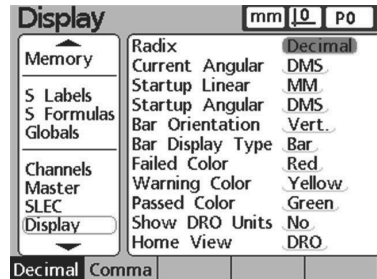
SLEC		mm	10	P0
Header Memory	Channel	C1		
	Enabled	On		
S Labels	Station	1		
S Formulas	Standard	1.0000000		
Globals	Observed	1.0076000		
Channels Master	MZ Offset	0.3552400		
SLEC				
Off	On			

Display screen

The Display screen contains fields for configuring LCD display parameters.

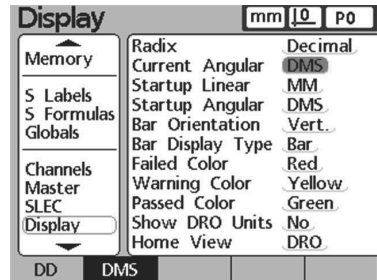
Radix for numeric displays

The Radix field is used to specify the radix displayed in numeric fields. Use the Decimal (1.0) or Comma (1,0) softkey to enter the desired setting.



Display mode for angles

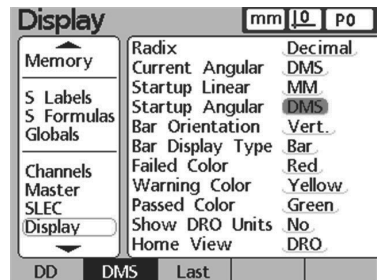
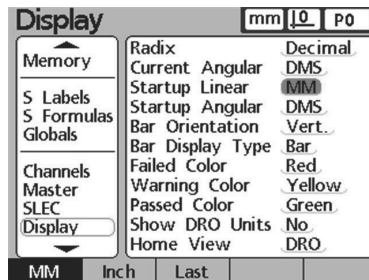
The Current Angular field is used to specify the display mode for angles until system power is cycled. When power is cycled, the start-up angular setting will be used to define the display of angles. Current angular displays of measured angles can be set to decimal degrees or to degrees, minutes and seconds. Use the DD or DMS softkey to enter the desired parameter. Angles can also be toggled between DD and DMS using the Extra menu from the DRO screen.



Startup angular and linear display modes

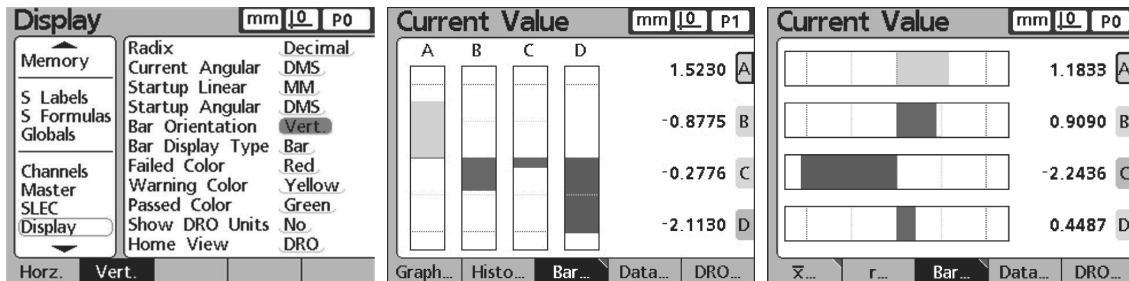
The Startup Angular and Startup Linear fields are used to specify the default display of angular and linear measurements when power is applied to the system. These display settings can be changed temporarily but will revert to the start-up defaults unless the Last setting is selected. The Last setting can be selected to start the system using the last units that were active at shutdown.

Linear measurements can be displayed in English or metric units of measure. Angular measurements can be displayed in degrees, minutes and seconds or in decimal degrees. Enter the desired settings using the MM, Inch or Last softkey.



Bar graph orientation

The Bar Orientation field is used to specify the horizontal or vertical orientated dimension bar graphs.



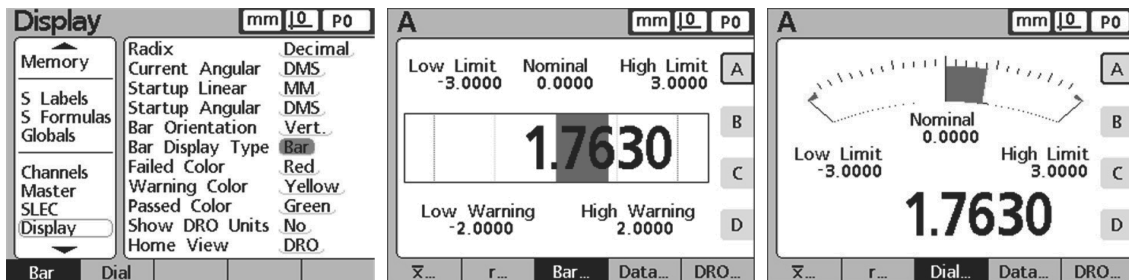
Press the Vert or Horz softkeys...

to show vertical...

or horizontal bars

Bar graph or dial displays

The Bar Display Type field is used to specify a bar graph or dial for dimension current value readings from a single channel.



Press the Bar or Dial softkeys...

to show bar graphs...

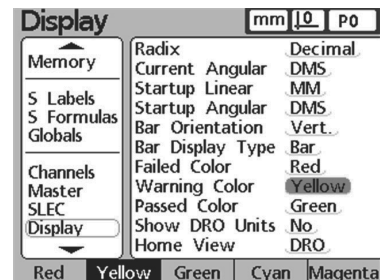
or dials

Colors that indicate measurement results

The Failed, Warning and Passed Color fields are used to specify colors used on DRO current value, graph, data and SPC screens to indicate measurement result status.

Use the softkeys under the LCD screen to specify colors. The default colors are:

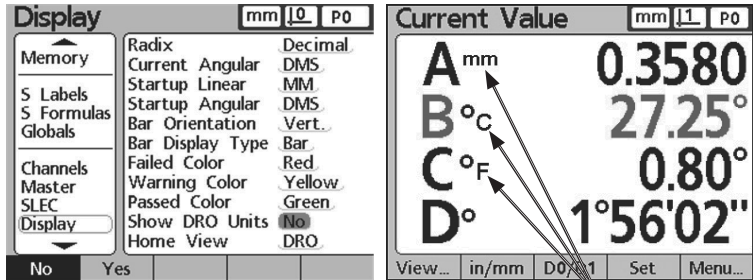
- Red = Tolerance test failed
- Yellow = Tolerance test passed, but is above nominal limits
- Green = Tolerance test passed within nominal limits



Units of measure

Units of measure can be displayed near dimension labels on the DRO screen to increase clarity.

The Show DRO units field is used to enable the display of units of measure. Press the Yes softkey to display units of measure on the DRO.

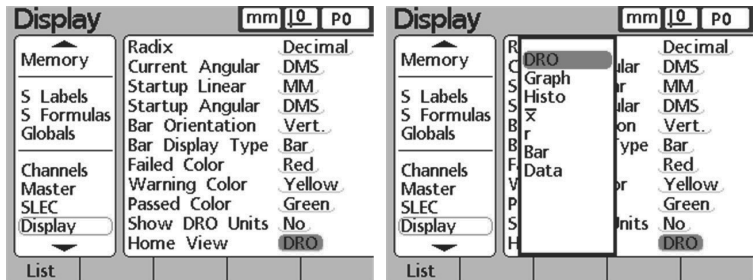


Units of measure

Home screen

The Home View field is used to specify the first screen that will be displayed when power is applied to the P-400 DRO. The Home View will also be displayed when the Finish key is pressed from another view.

To specify the home view screen, press the List softkey, select the desired Home View from the list and then press the Enter key.



Reports screen

The Reports screen contains fields for formatting and specifying the contents of printed reports.

Many fields provide the opportunity to turn report features on or off with selections of Yes or No. Select Yes in these fields to enable the features:

- Time Stamp: Date and time data was collected
- Divider Lines: Row and column lines
- Dimension Labels: Dimension labels at tops of columns
- Dimension Units: Units of measure printed with values
- Page Numbers: Report page numbers

Report		mm	10	P0
S Labels	Record Number	No		
S Formulas	Time Stamp	No		
Globals	Divider Lines	Yes		
Channels	Dimension Labels	Yes		
Master	Dimension Units	Yes		
SLEC	Lines Per Page	60		
Display	Cols Per Page	5		
Report	Recs To Print	Prompt		
Rep Chars	Page Numbers	Yes		
	Orientation	Default		
	Text Size	Default		
No	Yes	Relative		

Other selections should be made to adjust the print format to meet the unique requirements of individual reports.

Rec No.	Time/Date	A	B	C	D
9	8.07.19 AM 1-21-03	0.7090 mm	0.7390 mm	0.7660 mm	0.7840 mm
8	8.07.16 AM 1-21-03	0.7100 mm	0.7390 mm	0.7670 mm	0.7870 mm
7	8.07.14 AM 1-21-03	0.7080 mm	0.7380 mm	0.7650 mm	0.7840 mm
6	8.07.12 AM 1-21-03	0.7090 mm	0.7390 mm	0.7660 mm	0.7840 mm
5	8.07.10 AM 1-21-03	0.7130 mm	0.7420 mm	0.7700 mm	0.7890 mm
4	8.07.08 AM 1-21-03	0.7120 mm	0.7420 mm	0.7700 mm	0.7890 mm
3	8.07.06 AM 1-21-03	0.7090 mm	0.7390 mm	0.7670 mm	0.7860 mm
2	8.07.04 AM 1-21-03	0.7080 mm	0.7380 mm	0.7650 mm	0.7830 mm
1	8.07.00 AM 1-21-03	0.7110 mm	0.7400 mm	0.7680 mm	0.7870 mm

Annotations in the image:

- Time Stamp**: Points to the Time/Date column header.
- Dimension Labels**: Points to the column headers A, B, C, and D.
- Record Number**: Points to the Rec No. column header.
- Divider Lines**: Points to the horizontal lines separating rows.
- Dimension Units**: Points to the 'mm' unit in the data cells.
- Page Numbers**: Points to 'Page 1' at the bottom left.

Record number

Two numbers are displayed in the top-left corner of the data view screen under the time and date. The left number is the record ID and the right number is the value of the dimension selected. In this example, the value of dimension A in record number 242 is 1.3013.

Dimension value within this record

Record ID#

Dimension selected

A	B	C	D	
0.8013	0.9616	0.6218	-0.0193	A
0.8013	0.9616	0.6218	-0.0193	
1.3013	1.4616	1.1218	0.4808	B
1.3013	1.4616	1.1218	0.4808	
1.3013	1.4616	1.1218	0.4808	C
1.3013	1.4616	1.1218	0.4808	
1.3013	1.4616	1.1218	0.4808	D
1.3013	0.9616	1.1218	0.4808	
1.3013	0.9616	1.1218	0.4808	

The record ID shows the relative position of the highlighted record within the total database of records. The most recent record appears at the top of the list, and is assigned the highest record ID number. When the number of records stored in the database equals the maximum records specified in the SPC setup screen, storing a new record replaces the oldest record. The record database is a pushdown stack.

Press the No softkey to omit record ID numbers from reports, press the Yes softkey to include the absolute ID number, or click Relative to include the relative ID number.

Report

Record Number No

Time Stamp No

Divider Lines Yes

Dimension Labels Yes

Dimension Units Yes

Lines Per Page 60

Cols Per Page 5

Recs To Print Prompt

Page Numbers Yes

Orientation Default

Text Size Default

No Yes Relative

Lines per page

Horizontal divider lines and lines of text are considered lines. Enter the desired number of report lines.

Report

Record Number No

Time Stamp No

Divider Lines Yes

Dimension Labels Yes

Dimension Units Yes

Lines Per Page 60

Cols Per Page 5

Recs To Print Prompt

Page Numbers Yes

Orientation Default

Text Size Default

Columns per page

Only vertical columns of text are considered columns. The example report shown earlier contains 6 columns of text. Enter the desired number of report columns.

Report

Record Number No

Time Stamp No

Divider Lines Yes

Dimension Labels Yes

Dimension Units Yes

Lines Per Page 60

Cols Per Page 5

Recs To Print Prompt

Page Numbers Yes

Orientation Default

Text Size Default

Type of records to be printed

The records printed on a report can include a range specified by the user, records not yet printed (New), all records in the database or only the selected records.

Range

The user will be prompted to specify the number of records to print.

New

Only records that have not yet been printed will be printed.

All

All records in the database will be printed.

Selected

The highlighted record will be printed.

Prompt

The user will be prompted to select records to be printed.

Page orientation

Specify the report orientation as portrait or landscape.

Text Size

Specify text size as normal or small.

Report		mm	10	PO
S Labels	Record Number	No		
S Formulas	Time Stamp	No		
Globals	Divider Lines	Yes		
Channels	Dimension Labels	Yes		
Master	Dimension Units	Yes		
SLEC	Lines Per Page	60		
Display	Cols Per Page	5		
Report	Recs To Print	Prompt		
Rep Chars	Page Numbers	Yes		
	Orientation	Default		
	Text Size	Default		
Range	New	All	Selected	Prompt

Report		mm	10	PO
S Labels	Record Number	No		
S Formulas	Time Stamp	No		
Globals	Divider Lines	Yes		
Channels	Dimension Labels	Yes		
Master	Dimension Units	Yes		
SLEC	Lines Per Page	60		
Display	Cols Per Page	5		
Report	Recs To Print	Prompt		
Rep Chars	Page Numbers	Yes		
	Orientation	Default		
	Text Size	Default		
Default	Portrait	Landsc.		

Report		mm	10	PO
S Labels	Record Number	No		
S Formulas	Time Stamp	No		
Globals	Divider Lines	Yes		
Channels	Dimension Labels	Yes		
Master	Dimension Units	Yes		
SLEC	Lines Per Page	60		
Display	Cols Per Page	5		
Report	Recs To Print	Prompt		
Rep Chars	Page Numbers	Yes		
	Orientation	Default		
	Text Size	Default		
Default	Normal	Small		

Report characters screen

Report data can include ASCII codes such as Carriage Return, Line Feed and others to control printer functions and determine print formatting based on the unique requirements of specific printers. Multiple ASCII codes can be included in a single field when separated by spaces.

Enter the required ASCII codes into the formatting fields. Fields are available for inserting ASCII control or character codes:

- Before and after lines of text (Pre line and post line)
- Before and after the form (Pre form and post form)
- After each dimension value (+ Dim)
- After each unit of measure (+ Unt)



NOTE

A complete list of ASCII codes is contained in **Chapter 6: Communication.**

Rep Chars		mm	10	P0
S Formulas	Pre Line			
Globals	Post Line	10	13	
Channels	Pre Form			
Master	Post Form	12		
SLEC	+Dim	32		
Display	+Unt	32		
Report				
Rep Chars				
Send				

Send screen

The Send screen contains fields for specifying the contents of record data files transmitted to computers. The Auto Send record feature can also be enabled in this screen.

Auto Send Rec

Record data can be transmitted automatically as each record is entered into the database. Enter Yes into the Auto Send Rec field to enable, or the No to disable this feature.

Record number

Enter Yes to include the absolute ID number. Enter Relative to include the relative ID number.



NOTE

Refer to the discussion of record numbers for the Report setup screen earlier in this chapter for more details regarding record number choices.

Record date, label and units of measure

Three fields provide the opportunity to include or omit record data with selections of Yes or No. Select Yes in these fields to include data.

- Time Stamp Date and time data was collected
- Dimension Labels Dimension labels at tops of column
- Dimension Units of measure printed with values

Record content

The records transmitted can include a range specified by the user; records not yet transmitted (New), all records in the database or only the selected record.

Range

The user will be prompted to specify the number of records to transmit. The most recently acquired record will be transmitted.

New

Only records that have not yet been transmitted will be sent.

Send		mm	10	P0
S Formulas	Auto Send Rec	No		
Globals	Record Number	No		
	Time Stamp	No		
Channels	Dimension Labels	Yes		
Master	Dimension Units	Yes		
SLEC	Recs To Send	Prompt		
Display	Min Dimen Size	Smallest		
Report				
Rep Chars				
Send				
	No	Yes		

Send		mm	10	P0
S Formulas	Auto Send Rec	No		
Globals	Record Number	No		
	Time Stamp	No		
Channels	Dimension Labels	Yes		
Master	Dimension Units	Yes		
SLEC	Recs To Send	Prompt		
Display	Min Dimen Size	Smallest		
Report				
Rep Chars				
Send				
	No	Yes	Relative	

Send		mm	10	P0
S Formulas	Auto Send Rec	No		
Globals	Record Number	No		
	Time Stamp	No		
Channels	Dimension Labels	Yes		
Master	Dimension Units	Yes		
SLEC	Recs To Send	Prompt		
Display	Min Dimen Size	Smallest		
Report				
Rep Chars				
Send				
	No	Yes		

Send		mm	10	P0
S Formulas	Auto Send Rec	No		
Globals	Record Number	No		
	Time Stamp	No		
Channels	Dimension Labels	Yes		
Master	Dimension Units	Yes		
SLEC	Recs To Send	Prompt		
Display	Min Dimen Size	Smallest		
Report				
Rep Chars				
Send				
	Range	New	All	Selected
				Prompt

All

All records in the database will be transmitted.

Selected

The highlighted record will be transmitted.

Prompt

The user will be prompted to select records to be transmitted. The user choices will include: range, new, all, and selected.

Min Dimen Size

Dimension data can be transmitted over the RS-232 connection with or without formatting placeholders. For example:

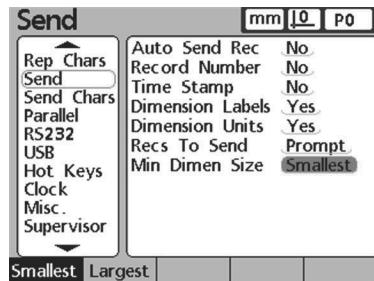
8.217 with placeholders (Largest) sends data spaces for a sign character, 8 digits and a decimal point.

```
| | | | | 8|.2|1|7|
```

8.217 without placeholders (Smallest) sends only the required 5 data spaces.

```
|8|.2|1|7|
```

Enter Largest to send data with placeholders.



Send characters screen

Transmitted data can include ASCII codes such as Carriage Return (ASCII code 10), Line Feed (ASCII code 13) and others to provide formatting based on the requirements of the receiving computer software. Multiple ASCII codes can be included in a single field when separated by spaces.

Enter the required ASCII codes into the formatting fields using the numeric keypad.

Fields are available for inserting ASCII control or character codes:

- Before and after record data (- Snd and + Snd)
- Before and after the header label (- Lbl and + Lbl)
- Before and after each dimension value (- Dim and + Dim)
- Before and after each unit of measure (- Unt and + Unt)



NOTE

A complete list of ASCII codes is contained in [Chapter 6: Communication](#).

Parallel screen

The Parallel screen contains fields for enabling remote control of the P-400 DRO and specifying a parallel port data debounce interval.

Remote control

P-400 DRO measurements can be controlled by a remote computer, PLC or some other device that sends ASCII command codes to the P-400 DRO over the RS-232 serial port.



NOTE

ASCII command codes are provided in [Chapter 6: Communication](#).

Remote control of the P-400 DRO is limited to measurements conducted under the supervision of an operator, and the P-400 DRO will accept commands only while displaying the DRO or View screens. To facilitate this remote control feature, a “receive ready” flag is set on Dout (1), parallel port pin 2 when the DRO or a View screen is displayed. The remote computer or other controlling device can send commands upon detecting the receive ready flag. Commands sent to the P-400 DRO when Dout (1) is logic level 0 will be ignored.

To enable the remote control feature, set the Data mode to I/O and then set Remote to Yes.

I/O Debounce interval

The parallel port is used as a general purpose I/O port. The source of logic levels presented to the parallel port pins can be solid state or hard contact switching devices. When hard contact switching devices are used, switching noise is often generated by contact bounce. The effects of switching noise are eliminated by validating the input logic levels for a short debounce time after the first level change occurs at the port. Enter this debounce time into the I/O Debounce field in milliseconds.

Parallel screen configuration:

- mm: 10, po: 0
- Remote Control: No
- I/O Debounce: 50
- Channels: Master, SLEC, Display, Report, Rep Chars, Send, Send Chars, Parallel, RS232
- Buttons: No, Yes

Parallel screen configuration:

- mm: 10, po: 0
- Remote Control: No
- I/O Debounce: 50
- Channels: Master, SLEC, Display, Report, Rep Chars, Send, Send Chars, Parallel, RS232
- Buttons: No, Yes

RS-232 screen

The RS-232 screen contains fields for specifying the RS-232 serial port settings for communication with a computer or RS-232 channel input device.

UART ID

P-400 DROs that include a second RS-232 serial port for RS-232 input device connections must be configured to communicate with computers on either the primary or secondary port. Typically, computer communication takes place on the primary port, and RS-232 probe networks are attached to the secondary port. However, either port can be designated as the communication port. Use the Dec and Inc softkeys to specify the desired port (UART ID).

RS232		mm	IO	P0
Channels	Uart Id	Primary		
Master	Baud	115200		
Display	Word Len	8		
Hot Keys	Stop Bits	1		
Report	Parity	None		
Rep Chars	Handshake	Hard.		
Send	EOC Delay	0		
Send Chars	EOL Delay	0		
Parallel	Data	Send		
RS232				
Dec	Inc			

Baud rate

The Baud field is used to specify the baud rate of serial data. Use the Dec or Inc softkey to decrease or increase the baud rate from 1200 to 115,200.

RS232		mm	IO	P0
Channels	Uart Id	Primary		
Master	Baud	115200		
Display	Word Len	8		
Hot Keys	Stop Bits	1		
Report	Parity	None		
Rep Chars	Handshake	Hard.		
Send	EOC Delay	0		
Send Chars	EOL Delay	0		
Parallel	Data	Send		
RS232				
Dec	Inc			

Word length

The Word Len field is used to specify the number of bits contained in each data word. Use the 7 or 8 softkey to specify the word length.

RS232		mm	IO	P0
Channels	Uart Id	Primary		
Master	Baud	115200		
Display	Word Len	8		
Hot Keys	Stop Bits	1		
Report	Parity	None		
Rep Chars	Handshake	Hard.		
Send	EOC Delay	0		
Send Chars	EOL Delay	0		
Parallel	Data	Send		
RS232				
7	8			

Stop bits

The Stop Bits field is used to specify the number of stop bits included after each data word. Use the 1 or 2 softkey to specify the number of stop bits.

RS232		mm	IO	P0
Channels	Uart Id	Primary		
Master	Baud	115200		
Display	Word Len	8		
Hot Keys	Stop Bits	1		
Report	Parity	None		
Rep Chars	Handshake	Hard.		
Send	EOC Delay	0		
Send Chars	EOL Delay	0		
Parallel	Data	Send		
RS232				
1	2			

Parity

The Parity field is used to specify odd or even parity for error checking, or to omit parity error checking. Use the None, Odd or Even softkeys to specify parity error checking parameters.

RS232		mm	10	PO
Channels	Uart Id	Primary		
Master	Baud	115200		
Display	Word Len	8		
Hot Keys	Stop Bits	1		
Report	Parity	None		
Rep Chars	Handshake	Hard.		
Send	EOC Delay	0		
Send Chars	EOL Delay	0		
Parallel	Data	Send		
RS232				
		None	Odd	Even

Handshaking

The Handshake field shows the type of synchronous signaling used by the system to prevent data collisions on the serial port. This is set to hardware and cannot be changed.

End of character (EOC) delay

The EOC delay field is used to specify the delay inserted after each character is transmitted. This delay can be increased or decreased to accommodate various serial devices. Use the numeric keypad to specify delays (in milliseconds) from 0 to 10 seconds between characters.

RS232		mm	10	PO
Channels	Uart Id	Primary		
Master	Baud	115200		
Display	Word Len	8		
Hot Keys	Stop Bits	1		
Report	Parity	None		
Rep Chars	Handshake	Hard.		
Send	EOC Delay	0		
Send Chars	EOL Delay	0		
Parallel	Data	Send		
RS232				

Specifying end of line (EOL) delay

The EOL delay field is used to specify the delay inserted after each line is transmitted. This delay can be increased or decreased to accommodate various serial devices. Use the numeric keypad to specify delays (in milliseconds) from 0 to 10 seconds between lines.

RS232		mm	10	PO
Master	Uart Id	Primary		
Display	Baud	115200		
Hot Keys	Word Len	8		
Report	Stop Bits	1		
Rep Chars	Parity	None		
Send	Handshake	Hard.		
Send Chars	EOC Delay	0		
Parallel	EOL Delay	0		
RS232	Data	Send		
SLEC				

Serial port data type

Data can be sent to the serial port as a report formatted in the Report Setup screen, or as record data formatted in the Send Setup screen, or as both.

The serial port can also be disabled for data transmission by selecting the None softkey.

RS232		mm	10	PO
Channels	Uart Id	Primary		
Master	Baud	115200		
Display	Word Len	8		
Hot Keys	Stop Bits	1		
Report	Parity	None		
Rep Chars	Handshake	Hard.		
Send	EOC Delay	0		
Send Chars	EOL Delay	0		
Parallel	Data	Send		
RS232				
		None	Send	Report
			Both	

USB screen

The USB screen contains fields for specifying the RS-232 serial port settings for communication with a computer or RS-232 input channel device.

Data

Data can be sent to the USB port as a report formatted in the Report Setup screen, or as record data formatted in the Send Setup screen, or as both.

The USB port can also be disabled for data transmission by pressing the None softkey.

Destination

Data can be sent through the USB port to be printed on a printer or to be stored as a file on a USB flash drive. Files stored on flash drives are named *DataN.txt* by the P-400 DRO system, where *N* denotes the number of the data file.

File type

The USB port data file type can be specified to replace existing files (of the same name) on the USB flash drive, append to the existing file or create new files that are auto-numbered sequentially in ascending order (Data1.txt, Data2.txt.....DataN.txt).

Current auto (file) number

When the USB data file type is specified as *AutoNo*, the file number of the next file saved to the USB drive can be manually specified by entering the desired number into the *Cur Auto No* data field.

For example, entering a 2 into the *Cur Auto No* field will cause the next data file saved on the USB drive to be named *Data2.txt*. Any file that already exists on the USB flash drive with the same name will be overwritten.

USB screen showing the Report data type selected. The screen displays a menu on the left with options: Master, SLEC, Display, Report, Rep Chars, Send, Send Chars, Parallel, RS232, and USB. The right side shows fields for Data (Report), Destination (HP2), File Type (Replace), and Cur Auto No. (1). The bottom navigation bar includes None, Send, Report, and Both.

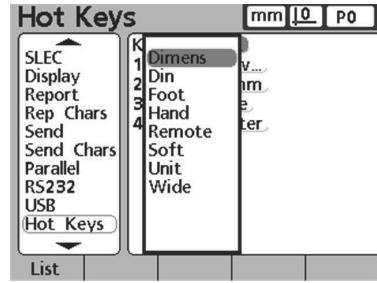
USB screen showing the File data type selected. The screen displays a menu on the left with options: Master, SLEC, Display, Report, Rep Chars, Send, Send Chars, Parallel, RS232, and USB. The right side shows fields for Data (Report), Destination (HP2), File Type (Replace), and Cur Auto No. (1). The bottom navigation bar includes File, HP2, and other options.

USB screen showing the Replace data type selected. The screen displays a menu on the left with options: Master, SLEC, Display, Report, Rep Chars, Send, Send Chars, Parallel, RS232, and USB. The right side shows fields for Data (Report), Destination (HP2), File Type (Replace), and Cur Auto No. (1). The bottom navigation bar includes Replace, Append, and AutoNo.

USB screen showing the AutoNo data type selected. The screen displays a menu on the left with options: Master, SLEC, Display, Report, Rep Chars, Send, Send Chars, Parallel, RS232, and USB. The right side shows fields for Data (Report), Destination (HP2), File Type (Replace), and Cur Auto No. (1). The bottom navigation bar includes other options.

Hot Keys screen

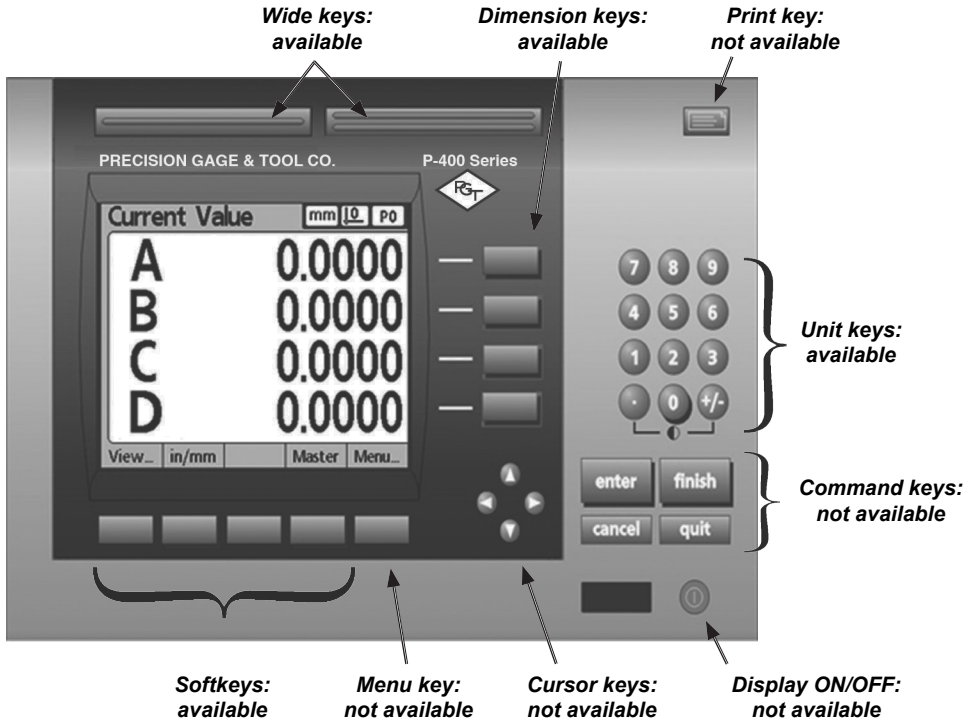
The Hot Keys screen is used to map frequently used P-400 DRO functions, custom P-400 DRO functions or screen views to front panel keys, remote keypad keys, foot switch keys, hand switch keys and parallel port connector pins. Hot keys can save time by eliminating the need to navigate through menus to initiate a function, or by making a function more accessible through a footswitch, handswitch or remote keypad.



Hot key screen showing the menu of hot key types

Front panel keys for hot key mapping

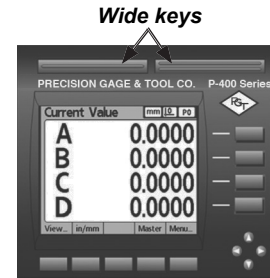
Front panel keys available for Hot Key mapping are shown below and included in menus of Hot Key types.



Front panel keys available for Hot Key mapping

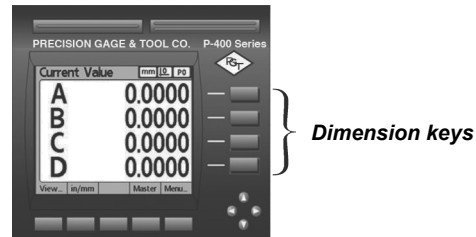
Wide keys

Both wide keys are available for Hot Key mapping. Hot Key functions assigned to wide keys can be invoked at any time.



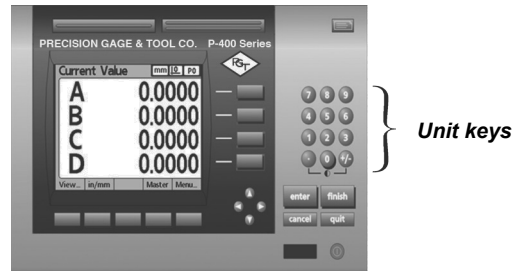
Dimension keys

The 4 dimension keys at the right of the LCD are available for Hot Key mapping.



Unit keys

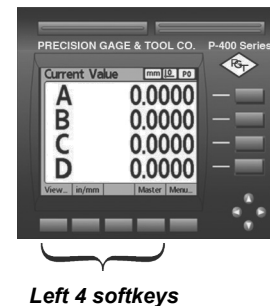
All unit keys except the decimal point and +/- keys are available for Hot Key mapping. Hot Key functions assigned to unit keys can be invoked at any time unless the system expects a numeric entry to complete a task.



Softkeys

The left 4 softkeys are available for Hot Key mapping. The right softkey under the LCD is used to access menus and is unavailable for Hot Key mapping.

Functions assigned to softkeys can be invoked only when the home screen is displayed. At other times, softkey functions are permanently assigned by the system for menu, screen and function selection or dimension selection.



Remote switches and parallel port pins for hot key mapping

The foot switch, hand switch and remote keypad are also available for hot key mapping.

Foot switch

The foot switch is used interchangeably with the hand switch. Both foot switch keys are available for Hot Key mapping. Hot Key functions assigned to foot switch keys can be invoked at any time.



Hand switch

The hand switch is used interchangeably with the foot switch. Both hand switch keys are available for Hot Key mapping. Hot Key functions assigned to hand switch keys can be invoked at any time.



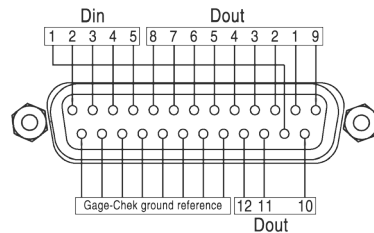
Remote Key Pad

All numeric remote keys are available for Hot Key mapping. Hot Key functions assigned to numeric remote keys can be invoked at any time unless the system expects a numeric entry to complete a task.



Parallel port input pins

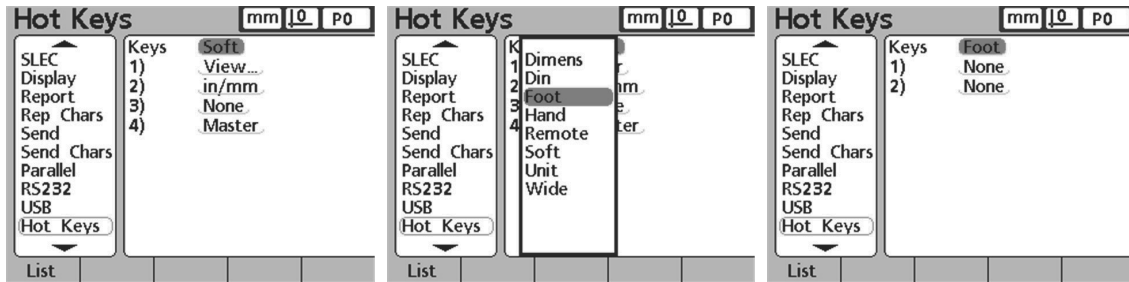
The parallel port is used as a general purpose I/O data port. The 5 input lines (Din 1 through Din 5) of the parallel port are available for hot key mapping.



Assigning Hot Key functions

The method used to assign hot key functions is identical for all hot key types. The procedure is illustrated by the examples shown in the next few pages.

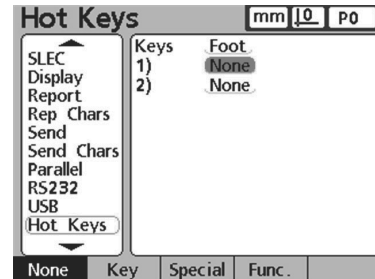
- 1 Press the List softkey. The available hot key types will be displayed. Highlight a hot key type and press the Enter key.



Press the list key, select a hot key type and press the Enter key

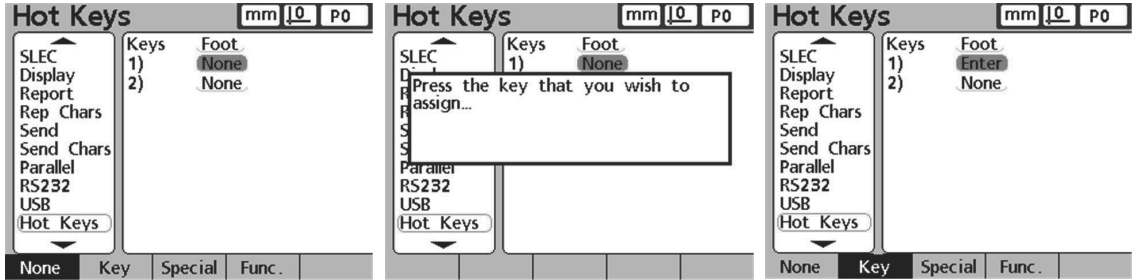
- 2 Select a specific key for hot key function assignment and then select a function category at the bottom of the screen, The function categories include:

- None: No assignment will be made; this will not be a hot key.
- Key: A front panel key function will be assigned by pressing one of the front panel keys.
- Special: A P-400 DRO system function will be assigned from the Special menu.
- Func: A custom P-400 DRO function will be assigned. User-defined functions can be assigned to all hot key types except dimensions (Dimens).



Key

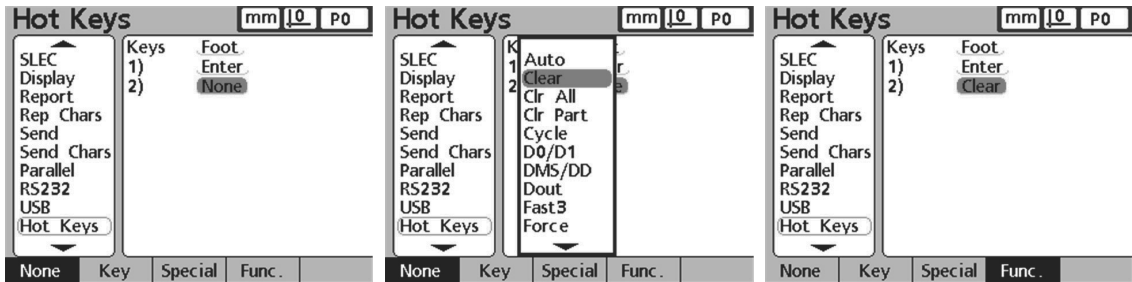
Press the Key softkey, then press the front panel key function that you wish to assign to the hot key. In this example, the Enter key function was assigned to footswitch #1. Now, the Enter key and footswitch #1 can be used interchangeably to enter data at the conclusion of a test, or to make menu selections.



Press the Key softkey and then press a front panel key (such as Enter) to assign the front panel key's function to the hot key

Special

Press the Special softkey. The list of system hot key functions will be displayed. Highlight the system function you wish to assign and then press the Enter key. In this example, the Clear function was assigned to footswitch #2. Now, the Clear function can be initiated by simply pressing foot switch #2.



Press the Key softkey and then press a front panel key (such as Enter) to assign the front panel key's function to the hot key

The Special menu functions are slightly different for:

- Softkeys
- Dimension keys
- Unit, wide, foot keys, hand keys, remote keys and Din pins

The functions available for each category of hot key are described in the next few pages.

As shown by this table, the functions mapped to dimension keys (Dimens) are limited to typical dimen-

Advances to the next part number. Part numbers are cycled in a continuous loop.

D0/D1

Toggles between the display of current values for the absolute datum (datum 0) and the incremental datum (datum 1).

Data

The Data function selects the data table view of stored records.

DMS/DD

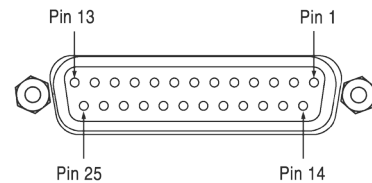
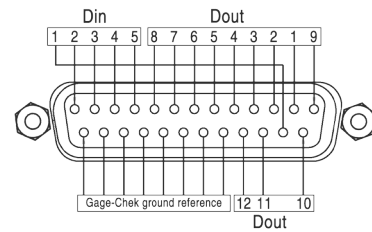
Toggles between the current presentation of degrees/minutes/seconds and decimal degrees for angular measurements.

Dout

Defines the logic state of one of the 12 parallel output pins to:

- Off: Logic 0 (0 volts)
- On: Logic 1 (5 volts)
- Toggle: Changes from one logic level to the other on a specified output pin.

When the Dout function is selected, additional screens are provided for pin and logic level assignment.



NOTE
Logic ground is wired to pins 18 through 25.



DRO

The DRO function selects the DRO view of current values.

The Fast3 function samples the channel 2 input each time the channel 1 input changes a specified sample increment. If the sampled value of channel 2 falls outside a specified range, all base-channel (first 1, 4 or 8 channels) input values will be stored in a dedicated memory array, otherwise samples will not be stored. This sampling process continues until one of the following occurs:

- 1) The user aborts the process by pressing the Quit or the Cancel key
- 2) The user clears memory and restarts the process by pressing the Enter key
- 3) The user successfully completes the process by pressing the Finish key
- 4) The process is automatically completed after 50,000 sets of channel positions have been stored

Refer to [Chapter 5: Operation](#) for more details regarding the Fast3 function.

Force

The Force function cycles through the display of units of force measurement as the hot key is repeatedly pressed. When the Force function is assigned to a softkey, the unit of force measurement will be displayed on the LCD above the softkey. When the Force function is assigned to something other than a softkey, the Show DRO Units function must be enabled in the Display setup screen to display the units of measure on the DRO. Units of force measurement include:

N: Newtons
gf: Grams force
lbf: Pounds force

Graph

The Graph function selects the line graph view of stored records.

Histogram

The Histogram function selects the histogram graph view of stored records for display on the DRO screen

Hold

This toggle function holds (freezes) or releases the current value displayed on the LCD for this dimension.

In/mm

Toggles between the display of dimension values between inches and mm.

Master

Displays the Master screen for calibrating or presetting inputs.

Part No.

The part number, selected by the user during Hot Key setup, becomes the current part when the key is pressed.

Part?

Displays a pop-up screen that allows the user to specify a new part number.

Preset

Presets this dimension's datum.

Pressure

The Pressure function cycles through the display of units of pressure measurement as the hot key is repeatedly pressed. When the Pressure function is assigned to a softkey, the unit of pressure measurement will be displayed on the LCD above the softkey. When the Pressure function is assigned to something other than a softkey, the Show DRO Units function must be enabled in the Display setup screen to display the units of measure on the DRO. Units of pressure measurement include:

ATM: Atmospheres

Bar: Bars

Pa: Pascals

PSI: Pounds per square inch

Rad/Dia

Toggles between radius and diameter measurement types on the DRO screen if radius or diameter was specified in the Formats setup screen earlier. Toggles between radius and diameter on single dimensions when assigned to a dimension key, or on all dimensions when assigned to other keys.

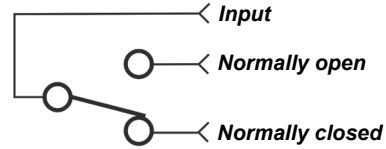
Recall

Recalls and applies this dimension's last used datum preset.

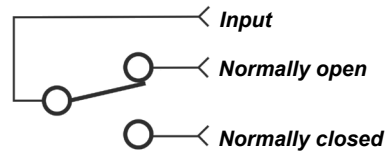
Relay

The output states of Relay 1 and Relay 2 can be assigned to hot keys. The output state of each relay is independent of the other, and can be the de-energized (0), or energized (1) or toggled (0/1). The list of relay operations includes:

- R1 0:
Relay 1 is de-energized (off, 0)
- R1 1:
Relay 1 is energized (on, 1)
- R1 0/1:
Relay 1 is toggled between states (on to off, or off to on)
- R2 0:
Relay 2 is de-energized (off, 0)
- R2 1:
Relay 2 is energized (on, 1)
- R2 0/1:
Relay 2 is toggled between states (on to off, or off to on)



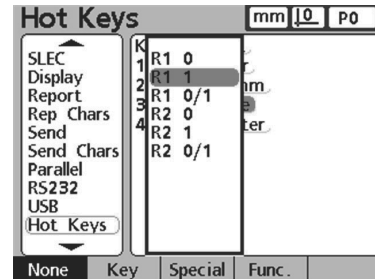
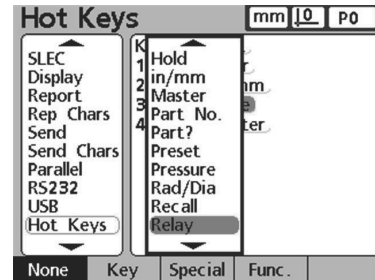
Relay in a de-energized state
Example: R1 0



Relay in a energized state
Example: R1 1

To assign a relay output state to a hot key:

- 1 Select a key for hot key assignment, and then press the Special softkey to display the list of system functions.
- 2 Highlight the Relay function, and then press the Enter key to display the relay state list.
- 3 Highlight the desired relay/relay state, and then press Enter to assign the relay state to the hot key.



CAUTION



Be careful to limit relay contact voltage and current to the maximum ratings shown in **Chapter 8: Reference**. Exceeding the maximum ratings can damage the P-400 DRO relay and void the product warranty.

Resets the minimum or maximum values accumulated during dynamic measurements for this dimension.

r

The *r* function selects the line graph view of ranges of stored records for display on the DRO screen.

Send

Transmits the current value displayed on the LCD for this dimension.

The Send function transmits data to a printer or a computer or both depending on parameters configured in the Parallel or RS-232 setup screens.

Send Rec

The Send Rec function transmits the last (most recent) record, a range of records, or all records.

Master

This function displays a pop-up screen that allows the user to set selected channels to specific values or ranges of values as determined by the Allow Full field of the Calibrate setup screen. Please refer to [Chapter 5: Operation](#) for more details regarding the use of the Master function.

View

Changes to the DRO and SPC data view for all dimensions.

Zero

Zeros the current datum for all dimensions.

xbar

The *xbar* function selects the line graph view of the mean of stored records for display on the DRO screen.

Function

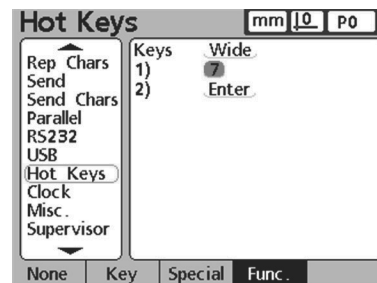
Press the Function softkey to map a hot key to a custom P-400 DRO function, and then enter the function number. The mapped custom function will be executed when the key is pressed. Custom functions cannot be mapped to dimension keys.

NOTE

Custom P-400 DRO functions are described in [Chapter 4: Formulas](#).



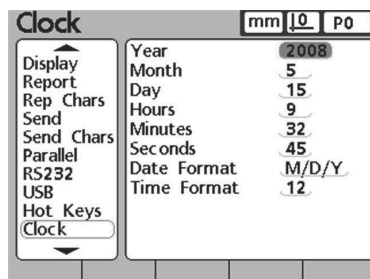
Clock screen



The Clock screen contains fields for setting and formatting displays of date and time shown on the LCD and printed on reports.

Setting the date and time

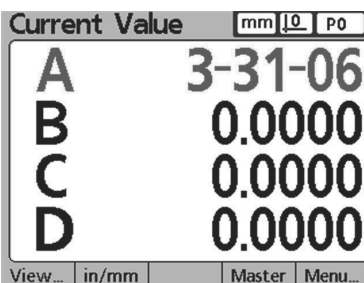
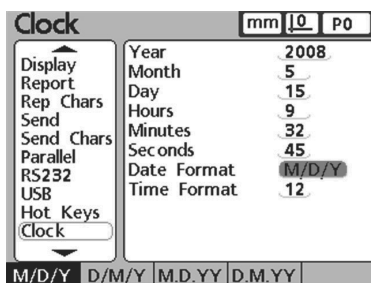
Use the numeric keypad to enter data into the Year, Month and Day fields for date, or Hours, Minutes and Seconds fields for time.



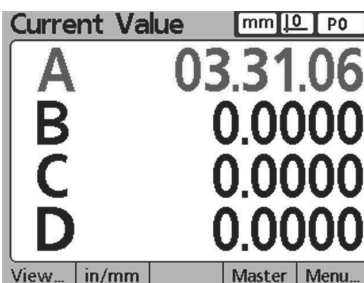
The time must be entered into the Hours field in the 24 hour format, but can be displayed in either the 12 hour or 24 hour format. For example, 7:00 PM must be entered into the Hours field as 19, but can be displayed as 1900 or 7 PM depending on the selection of the 12 or 24 hour display format.

Specifying a date format

Highlight the Date Format field and use softkeys under the LCD to specify the format for displaying the date on the LCD and printed reports.



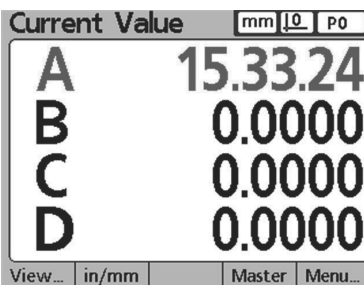
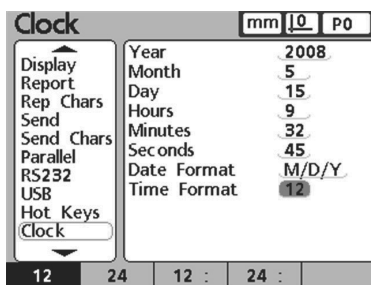
M/D/Y format



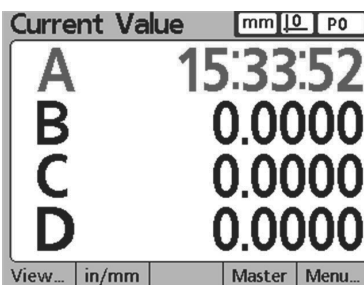
M.D.YY format

Specifying a time format

Highlight the Time format field and use softkeys under the LCD to specify the 24 hour or 12 hour format for displaying time on the LCD and printed reports.



24 format



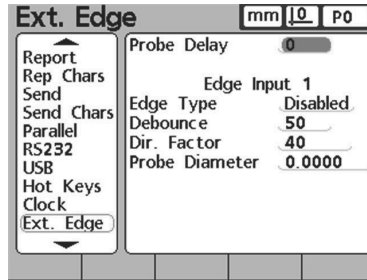
24 : format

External edge screen

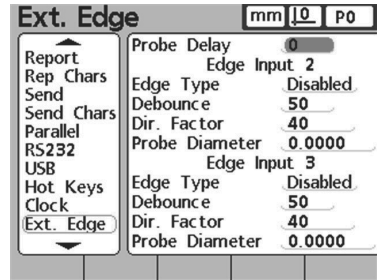
The External edge screen contains fields for specifying the touch probe parameters for optional edge detection functions.

Edge input

The External edge options are provided for one or two touch probes. The setup parameters are identical for all touch probes.



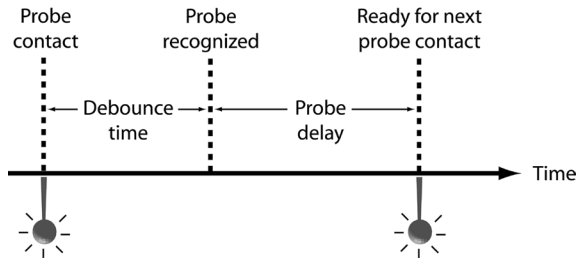
Single touch probe screen



Double touch probe screen

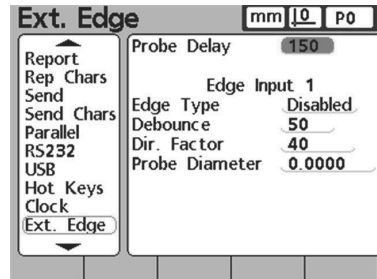
External edge probe timing

Probe and debounce delays can be included to limit probe input rate and provide immunity to noise. The impact of probe delay and debounce values is shown in this diagram.



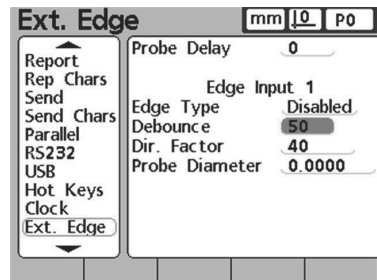
Probe delay

The Probe Delay field is used to limit the probe input rate. Enter the delay between valid probe hits into the Probe Delay field in milliseconds.



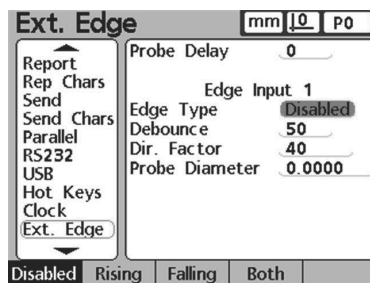
Debounce time

The effects of electrical noise caused by mechanical switch contact bounce can be eliminated by specifying a settling time in milliseconds. Enter the desired time into the Debounce field in milliseconds.



Edge type

The direction of the touch probe signal that will be recognized as a valid probe contact is specified in the Edge Type field. Valid signals can be rising, falling or both (either rising or falling). The external edge probe can also be disabled.



Direction factor

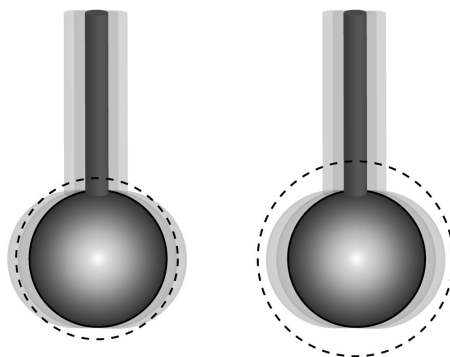
The P-400 DRO continuously monitors the direction of probe motion to insure that probe-tip compensation is applied to the correct side of the probe. When the probe direction changes, a minimum number of counts in the new direction must be accumulated to verify that the direction change is valid.

Probe direction errors occur when probe-tip compensation is applied to the wrong side of the probe tip. The P-400 DRO prevents probe direction errors by monitoring the direction of probe movement and applying compensation to the leading side of the probe tip center. The P-400 DRO then confirms probe direction changes by accumulating a minimum number of counts in the new direction before changing probe tip compensation. This minimum number of counts creates a zone around the tip referred to as the direction factor, and can be changed to accommodate different CNC hardware and application requirements.

Probe direction errors are usually caused by mechanical vibration or incorrect probing technique. The direction factor can be adjusted to minimize or eliminate both types of error.

Probe vibration

Direction errors are generated when the direction factor is smaller than the number of counts generated by mechanical vibration. Set the direction factor to a count value higher than probe vibration to eliminate errors due to typical probe vibration.

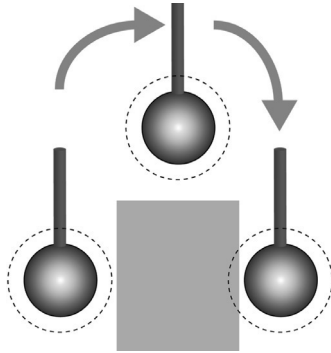


Dir. Factor lower than vibration causes errors

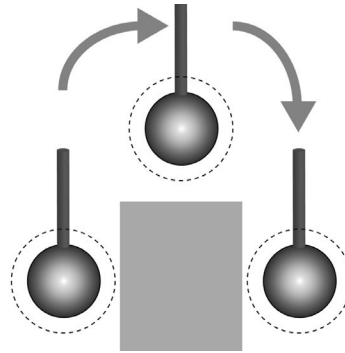
Dir. Factor higher than vibration eliminates errors

Probing technique

Direction errors are generated when probing paths are so close to part surfaces that direction changes cannot be verified. The examples that follow illustrate incorrect and then correct probing paths for the verification of horizontal direction changes.



Incorrect probing technique
 The probe is lowered too close to the part surface, detection of probe direction change is impossible

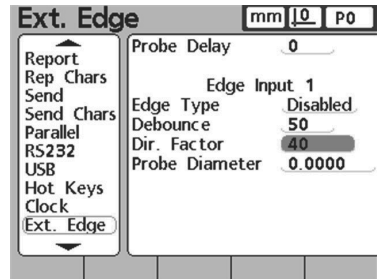


Correct probing technique
 The probe is lowered far enough from the part surface, detection of probe direction change is possible

Enter the minimum number of counts in the new direction into the Dir. Factor field. This number should typically be 40 or greater.

Teaching the P-400 DRO a probe diameter

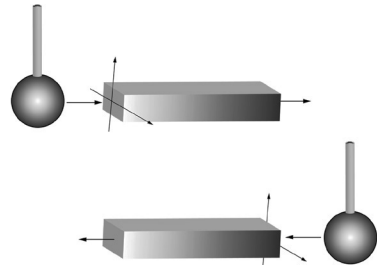
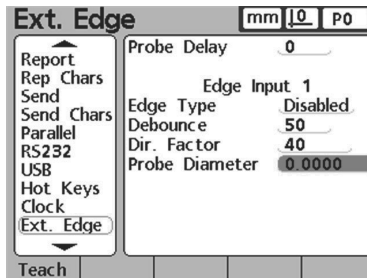
During measurements involving the touch probe, the P-400 DRO subtracts the radius of the touch probe tip to determine true position of the probe. Since probe tip diameters can vary, the P-400 DRO must determine the exact diameter from a test that utilizes a known standard.



To teach the P-400 DRO the probe diameter:

1 Highlight the Probe Diameter field and press the Teach softkey. Instructions will be presented that describe the entire teach process.

2 Follow the instructions being careful to make orthogonal probe contacts with both sides of the standard.



Misc screen

The Misc screen contains fields for specifying keypad, LCD display, audio, SPC performance display, slew rate and screen saver parameters.

Key delay

The Key Delay field is used to adjust the rate at which front panel key presses will be accepted, and characters will be repeated when a front panel key pressed and held down. As the delay value is increased, the rate of key entry and auto-repeat decreases.

Misc.		mm	10	PO
Report	Key Delay	3		
Rep Chars	Volume	10		
Send	Data Entry Msg	1.0		
Send Chars	Switch View	0.000		
Parallel	Cpk/Ppk Display	Ppk Pp		
RS232	Slew Limit	50000		
USB	Start Scr Saver	10		
Hot Keys	Scr Saver Off	20		
Clock	Startup Hold	Yes		
Misc.	Strict Unit Check	Yes		

Speaker volume

The Volume field is used to adjust the loudness of P-400 DRO speaker tones that signal key presses and alerts. Volume settings range from 0 to 10. A volume setting of 0 disables the audio output.

Misc.		mm	10	PO
Report	Key Delay	3		
Rep Chars	Volume	10		
Send	Data Entry Msg	1.0		
Send Chars	Switch View	0.000		
Parallel	Cpk/Ppk Display	Ppk Pp		
RS232	Slew Limit	50000		
USB	Start Scr Saver	10		
Hot Keys	Scr Saver Off	20		
Clock	Startup Hold	Yes		
Misc.	Strict Unit Check	Yes		

Data entry message time

The Data Entry Msg field is used to specify the duration of the display of the data entry confirmation message “Data has been added to the database” each time a value is entered. For example, when this value is 2, the message will be displayed for approximately 2 seconds. Durations range from 0 to 9999. When the value is 0, no message is displayed. When the value is very large, the message will be displayed until the user presses the Quit key, or the duration is allowed to complete.

Misc.		mm	10	PO
Report	Key Delay	3		
Rep Chars	Volume	10		
Send	Data Entry Msg	1.0		
Send Chars	Switch View	0.000		
Parallel	Cpk/Ppk Display	Ppk Pp		
RS232	Slew Limit	50000		
USB	Start Scr Saver	10		
Hot Keys	Scr Saver Off	20		
Clock	Startup Hold	Yes		
Misc.	Strict Unit Check	Yes		

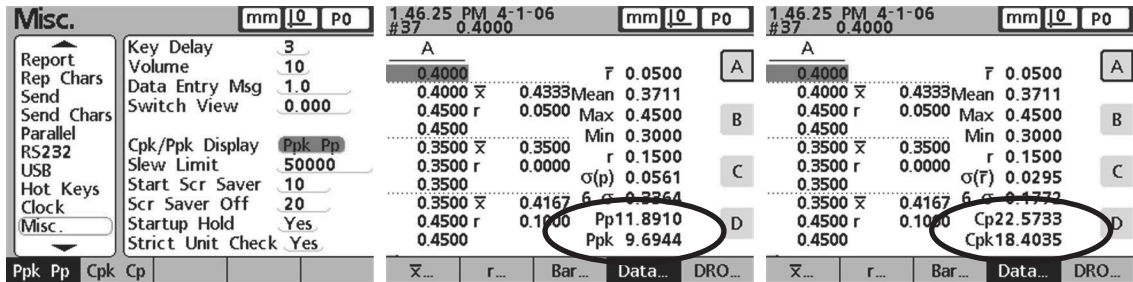
Switch view

Normally, the user presses softkeys to select the screens displayed on the LCD. However, the P-400 DRO can be programmed to automatically change the DRO, bar or dial views to display a dimension in response to activity on the channel included in its formula. The Switch View field is used to specify the range of motion required on any channel input to switch DRO, bar or dial views to the associated dimension. When the Switch View field is zero, no switching occurs.

Misc.		mm	10	PO
Report	Key Delay	3		
Rep Chars	Volume	10		
Send	Data Entry Msg	1.0		
Send Chars	Switch View	0.000		
Parallel	Cpk/Ppk Display	Ppk Pp		
RS232	Slew Limit	50000		
USB	Start Scr Saver	10		
Hot Keys	Scr Saver Off	20		
Clock	Startup Hold	Yes		
Misc.	Strict Unit Check	Yes		

Cpk/Ppk display

Select Cpk or Ppk performance values for display in the Data view screen for a single dimension.



Press Ppk Pp or Cpk Cp...

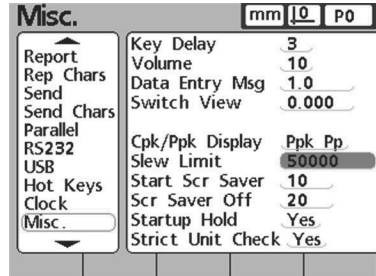
to display Ppk Pp...

or Cpk Cp

Slew limit

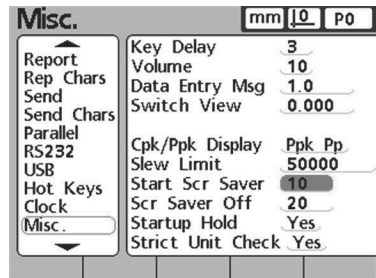
High input slew rates resulting from rapid input encoder motion can result in erroneous measurements. Erroneous measurements are avoided by displaying encoder error warnings when encoder values change at very high rates.

Enter the slew rate limit into the Slew Limit field in counts (increments of resolution) per second. For example, at a channel resolution of 0.001 mm, a slew rate limit of 50,000 will result in warning messages at encoder motion rates higher than 50 mm per second.



Start Scr saver

The Start Scr Saver field is used to specify the minutes of P-400 DRO inactivity before the LCD screen saver is displayed. The screensaver is disabled when 9999 is entered into this field.



Scr saver off

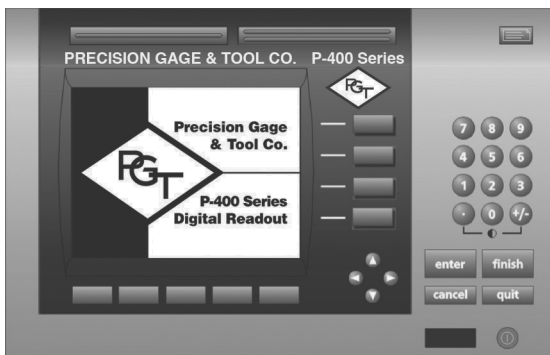
The Screen Saver Off field is used to specify the range of motion in counts (increments of resolution) required on any channel to turn the screensaver off. For example, when Scr Saver off = 20, and the channel resolution is 0.001 mm, a movement of 0.020 mm will turn the screen saver off. When the Screen Saver Off field is zero, only pressing a front panel key will turn the screensaver off.

Misc.		mm	10	PO
Report	Key Delay	3		
Rep Chars	Volume	10		
Send	Data Entry Msg	1.0		
Send Chars	Switch View	0.000		
Parallel	Cpk/Ppk Display	Ppk Pp		
RS232	Slew Limit	50000		
USB	Start Scr Saver	10		
Hot Keys	Scr Saver Off	20		
Clock	Startup Hold	Yes		
Misc.	Strict Unit Check	Yes		

Startup hold

The PG&T screen is displayed upon startup. Enter No into the Startup hold field to display the startup screen for a few seconds and then automatically display the DRO. Enter Yes to display the startup screen until the user presses the Enter key.

Misc.		mm	10	PO
Report	Key Delay	3		
Rep Chars	Volume	10		
Send	Data Entry Msg	1.0		
Send Chars	Switch View	0.000		
Parallel	Cpk/Ppk Display	Ppk Pp		
RS232	Slew Limit	50000		
USB	Start Scr Saver	10		
Hot Keys	Scr Saver Off	20		
Clock	Startup Hold	Yes		
Misc.	Strict Unit Check	Yes		
		No	Yes	



Quadra-Chek startup screen

Strict Unit Check

Enter Yes into the Strict Unit Check field to prevent calculations with mixed units of measure. For example:

When Yes, the calculation:

15 mm + 2.0 inches will not be allowed because of mixed units

When No, the calculation:

15 mm + 2.0 inches = 17.0 only numeric coefficients are used

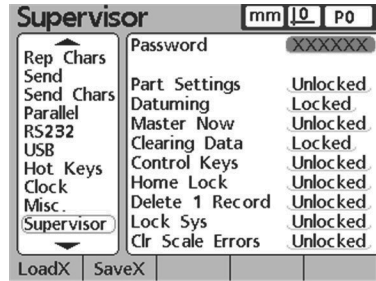
Misc.		mm	10	PO
Report	Key Delay	3		
Rep Chars	Volume	10		
Send	Data Entry Msg	1.0		
Send Chars	Switch View	0.000		
Parallel	Cpk/Ppk Display	Ppk Pp		
RS232	Slew Limit	50000		
USB	Start Scr Saver	10		
Hot Keys	Scr Saver Off	20		
Clock	Startup Hold	Yes		
Misc.	Strict Unit Check	Yes		
		No	Yes	

Supervisor screen

The supervisor screen provides fields for entering the system password required to edit setup parameters and fields for locking or unlocking critical functions.

Password

Enter the Supervisor Password into the Password field to edit setup parameters or unlock critical functions shown in this screen..



Unlocking and locking critical functions

Once the supervisor password is entered, most functions shown on this screen are locked or unlocked by highlighting the function and pressing the unlocked or lock softkey presented at the bottom of the LCD. Locking a function makes it unavailable for use. For example, when datuming is locked datums cannot be set, preset or cleared by the operator. The critical functions include:

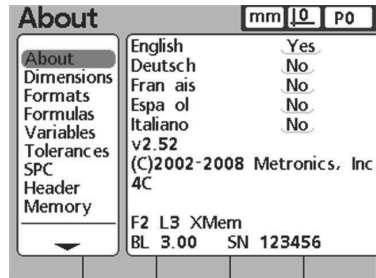
Part settings

Part settings are found in the area above the first horizontal dividing line on the left side of the Setup menu screens.

Datuming

Datuming functions include setting, presetting and clearing absolute and incremental datums.

Part settings



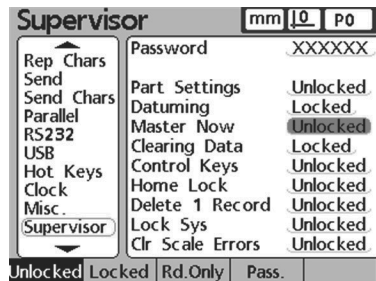
Master now

Unlock or lock the Master function using the Unlock or Lock softkey. Refer to [Chapter 5: Operation](#) for details regarding the Master function.

Press the Rd. Only softkey to allow the display of mastered values while prohibiting changes. Press the Pass softkey to restrict the Mastering function to those who enter the required supervisor password.

Clearing data

Measurement data can be removed from the Gage-Chek database by the operator when this function is unlocked. Refer to [Chapter 5: Operation](#) for details regarding clearing datums.



Control keys

In normal operation, the user conducts measurements using the measurement control keys. However, when the P-400 DRO is operated from a remote computer or PLC, it is often desirable to lock the control keys to eliminate the possibility that a user key operation will interfere with remotely controlled measurements.

Home lock

Normally the user can designate the home view in the Display setup screen described earlier in this chapter. However, the home view can be locked by the supervisor to prevent changes.

Delete 1 Record

Single database records can normally be deleted from the View screen by the operator. Enter Lock into the Delete 1 Record field to prevent single record deletions.

Single database record

2 26.59 PM 4-2-06				
#38 0.0080				
mm | 0 | P0				
A	B	C	D	
0.0080	0.0140	0.0180	0.0020	A
-0.0020	0.0040	0.0070	-0.0080	
0.0030	0.0060	0.0120	-0.0060	B
0.0010	0.0040	0.0100	-0.0080	
				C
				D

Graph... Histo... Bar... Data... DRO...

Lock Sys

Enter Lock into the Lock Sys field to prevent changes to Global variables and system formulas that are used in formulas across a number of parts.

Clr Scale Errors

Channel input malfunctions cause scale error messages that can be disabled by the user. Under some circumstances it can be undesirable to allow the user to disable these messages and continue operation. Enter Lock into the Clr Scale Errors field to restrict disabling error messages to those with a valid supervisor password.

Supervisor		
mm | 0 | P0		
Rep Chars	Password	XXXXXX
Send	Part Settings	Unlocked
Send Chars	Datuming	Locked
Parallel	Master Now	Unlocked
RS232	Clearing Data	Locked
USB	Control Keys	Unlocked
Hot Keys	Home Lock	Unlocked
Clock	Delete 1 Record	Unlocked
Misc.	Lock Sys	Unlocked
Supervisor	Clr Scale Errors	Unlocked
	Unlocked	Locked

Chapter 4:

Formulas

Formulas define dimensions that are displayed on the LCD screen. Formulas can be created that simply make a dimension equal in value to a channel input, or that calculate a dimension from one or more channels using powerful math, logic or other functions.

In this chapter, you'll learn the basics of creating formulas for the P-400 DRO. You'll learn to create formulas that use math, logic and data evaluation functions to calculate dimensions, and to use advanced functions that control or automate measurements.

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Introduction to formulas

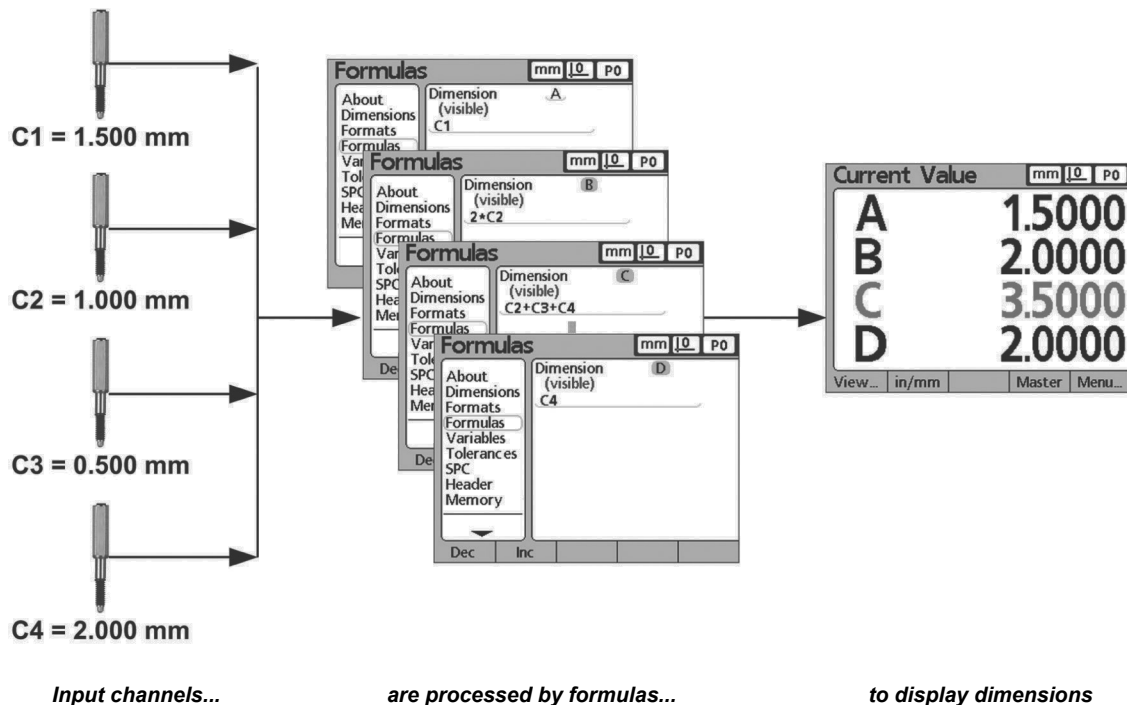
Formulas use channel inputs and formula functions to define visible dimensions, hidden dimensions and custom P-400 DRO functions. Formulas contain a dimension label at the top of a formula page, and arrange the defining channel functions, constants, and math, logic or control functions underneath.

The syntax of P-400 DRO formulas is typical of algebraic equations generally, and is similar to the syntax used to define cell values in spread-sheet applications such as Microsoft Excel.

The examples below show simple formulas that define visible dimensions A, B, C and D using channel inputs C1, C2, C3 and C4.

- A = C1 Dimension A is equal to the value of input channel 1
- B = 2 * C2 Dimension B is equal to 2 times the value of input channel 2
- C = C2 + C3 + C4 Dimension C is equal to the sum of the values of input channels 2, 3 and 4
- D = C4 Dimension D is equal to the value of input channel 4

The channel inputs, Formula screens and resulting DRO screen for these examples are shown below.



How do formulas relate input channels to dimensions?

Formulas can be constructed that simply make dimensions equal to channel inputs, or that calculate dimensions from one or more channels using math, logic or other functions. Formulas can be constructed by the user to display:

One dimension based on one channel input

For example: $A = C1$

One dimension based on multiple channel inputs

For example: $A = C1 + C2$

Multiple dimensions based on one channel input

For example: $A = C1$

$B = 2 * \pi * C1$

Multiple dimensions based on multiple channel inputs

For example: $A = C1$

$B = C2$

$C = C1 * C2$

Visible or hidden dimensions?

Dimensions can be visible to display values or hidden to perform operations.

Visible dimensions

Visible dimensions are used with basic and advanced functions to calculate, display and store values in the P-400 DRO database. For example, the formula: $A = 2 * \pi * \sqrt{B}$ uses visible dimension B in a formula with other functions to calculate and assign a value to visible dimension A, which is stored later in the P-400 DRO database by pressing the Enter key or executing a Trip function.

Hidden dimensions

Hidden dimensions are used with basic and advanced functions to perform operations. For example, the formula: $H1 = \text{if}(\text{fail}, \text{Relay}(1,1), \text{Relay}(1,0))$ uses the pass/fail state of all tolerance tests to control the state of output relay 1. Since values are not assigned to operations, no value will be stored in the P-400 DRO database.

When are dimensions stored in the P-400 DRO database?

Visible dimension values are displayed on the screen and are stored as records in the P-400 DRO database when the Enter key is pressed, or when a Trip function is executed. Hidden dimensions are used to perform operations, make decisions or manipulate variables, and are not displayed on the screen or stored in the database.

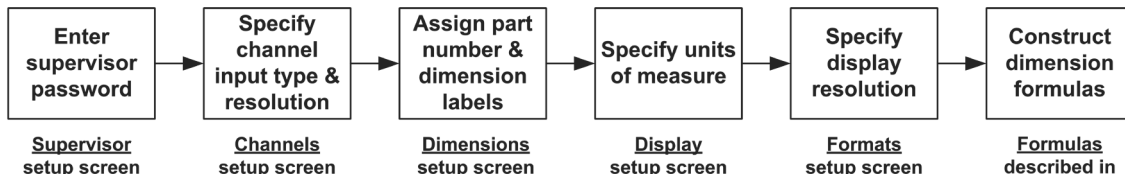
What can formulas do?

Formulas can be constructed to produce a wide variety of results depending on channel input values, tolerance tests, parallel port conditions, time, temperature and other test and environmental conditions. Formulas can:

- Assign values to dimensions derived from channel inputs or other dimensions
- Perform operations such as closing a relay contact, sending data to the parallel port, sending a message on the serial port or printing a report
- Perform conditional tests of measurement results, tolerance test results, parallel port data, or environmental conditions and make decisions based on the results
- Control the sequence of steps in a measurement process
- Semi-automate a measurement process
- Display messages and prompts for keyboard input
- Define custom P-400 DRO functions

When are formulas constructed or edited?

Formulas are constructed as the last step of the essential or minimum setup required to begin conducting measurements the first time the P-400 DRO is used. The first steps of the initial setup are performed using the setup screens described in [Chapter 3: Setup](#) and are diagrammed below:



Formulas are constructed as the last step of initial P-400 DRO setup

Once the P-400 DRO initial setup is complete and measurements begin, new formulas can be added and existing formulas can be edited or deleted as application requirements change.

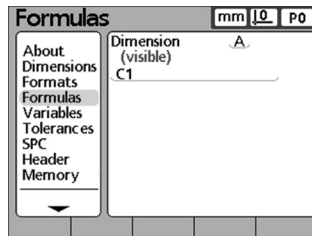
The remainder of this chapter describes formula construction and editing techniques and the use of formula functions. Examples are included that illustrate each new concept.

How can formulas be recorded for safekeeping?

Formulas and all other P-400 DRO settings can be stored on a USB drive as an .xml file from the Supervisor setup screen. Settings can also be stored on a USB drive as a text file by pressing the Print button when any setup screen is displayed. Please refer to the description of the Supervisor setup screen in [Chapter 3: Setup](#) for details.

Constructing and editing formulas

Formulas are constructed in the Formula Setup screen. Navigate to the Formula Setup screen from the home screen by pressing the Menu softkey, the Setup softkey, then repeatedly pressing the down cursor key until Formula is highlighted in the left portion of the screen.

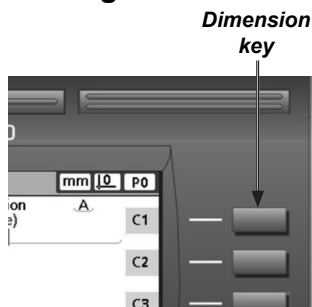


Formula setup screen

A default screen is shown above prior to the construction of any formulas. Initially dimensions are visible, are labeled alphanumerically and are defined to display the channels in your system.

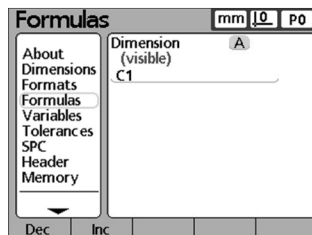
Disabling formulas temporarily for editing or troubleshooting

Normally, formulas are enabled and being evaluated by the system. However, formulas can be disabled temporarily for editing or troubleshooting by pressing the top dimension key at the right of the startup screen when power is applied to your system. Later, formulas will be re-enabled again upon exiting setup.



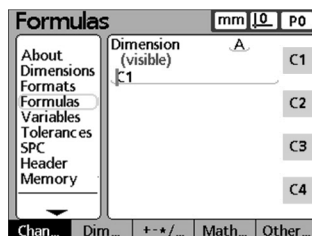
Selecting a dimension

Navigate to the Formula Setup screen, and highlight the first dimension. Dimensions can be decremented or incremented by pressing the Dec or Inc softkey.



Entering dimension formula functions

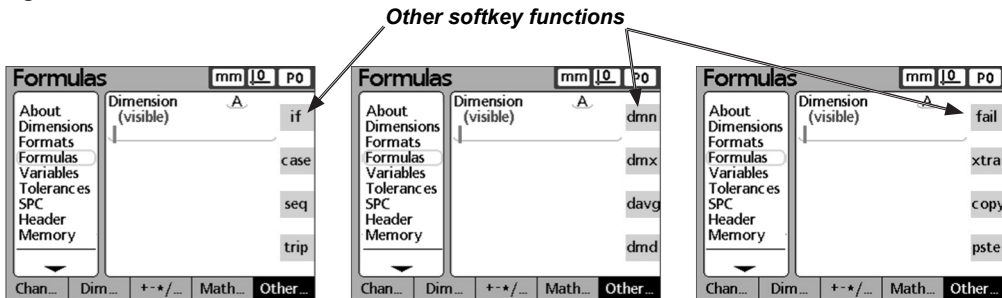
Press the down cursor arrow key to position the cursor on the formula line. A red cursor will appear at the extreme left of the formula line. This cursor indicates the insertion point for any new formula function. Move the cursor to the desired insertion point by pressing Cursor arrow keys.



Inserting formula functions

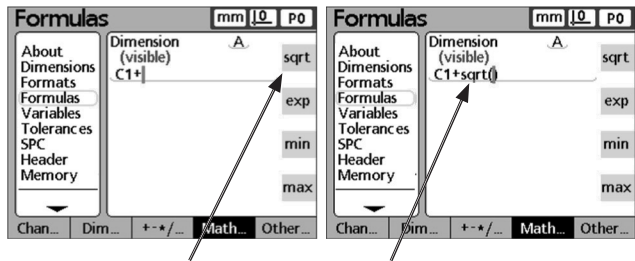
Softkeys under the screen control the display of channel and other functions required to construct formulas. Once displayed, formula functions are selected using the dimension keys at the right of the screen.

Repeatedly pressing any bottom softkey displays multiple sets of related functions for that softkey. For example, repeatedly pressing the Other softkey displays three sets of related functions near dimension keys at the right of the screen.



Pressing the Other softkey repeatedly displays all of its available functions

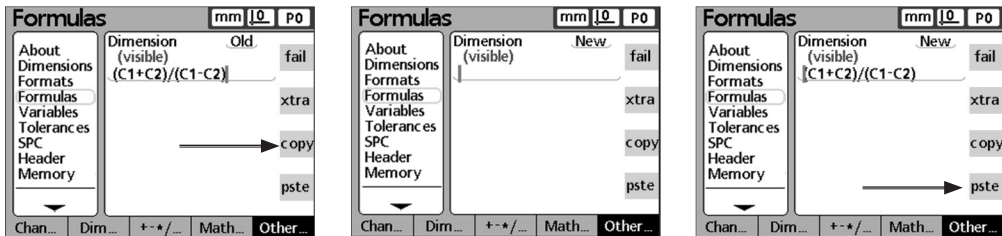
Pressing a dimension key at the right of a formula screen inserts the formula function associated with the key into a formula at the insertion point indicated by the vertical red cursor bar.



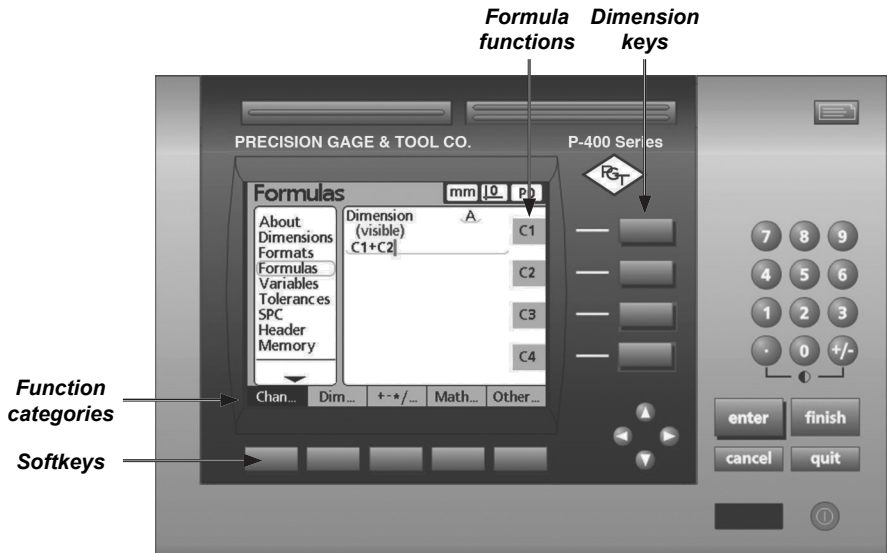
Pressing the sqrt dimension key inserts the sqrt function

Copying and Pasting formula functions

Formulas can be copied from one dimension and pasted into another. Copy a formula by positioning the cursor in the formula line, pressing the Other softkey and pressing the Copy dimension key. Paste the formula into another dimension formula screen by positioning the cursor in the formula line, pressing the Other softkey and pressing the Pste dimension key.



A formula is copied from the Old dimension and copied into the New dimension



Softkeys and dimension keys provide access to formula functions

Chan...	Dim...	+ - * /	Math	Other
C1	A	+	sqrt	if
C2	B	-	exp	case
C3	C	*	min	seq
C4	D	/	max	trip
		(	sin	dmin
Gage-Checks can be ordered with 1, 4, 8 or 16 inputs	The number of dimensions is specified for each part in the dimensions setup screen	)	asin	dmax
		,	cos	davg
		;	acos	dmd
		>	tan	fail
		>= (≥)	atan	xtra
		<	avg	copy
		<= (≤)	md	pste
		= (=)	abs	
		!= (≠)	mod	
		&& (AND)	int	
		|| (OR)	pi	
		-- (RANGE)		

*Xlatch is available in systems that include the external edge-detection option

- = Basic function
- = Advanced function
- = Editing function

xtra menu		
Ask	Global	Report
Beep	HwDmn	RsetDyn
ClrAlID	HwDmx	Scan
ClrData	HwLx	Send
ClrTrig	Lookup	SendMsg
DateStr	Loop	SendRec
Din	Master	SetColor
DinBin	MaxIndex	SetTrig
Display	MinIndex	Setup
Dout	OnEvent	Time
DoutBin	PartNo	TimeStr
FnCall	Preset	Var
FnDefine	Recall	Xlatch*
FnParam	Relay	
FnReturn	Remark	

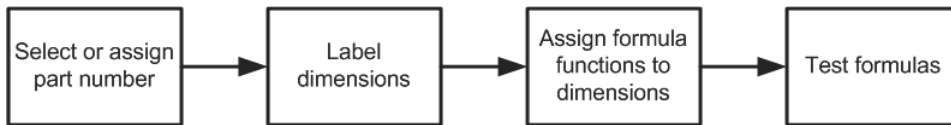
Basic, advanced and editing formula functions

Formula construction example

The exact steps required to construct or edit formulas are unique to each formula, and more generally to the measurements required for each part. Therefore, it would be impossible to present a single set of instructions that adequately cover the topic. Instead, what follows is a generic guide to formula editing and construction in the form of an example. More specific instructions and examples regarding the use of formula constants, channel, dimension and other functions are provided later in this chapter.

The four steps required to construct a formula are:

- 1 Select or assign a part number
- 2 Label the part's dimensions
- 3 Assign formula functions to each dimension
- 4 Test the formulas prior to actual use



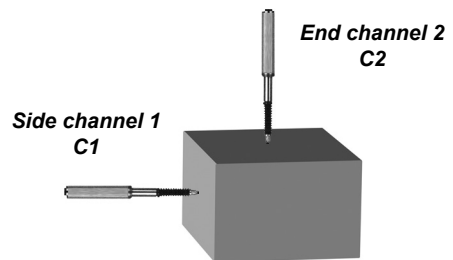
The following example will use the default Formula setup screen to construct a formula that calculates the perimeter of a rectangular block from the measurement of two sides.

The general form of the formula necessary to calculate the perimeter of a rectangular block is:

$$\text{Perimeter} = 2 (\text{side} + \text{end})$$

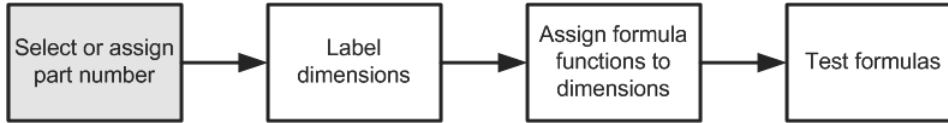
The specific formula that will be constructed in the Formula Setup screen is:

$$P = 2 * (C1+C2)$$

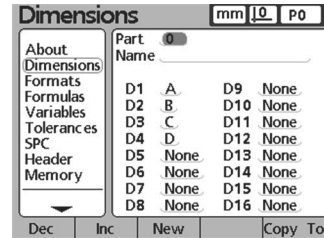


Select or assign a part number

Since separate dimension formulas can be created for each of up to 100 parts, begin by selecting the correct part.



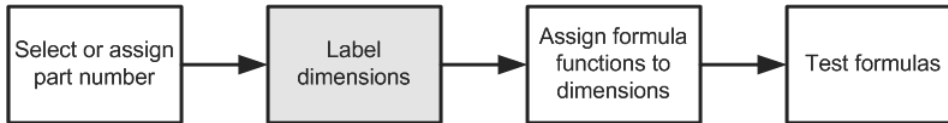
Navigate to the Dimensions Setup screen from the home screen by pressing the Menu softkey, the Setup softkey, then the down Cursor key. Press the right Cursor key to highlight the Part field.



Press the Dec or Inc softkey, or the left or right wide key to display the desired part number in the Part field.

Label the part's dimensions

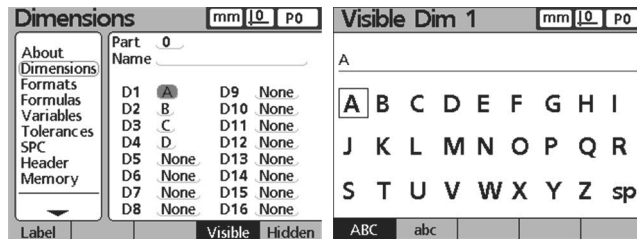
Each dimension label should reflect the purpose of its formula.



Relabel each dimension. Dimension labels can include up to 3 characters. Also give the part a name if desired. Part names can contain up to 8 alphanumeric characters. In this example dimensions are labeled:

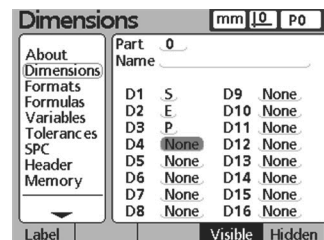
S = side, E = end and P = Perimeter.

While in the Dimensions Setup screen, press the down Cursor key to highlight the first dimension field. Press the Label softkey to display the Alpha Entry screen.



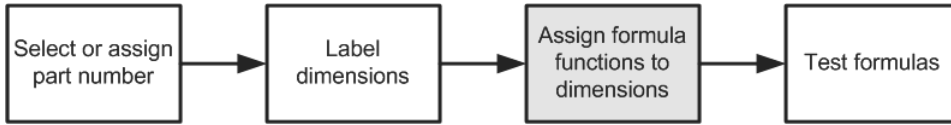
Replace each default dimension label by pressing the Cancel key to erase the label, entering the desired alpha character(s) for the dimension's new label, and then pressing the Finish key to return to the Dimensions screen.

Since only three dimensions are used in this example, the fourth dimension is deleted.

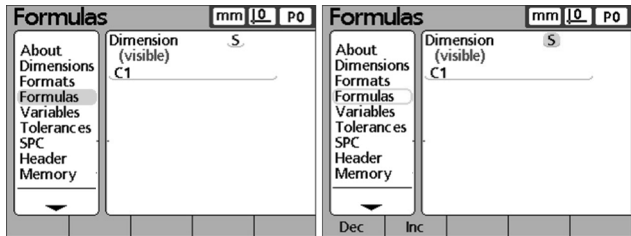


Assign formula functions to each dimension

Now that the correct part is selected, and the dimensions are labeled to reflect the measurement application, the dimension formulas must be constructed.

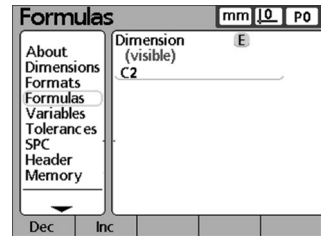


Navigate to the Formulas Setup screen and then press the right Cursor key to highlight the Dimension field. The default formula for dimension S (C1) will be displayed.

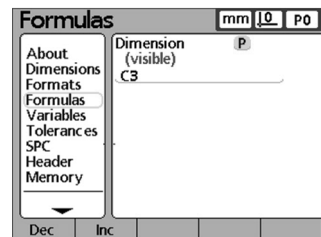


This formula already meets the requirement of our measurement application by displaying the side measurement as dimension S, so it will remain unchanged.

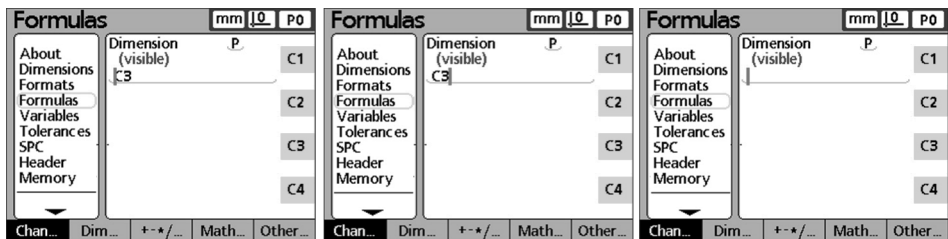
Display the formula for dimension E by pressing the Inc softkey. This formula also meets the application requirement by defining dimension E as the value of channel 2 (C2), so it will also remain unchanged.



Display the formula for dimension P by pressing the Inc softkey. This formula will be changed to calculate the perimeter measurement.



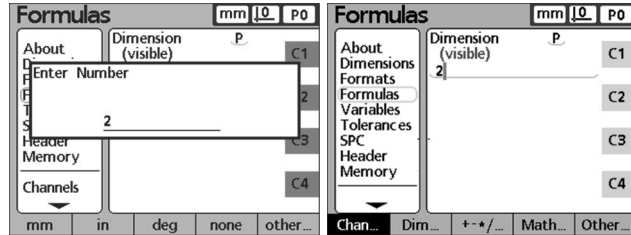
Press the down Cursor key to position the cursor in the third formula line. Press the right Cursor key to position the cursor on the right side of the C3 channel function. Press the Cancel key to delete the C3 channel function.



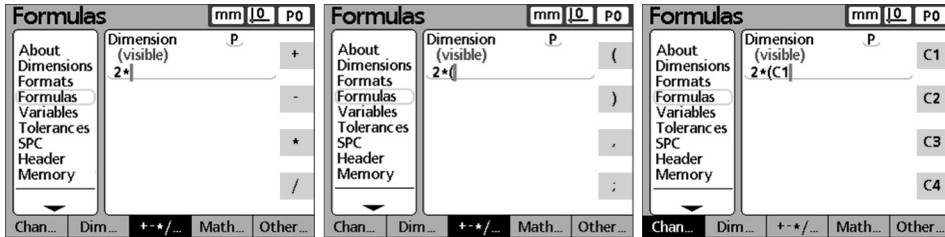
Now that the formula line for P is empty, the following new formula will be entered.

$$2 * (C1 + C2)$$

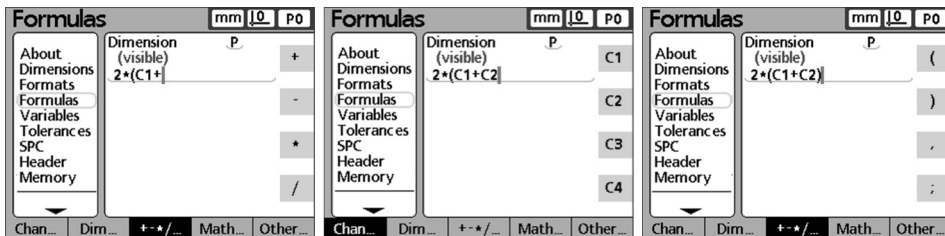
Press the numeric keypad 2 key, and then press the None softkey to make 2 a dimensionless constant.



Press the +-*/ softkey and insert the * multiplication symbol. Press the +-*/ softkey again to display parentheses, and then press the (softkey to insert the open parenthesis into the formula. Press the Chan softkey to display channel functions, and press the C1 softkey to insert the Channel 1 function.



Press the +-*/ softkey to display arithmetic functions, and press the + softkey to insert the plus sign. Press the Chan softkey to display channel functions, and press the C2 softkey to insert the Channel 2 function. Press the +-*/ softkey again to display parentheses, and press the) softkey to insert the closed parenthesis.

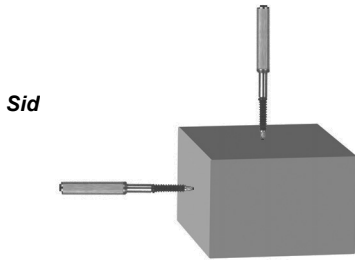


The formulas are now ready to test. Press the Finish key twice to display the DRO screen.

Test the formulas prior to use

Always test formulas thoroughly to confirm their correct operation before using them for inspection.

In this example, the P-400 DRO encoders are positioned against the side and end of a rectangular block. The DRO screen displays a side dimension of 1.759 mm and an end dimension of 1.255 mm. The resulting perimeter is calculated to be 6.028 mm, which is correct and confirms that the formulas are ready to use.



End 2

$$P = 2 * (C1 + C2)$$

$$6.028 = 2 * (1.759 + 1.255)$$

Formulas are OK

Current Value		mm	U	P0
S E P		1.7590		
		1.2550		
		6.0280		

Long formulas

Complex formulas can be entered that require more than a single formula line. When formulas exceed a single line, the formula is continued on subsequent lines. It is rare that a single formula cannot be displayed on a single screen. However, if a formula cannot be displayed on a single screen, the formula can be scrolled using the arrow cursor keys.

Formulas		mm	U	P0
About	Dimension		Big	C1
Dimensions	{visible}			
Formats	case((C1+C2)>=(C3-C1			C2
Formulas	),avl(C1,C2),(C1+C2)<			
Variables	(C3-C1),md(C1,C2))			
Tolerances				C3
SPC				C4
Header				
Memory				

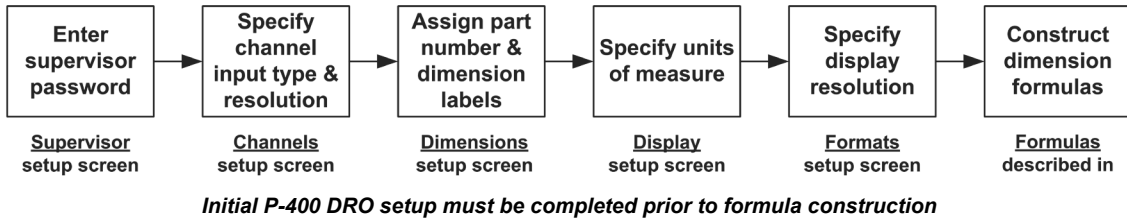
Deleting formula elements

Pressing the Cancel key deletes the element to the immediate left of the cursor. In the example below, the channel function C3 was removed from this formula for dimension P by moving the cursor to position to the right of C3, and then pressing the Cancel key.

Formulas		mm	U	P0
About	Dimension		P	C1
Dimensions	{visible}			
Formats	C3			C2
Formulas				
Variables				C3
Tolerances				C4
SPC				
Header				
Memory				

Formula functions

The remainder of this chapter describes formula functions in detail. Each description is accompanied by at least one example of use in a typical P-400 DRO formula. Study these examples prior to constructing your formulas. Also, complete the essential setup steps shown below and discussed earlier to constructing formulas.



Basic and advanced formula functions

Basic and advanced formula functions are displayed and selected in the Formula setup screen by pressing combinations of softkeys located below and at the right of the screen. P-400 DRO formula functions are shown under softkey column headings in the table below.

Chan...	Dim...	+ - * /	Math	Other			
C1	A	+	sqrt	if			
C2	B	-	exp	case			
C3	C	*	min	seq			
C4	D	/	max	trip			
		(	sin	dmin			
Gage-Checks can be ordered with 1, 4, 8 or 16 inputs	The number of dimensions is specified for each part in the dimensions setup screen	)	asin	dmax	*Xlatch is available in systems that include the external edge-detection option		
		,	cos	davg			
		;	acos	dmd			
		>	tan	fail			
		>= (≥)	atan	xtra	→ xtra menu		
		<	avg	copy	Ask	Global	Report
		<= (≤)	md	pste	Beep	HwDmn	RsetDyn
		== (=)	abs		ClrAID	HwDmx	Scan
		!= (≠)	mod		ClrData	HwLx	Send
		&& (AND)	int		ClrTrig	Lookup	SendMsg
		|| (OR)	pi		DateStr	Loop	SendRec
		-- (RANGE)			Din	Master	SetColor
					DinBin	MaxIndex	SetTrig
					Display	MinIndex	Setup
					Dout	OnEvent	Time
					DoutBin	PartNo	TimeStr
					FnCall	Preset	Var
					FnDefine	Recall	Xlatch*
					FnParam	Relay	
					FnReturn	Remark	

- = Basic function
- = Advanced function
- = Editing function

Basic and advanced formula functions

Basic formula functions

Basic functions calculate and display dimensions based on channel inputs, other dimensions, arithmetic operators, math functions and constants.

Later in this chapter, as part of the discussion of advanced functions, formulas will be shown assigning values to dimensions and performing other operations as well. Typically visible dimensions are used with basic functions to display values, and hidden dimensions are used with a combination of basic and advanced functions to display values or perform operations. For example, the formula:

$$A = 2 * \pi * \text{sqrt}(B)$$

uses basic functions to assign a numeric value to visible dimension A. This value is stored in the P-400 DRO database when the Enter key is pressed or when a Trip function is executed.

The use of hidden dimensions, system dimensions and advanced functions will be discussed later in this chapter. Basic functions include:

- Channel functions (C1,C2,C3,C4...) include channel inputs in formulas
- Dimension functions (D1,D2...H1,H2...S1,S2) include other dimensions in formulas
- Arithmetic operators (+ - * /) add, subtract, multiply or divide
- Parentheses () group terms within a formula
- Square roots (sqrt) find the square roots
- Exponents (exp) raise to a power
- Trig functions (sin, cos, tan) find trigonometric values
- Inverse trig functions (asin, acos, atan) find inverse trig values
- Absolute value (abs) remove sign (polarity)
- Integer (int) convert real numbers to whole numbers
- Constants (Numbers and pi) include values that don't change in formulas

Channel	Dimension	+ - * /	Math
C1	A	+	sqrt
C2	B	-	exp
C3	C	*	sin
C4	D	/	asin
		(	cos
Gage-Checks can be ordered with 1, 4, 8 or 16 inputs	The number of dimensions is specified for each part in the dimensions setup screen	)	acos tan atan abs int pi

Channel functions

Channel function values are determined by the outputs of measurement devices attached to channel input connectors on the rear panel of the P-400 DRO. These values can be offset, scaled or calibrated using the Master or SLEC/LEC error correction functions.

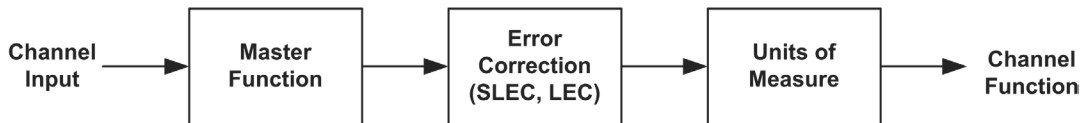
The Master function is available to operators using the front panel Master softkey, can be used in formulas and is used to offset or calibrate channel inputs. Error correction is only available to supervisors using the SLEC set up menu screen, and is used to compensate for transducer or encoder nonlinearities.



NOTE

The Master feature is discussed later in this chapter and in [Chapter 5: Operation](#). The SLEC and LEC error correction features are discussed in [Chapter 3: Setup](#).

Channel functions can be assigned units of measure for linear, angular or temperature values, or can simply be numeric (no unit of measure). Units of measure can be assigned by supervisors using the Channels setup screen.



Channel inputs are processed before becoming channel functions that are used in formulas

As shown above, channel functions used as variables in formulas can be:

- Direct from the channel inputs
- Level-adjusted and calibrated by the Master function or error correction
- Given linear, angular or temperature units of measure

Insert channel functions into formulas to include channel values in dimensions. Press the Chan softkey to insert channel functions.

Channel values can be assigned directly by making a dimension equal to a channel function or can be used in calculations as shown below.

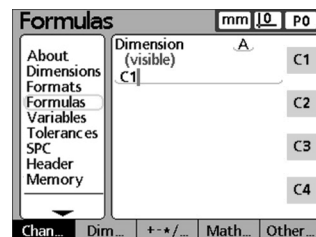
$$A = CI$$

$$A = (\text{Pi} * (CI \text{ exp}2))/4$$

Where:

A = Area

C1 = Diameter of a circle



Dimension functions

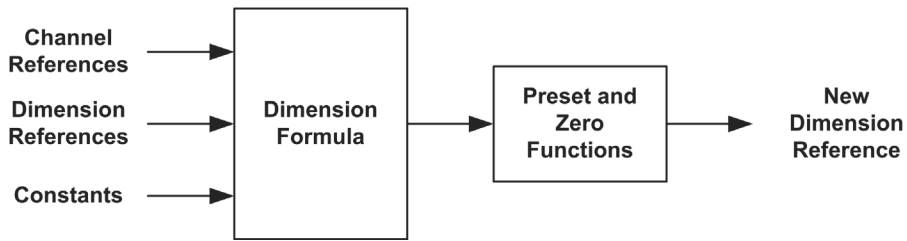
Dimension function values are determined by formulas acting on channel functions, constants or other dimension functions. Dimensions can be visible on the DRO and stored in the P-400 DRO database, or can be hidden and used to perform actions or define custom P-400 DRO functions.

Dimension values can be offset using the Preset function. The Preset function is available to operators using the front panel Preset softkey, and can also be used in formulas.



NOTE

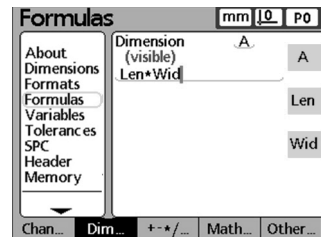
The Preset function is discussed more later in this chapter and in **Chapter 5: Operation.**



Channel functions, dimensions and constants are processed before becoming new dimension values that are used in formulas

Insert dimension functions into formulas to include values of existing dimensions in new dimensions. Press the Dim softkey to insert dimension functions.

Dimension values can be assigned to other dimensions or used in calculations as shown in this example.



$A = B$

$A = Len * Wid$

Where:

A = Area of a rectangle

Len = Length of a rectangle

Wid = Width of a rectangle

Arithmetic operators

Arithmetic operators are used to add, subtract, multiply and divide. The use of arithmetic operators in P-400 DRO formulas is consistent with the use of arithmetic operators generally.

Order of arithmetic evaluation

The order of evaluation of a collection of terms follows generally accepted practice, and is shown below:

- First evaluation: Terms in parentheses, innermost first
- Second evaluation: Exponentiation
- Third evaluation: Multiplication and division
- Fourth evaluation: Addition and subtraction

Units of measure

Dimensions acquire units of measure from channel functions, dimension functions and constants used in their defining formulas. For example, formulas containing numeric channel functions and numeric constants will produce numeric dimensions without units of measure.



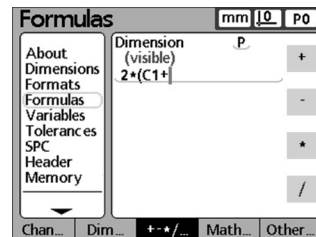
CAUTION

If combining and mixing units of measure in formulas violates standard math or physics conventions, type or mismatch errors will be generated.

Insert arithmetic operators into formulas as required by the application. Press the +/- softkey to insert arithmetic operators.

Arithmetic operators are combined with constants and variables to define dimensions as shown below.

- Addition: $A = C1 + C2$
 Subtraction: $B = 10 - C1$
 Division: $C = C1 / 1.5$
 Multiplication: $D = 2 * Pi * C1$



Parentheses

Parentheses are used to group terms within a formula for convenience and to improve readability. Grouped terms enclosed by parentheses are evaluated first and treated as a single term by the formula. Parentheses control the order of evaluation and make complex formulas easier to construct and read.



CAUTION

Parentheses must be used in opposing pairs. When a formula construction is complete, verify that the number of open parentheses equals the number of closed parentheses. Unmatched parentheses will generate formula error messages.

Insert parentheses into formulas as required by the application. Press the +/- softkey to insert Parentheses.

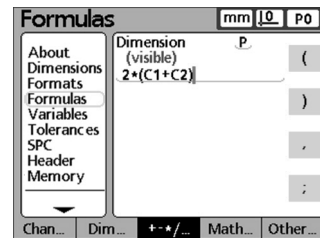
Parentheses are combined with arithmetic operators, math functions, constants and variables to define dimensions as shown below.

$$A = (\text{Pi} * (\text{C1 exp2}))/4$$

Where:

(C1 exp2) is the quantity C1 raised to the second power

(Pi * (C1 exp2)) is the entire numerator grouped as a single variable for division



Basic math functions

Basic math functions include:

- sqrt: Square root
- exp: Exponentiation
- Trig functions: sin, cos, tan, asin, acos, atan
- abs: Absolute value
- int: Integer
- pi: Constant

Square root function (sqrt)

The square root function (sqrt) is used to calculate the square root of a term. Square roots can be calculated for any dimensionless single term or collection of terms, or for terms that have square units of measure such as square inches.

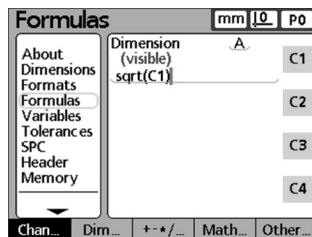
Press the Math softkey to insert the square root function. Parentheses for the term are provided. The syntax for using the square root function is shown below.

$$A = \text{sqrt}(\text{term})$$

For example:

$$A = \text{sqrt}(B)$$

$$A = 4\text{mm} \text{ when } B = 16 \text{ mm}^2$$



Exponent function (exp)

The exponent function (exp) is used to raise a term to a power. Exponents can be any dimensionless value or collection of values.

Press the Math softkey to insert the exponent function. Parentheses for the exponent must be provided when the exponent is a collection of values. The syntax for using the exponent function is shown below.

$$A = \text{Term}^{\text{expvalue}} \quad B = \text{Term}^{\text{exp}(\text{Collection of values})}$$

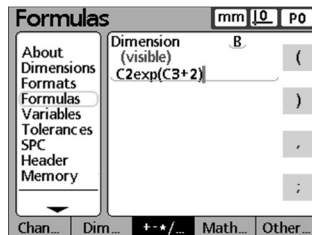
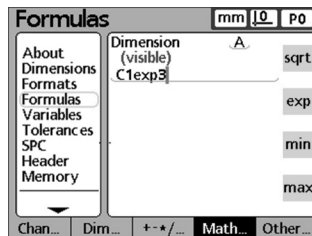
For example:

$$A = C1^{\text{exp}3}$$

$$A = 8\text{mm}^3 \text{ when } C1 = 2\text{mm}$$

$$B = C2^{\text{exp}(C3 + 2)}$$

$$B = 81\text{mm}^3 \text{ when } C3 = 2 \\ \text{and } C2 = 3\text{mm}$$



Trig and inverse trig functions (sin through atan)

Trig functions are used to calculate the sine, cosine or tangent of a term. Trig functions can be applied to any angular or numeric term or collection of terms, and will return dimensionless values.

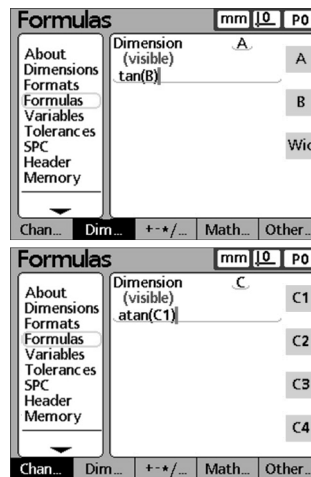
Inverse trig functions are used to calculate the arcsine, arccosine, or arctangent of a term. Inverse trig functions can be applied to any dimensionless term or collection of terms, and will return angular values.

Press the Math softkey to insert trig and inverse trig functions. Parentheses for the term are provided. Terms can include channel inputs, dimensions and constants. The syntax for using trig and inverse trig functions is:

$$A = \tan(\text{term}) \qquad C = \text{atan}(\text{term})$$

For example:

$$\begin{aligned} A &= \tan(B) & C &= \text{atan}(C1) \\ A &= 1 \text{ when } B = 45 \text{ degrees} & C &= 45 \text{ degrees when } C1 = 1 \end{aligned}$$



Absolute value function (abs)

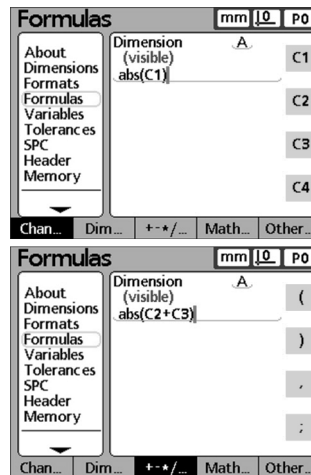
The Absolute value function is used to remove the sign from a negative term. Insert the Absolute value function to include the absolute value of a channel input, dimension or collection of terms.

Press the Math softkey to insert the absolute value function. Parentheses for the term are provided. The syntax for using the absolute value function is shown below.

$$A = \text{abs}(\text{term})$$

For example:

$$\begin{aligned} A &= \text{abs}(C1) & B &= \text{abs}(C2 + C3) \\ A &= 3 \text{ when } C1 = -3 \text{ or } +3 & B &= 17 \text{ when } C2 = -19 \text{ and } C3 = +2 \end{aligned}$$



Integer function (int)

The integer function is used to remove the fractional portion from a term, leaving only the integer portion. The integer function does not round mixed numbers. The fractional portion is simply removed. The Integer function includes the integer value of a channel input, dimension or collection of terms.

Press the Math softkey to display the Integer function. Parentheses for the term are provided. The syntax for using the integer function is shown below.

$$A = \text{int}(\text{term})$$

For example:

$$A = \text{int}(C1)$$

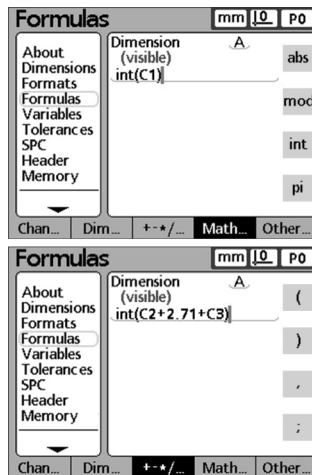
$$A = 2\text{mm}$$

$$\text{when } C1 = 2.9732\text{mm}$$

$$B = \text{int}(C2 + 2.71\text{mm} + C3)$$

$$B = 5\text{mm}$$

$$\text{when } C2 = 2.21\text{mm} \text{ and } C3 = 1.789\text{mm}$$

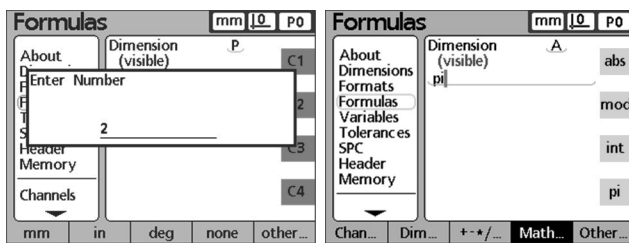


Pi and other constants

Constants are numeric values that do not change. The constant pi, or numbers entered from the numeric keypad are examples.

Insert constants into formulas to add, subtract, multiply, divide or raise a value to a power. Numeric constants are also used as arguments in logical, data evaluation and measurement control functions described later in the Advanced Functions portion of this chapter.

Press numeric keypad keys to enter numbers. The number will be displayed in a separate Enter Number popup screen. Insert the number into the formula by pressing the softkey for the desired unit of measure or the None softkey for constants with no units of measure. Press the Math softkey to insert pi.



Constants can be assigned to dimensions or used in calculations as shown below.

$$A = 0.7251$$

$$A = (\text{Pi} * (C1 \text{ exp}2))/4$$

Where:

A = Area in units²

pi = dimensionless constant 3.14...

2 = dimensionless constant used as a power of C1

4 = dimensionless constant used for division

Advanced formula functions

Advanced functions are used in visible and hidden dimension formulas to assign values, perform conditional tests and perform actions.

In this example, the formula assigns a value to visible dimension A that depends on the input value of C1. When C1 is greater than 1.5 mm, the dynamic minimum value of C2 is assigned to A, otherwise, the dynamic minimum value of C3 is assigned.

$$A = \text{if}(C1 > 1.5 \text{ mm}, \text{dmin}(C2), \text{dmin}(C3))$$

In this second example, a hidden dimension is used. Output relay 1 is set to its energized state (closed) when any tolerance test fails, otherwise, the relay is set to its deenergized state (open). Since a hidden dimension is used, no data is recorded in the P-400 DRO database.

$$H1 = \text{if}(\text{fail}, \text{Relay}(1,1), \text{Relay}(1,0))$$

Advanced functions include +-*/, Math and Other menus:

- Comma
Separate arguments for a single formula
- Semicolon
Separate formulas for a single dimension
- Greater than (>)
Logical test criterion
- Greater than or equal to (>=)
Logical test criterion
- Less than (<)
Logical test criterion
- Less than or equal to (<=)
Logical test criterion
- Equal to (==)
Logical test criterion
- Not equal to (!=)
Logical test criterion
- AND (&&)
Logical test condition
- OR (||)
Logical test condition
- RANGE (--)
Inclusive range of values between two specified points
- Minimum value (min)
Return the minimum value from a list
- Maximum value (max)
Return the maximum value from a list

+ - * /	Math	Other			
,	min	if			
;	max	case			
>	avg	seq			
>= (≥)	md	trip			
<	mod	dmin			
<= (≤)		dmax			
== (=)		davg			
!= (≠)		dmd			
&& (AND)		fail			
|| (OR)		xtra	xtra menu		
-- (RANGE)		copy	Ask	Global	Report
		pste	Beep	HwDmn	RsetDyn
			ClrAlID	HwDmx	Scan
			ClrData	HwLx	Send
			ClrTrig	Lookup	SendMsg
			DateStr	Loop	SendRec
			Din	Master	SetColor
			DinBin	MaxIndex	SetTrig
			Display	MinIndex	Setup
			Dout	OnEvent	Time
			DoutBin	PartNo	TimeStr
			FnCall	Preset	Var
			FnDefine	Recall	Xlatch*
			FnParam	Relay	
			FnReturn	Remark	

- Modulo (mod)
Return the remainder value from a division operation
- If
Logical true/false test that controls decisions and process flow
- Case
Logical range test that controls decisions and process flow
- Sequence (seq)
Control process to follow predetermined sequence of steps
- Trip
Automate process or SPC entry based on channel input or dimension levels
- Dynamic minimum (dmn)
Return the minimum sampled input value
- Dynamic maximum (dmx)
Return the maximum sampled input value
- Dynamic average (davg)
Return the average sampled input value
- Dynamic median (dmd)
Return the median sampled input value
- Fail
Return logic levels for dimension tolerance pass/fail
- Xtra
An additional menu of functions is accessed through the Xtra item and discussed later in this chapter

Commas and semicolons

Commas are used to separate arguments within formulas. Semicolons are used to separate formulas in a dimension formula screen.

Comma(,)

Most advanced functions require or permit the use of multiple arguments to support function calculations. When multiple arguments are used in a function, the comma is used to separate the arguments. Many advanced functions provide parentheses that include commas. In other cases, parentheses and commas must be added by the user.

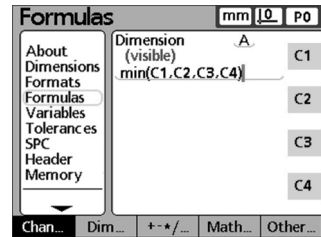
Insert commas into formulas as required by the function. Press the +/-*/ softkey to insert commas. The syntax for using commas is shown below.

$$A = \text{Function}(\text{arg1}, \text{arg2}, \text{arg3}, \dots, \text{argn})$$

For example:

$$A = \min(C1, C2, C3, C4)$$

A = the minimum of channel inputs C1, C2, C3, and C4



Semicolons(;)

The P-400 DRO permits the use of multiple formulas on a single dimension formula screen. When multiple formulas are used on a dimension screen, the semicolon is used to separate the formulas. When multiple formulas are included on one dimension screen, the leading formula defines the value of a dimension, while subsequent formulas perform some kind of operation. The dimension value is stored in the P-400 DRO database. The actions performed by subsequent formulas can change relay states, set output data, set variables and so on.

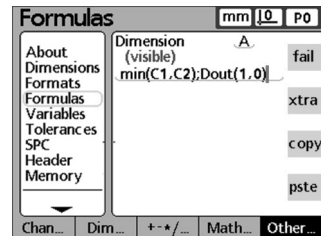
Insert semicolons into dimension screens between formulas as required. Press the +/-*/ softkey to insert semicolons. The syntax for using semicolons is shown below.

$$A = \text{Function 1}(\text{arg1}, \text{arg2}, \dots, \text{argn}); \text{Function 2}(\text{arg1}, \text{arg2}, \dots, \text{argn})$$

For example:

$$A = \min(C1, C2); \text{Dout}(1, 0)$$

A = the minimum of channel inputs C1 and C2
and
Output pin 1 of the primary parallel I/O port will be set to a logic 0



Logical and control functions

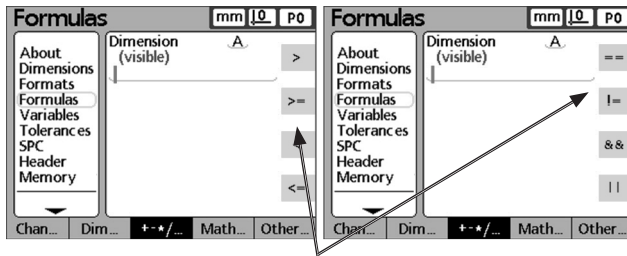
Logical functions assign values to dimensions or perform operations based on true/false and sorting tests of specified terms. True/false tests are performed by the If function. Sorting tests are performed by the Case function. Each test type uses the same set of test criteria and conditions.

Logical test criteria

The logical test criteria functions are only included in If and Case functions for true/false and sorting tests. Test criteria include:

- Greater than (>)
 - $5 > 3$ is true $5 > 5$ is false $5 > 6$ is also false
- Less than (<)
 - $3 < 5$ is true $3 < 3$ is false $3 < 2$ is also false
- Greater than or equal to (>=)
 - $5 >= 3$ is true $3 >= 3$ is also true $3 >= 4$ is false
- Less than or equal to (<=)
 - $3 <= 5$ is true $3 <= 3$ is also true $3 <= 2$ is false
- Equal to (==)
 - $5 == 5$ is true $5 == 4$ is false
- Not equal to (!=)
 - $5 != 4$ is true $5 != 5$ is false

Press the + - / softkey repeatedly to insert the test criteria functions.



Logical test criteria

Logical test conditions

The logical test condition functions are only included in If and Case functions for true/false and sorting tests. Test conditions include:

- Logical AND (&&)
 - True only when all values tested fit criterion

True/false test example:

For the condition (C1 = 2) && (C2 > 1)

(C1 = 2) && (C2 > 1) is false	when C1 = 1.9 and C2 = 2.0
(C1 = 2) && (C2 > 1) is false	when C1 = 1.9 and C2 = 2.5
(C1 = 2) && (C2 > 1) is true	when C1 = 2.0 and C2 = 2.0
(C1 = 2) && (C2 > 1) is true	when C1 = 2.0 and C2 = 2.1

- Logical OR (||)
 - True when any value tested fits criterion

True/false test example:

For the condition (C1 = 2) || (C2 > 1)

(C1 = 2) || (C2 > 1) is false	when C1 = 1.9 and C2 = 1.0
(C1 = 2) || (C2 > 1) is true	when C1 = 1.9 and C2 = 2.5
(C1 = 2) || (C2 > 1) is true	when C1 = 2.0 and C2 = 1.9
(C1 = 2) || (C2 > 1) is true	when C1 = 2.0 and C2 = 2.1

- RANGE (--)
The evaluation of Range depends on the formula that includes it. Ranges can be included in the following formula functions:

Din	Avg	Max
Dout	Med	MinIndex
Min	RsetDyn	MaxIndex

Din

Din ranges can only be specified for the data input pins of the parallel connector.

Syntax: Din (1--n) Specifies Din (1) through Din (n)

Din example: If (Din (1--4) > 0, SendRec, 0)

If any Din in the range Din (1) through Din (4) is greater than zero, send our record, otherwise do nothing

Dout

Dout ranges can only be specified for the data output pins of the parallel connector.

Syntax: `Dout (1--n)` Specifies Dout (1) through Dout (n)

Dout example: `Dout (1--4, 1)`

Sets all Dout in the Range Dout (1) through Dout (4) to a logic 1

Min and Max

Min and Max Ranges can be specified for channels, dimensions and system dimensions.

Syntax: `Min (V1--Vn)` or `Max (V1--Vn)` Specifies the min or max of values V1 through Vn

Min example: `A=Min(C1--C16)`

Dimension A user signed the minimum channel value in the range channel 1 through channel 16

MinIndex and MaxIndex

The index location of the minimum or maximum value in a range can be specified for channels, dimensions and system dimensions.

Syntax: `MinIndex(V1--Vn)` or `MaxIndex(V1--Vn)`

Specifies the location within the parentheses (index) of the minimum or maximum value

MaxIndex example: `A= MaxIndex (C1--C4)`

Dimension A is assigned a number 2 when C2 is the maximum value in the range channel 1 through channel 4

Avg

Avg range can be specified for channels, dimensions and system dimensions.

Syntax: `Avg(V1--Vn)` Specifies the average of values in the range

Avg example: `A=(C1--C8)`

Dimension A is assigned the average of values in the range channel 1 through channel 8

Med

Med range can be specified for channels, dimensions and system dimensions.

Syntax: `Med(V1--Vn)` Specifies the median of values in the range

Med example: `A=(C1--C8)`

Dimension A is assigned the median of values in the range channel 1 through channel 8

RsetDyn

RsetDyn range can only be specified for channels.

Syntax: `RsetDyn(C1--Cn)` Resets the dynamic functions in the range

RsetDyn example: `RsetDyn(C1--C4)`

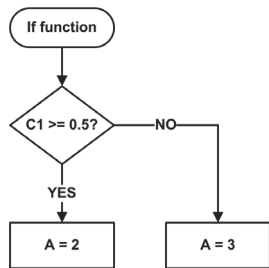
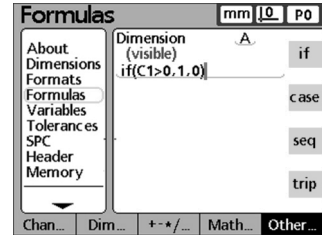
Performs a reset of all dynamic functions for channels in the range channel 1 through channel 4

If function

The If function performs a logical true/false test and assigns a value to a dimension or performs an operation based on the outcome of the test. The logical test uses test criteria and conditions described in earlier paragraphs. Tests can be performed on channels, dimensions, system dimensions, custom P-400 DRO functions, parallel port input pins, database contents, time, output relay state and variables.

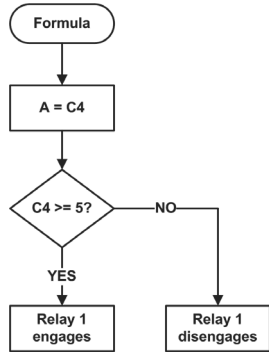
Press the Other softkey to insert the If function. The syntax of the If function is:

$A = \text{if}(\text{Logical test criterion, result when true, result when false})$



In this example, a value is assigned to a visible dimension:

$A = \text{If}(C1 \geq 0.5\text{mm}, 2.0, 3.0)$
 $A = 2.0$ when $C1$ is greater than or equal to 0.5mm
 $A = 3.0$ when $C1$ is less than 0.5mm



In this example, an If function is appended to a dimension formula using the semicolon function described earlier. This If function performs an operation; it engages or disengages relay contact 1 depending on the value of $C4$.

$A = C4; \text{If}(C4 \geq 5\text{mm}, \text{Relay}(1,1), \text{Relay}(1,0))$
 $A = C4$ and Relay 1 engages when $C4$ is greater than 5mm
 $A = C4$ and Relay 1 disengages when $C4$ is equal to or less than 5mm

This If function could also be assigned to a hidden dimension as shown below:

$H1 = \text{If}(C4 \geq 5\text{mm}, \text{Relay}(1,1), \text{Relay}(1,0))$

Suppressing If logical test results

When the If function is used to perform operations, the true or false result can be suppressed by inserting a numeric zero constant in either the true or false result position. In the example shown below, no operation is performed when the logical test result is false.

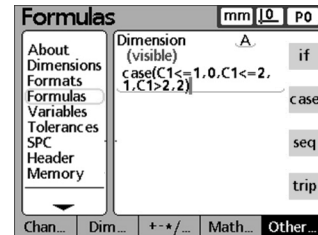
$H1 = \text{If}(\text{Fail}(), \text{Beep}, 0)$

Case function

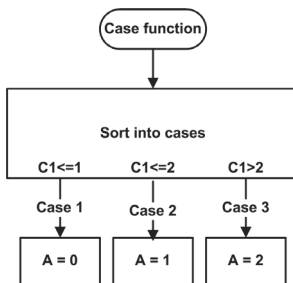
The Case function performs logical sorting tests to assign values to dimensions or perform operations based on the test result case, or classification. The logical tests use test criteria and conditions described in earlier paragraphs. Tests can be performed on channels, dimensions, system dimensions, custom P-400 DRO functions, parallel port input pins, database contents, time, output relay state and variables.

Press the Other soft-key to display the Case function. The syntax of the Case function is:

$A = \text{Case}(\text{Test 1, result 1, test 2, result 2, ...test n, result n})$



In this example a value is assigned to a visible dimension:



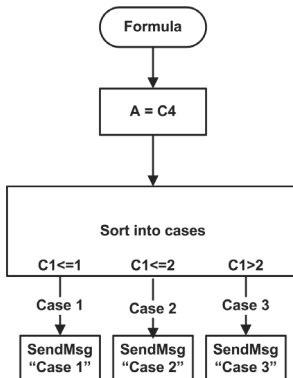
$A = \text{Case}(C1 \leq 1\text{mm}, 0, C1 \leq 2\text{mm}, 1, C1 > 2\text{mm}, 2)$

$A = 0$ when $C1 \leq 1\text{mm}$

$A = 1$ when $C1 \leq 2\text{mm}$

$A = 2$ when $C1 > 2\text{mm}$

In this example, a Case function is appended to a dimension formula using the semicolon function described earlier. This Case function will perform an operation; it sends one of three messages depending on the value of C1.



$A = C4; \text{Case}(C1 \leq 1\text{mm}, \text{SendMsg "Case 1"},$

$C1 \leq 2\text{mm}, \text{SendMsg "Case 2"}, C1 > 2\text{mm}, \text{SendMsg "Case 3"})$

$A = C4$ and when $C1 \leq 1\text{mm}$ the message "Case 1" is sent to the RS-232 port

$A = C4$ and when $C1 \leq 2\text{mm}$ the message "Case 2" is sent to the RS-232 port

$A = C4$ and when $C1 > 2\text{mm}$ the message "Case 3" is sent to the RS-232 port

This Case function could also be assigned to a hidden dimension as shown below:

$H1 = \text{Case}(C1 \leq 1\text{mm}, \text{SendMsg "Case 1"}, C1 \leq 2\text{mm}, \text{SendMsg "Case 2"}, C1 > 2\text{mm}, \text{SendMsg "Case 3"})$

Suppressing Case sort results

When the Case function is used to perform operations, any sort result can be suppressed by inserting a numeric zero constant in the sort result position. In the example shown below, no operation is performed for the second sort result.

$H1 = \text{Case}(C1 \leq 1\text{mm}, \text{SendMsg "Case 1"}, C1 \leq 2\text{mm}, 0, \text{SendMsg "Case 3"})$



NOTE

Case function tests are performed from left to right and only one result will be generated. This precludes the possibility of more than one result being generated for a single Case function. For example, while a value of 0.75 for C1 in the example above would satisfy the first two tests, only the first test will generate a result.

Incomplete case sets and default cases

Case functions use logical test criteria and conditions to sort a potentially broad set of inputs into a relatively small collection of well-defined output categories. This logical sorting works well unless the inputs include a case that is not defined as an output category. A simple example of incomplete case sets is provided here.

$$A = \mathbf{Case}(C1 < 1, 0, C1 > 1, 1)$$

$$A = 0 \text{ when } C1 < 1$$

$$A = 1 \text{ when } C1 > 1$$

$$A \text{ is undefined when } C1 = 1$$

The case $C1 = 1$ must be included to provide a complete set of cases

Each Case function must include a complete set of cases. A Case function with an incomplete case set will not work and will generate an error message.

Default cases provide an output category for any inputs that do not fit into the defined set of cases. The syntax for a default case is:

$$A = \mathbf{Case}(\text{Test 1, result 1, test 2, result 2, test n, result n...empty test, default result})$$



Default case

All inputs that do not fit into defined case sets produce the default result. Revising the example shown above to include a default case results in the following:

$$A = \mathbf{Case}(C1 < 1, 0, C1 > 1, 1, , 2)$$

$$A = 0 \text{ when } C1 < 1$$

$$A = 1 \text{ when } C1 > 1$$

$$A = 2 \text{ when } C1 = 1$$

While it is relatively easy to define complete sets of cases for simple applications, it is good practice to include default cases in all Case function formulas, thereby avoiding the possibility of undefined results.

min and max functions

The min or max functions are used to find minimum or maximum values in a specified list. The list of values can include channels, dimensions and database content. The min or max functions can be used to assign values to dimensions, system dimensions, custom P-400 DRO functions or specify criteria for a comparison test.

Press the Math softkey to insert the min and max functions. The syntaxes of the min and max functions are identical:

$A = \mathit{min}(\text{value1, value2, ...value n})$
Assigns the minimum list value to A

$A = \mathit{max}(\text{value1, value2, ...value n})$
Assigns the maximum list value to A

For example:

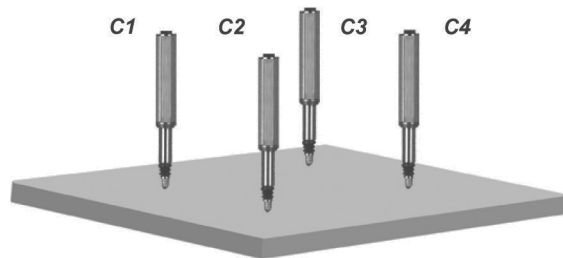
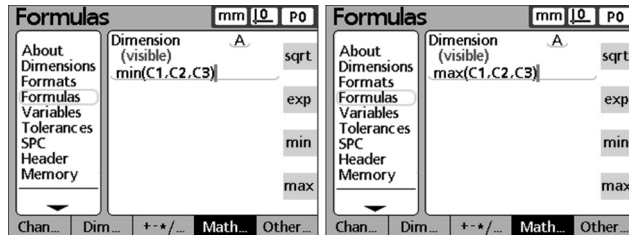
$A = \mathit{max}(C1, C2, C3)$
A = 6mm when C1 = 6mm, C2 = 3mm and C3 = 2mm

In another example, multiple terms are grouped by parentheses and treated as a single term:

$A = \mathit{min}((C1+C2), C3)$
A = 3mm when C1 = 1mm, C2 = 2mm, and C3 = 4mm

Min and max functions can be used to evaluate many inputs simultaneously to produce a single result. The flatness measurement in this example illustrates this (many channels to one dimension) capability. The multiple channel inputs are distributed across a surface, and then flatness is evaluated by simultaneously calculating the difference between the highest and lowest points on the surface.

$F = \mathit{max}(C1, C2, C3, C4) - \mathit{min}(C1, C2, C3, C4)$



NOTE

Min and max functions will not accept mixed units of measure.

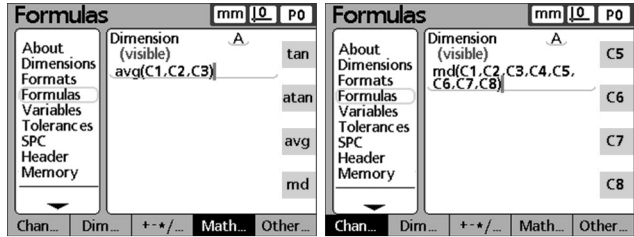
avg and md functions

The avg or md functions are used to find average or median values in a specified list. The list of values can include channels, dimensions and database content. The avg or md functions can be used to assign values to dimensions, system dimensions, custom P-400 DRO functions or specify criteria for a comparison test.

Press the Math softkey to insert the avg and md functions. The syntaxes of the avg and md functions are identical:

A = **avg**(value1, value2, ...value n)
 Assigns the average list value to A

A = **md**(value1, value2, ...value n)
 Assigns the median list value to A



For example:

A = **avg**(C1,C2,C3)
 A = 3.67mm when C1 = 6mm, C2 = 3mm and C3 = 2mm

and

A = **md**(C1,C2,C3,C4,C5,C6,C7,C8)
 A = 4mm when C1 = 2mm, C2 = 2mm, C3 = 2mm, C4 = 3mm,
 C5 = 4mm, C6 = 5mm, C7 = 6mm, C8 = 6mm



NOTE
 avg and md functions will not accept mixed units of measure.

Mod function

The Modulo (mod) function is used to return the remainder of a division operation. Modulo values can be calculated for any term or collection of terms. The dividend and divisor are specified by the user as arguments of the mod function. When the division is performed, the remainder is assigned to a dimension.

Press the Math softkey to display the Modulo function. The syntax for finding the remainder of a division is:

$$A = \text{mod}(\text{Dividend, divisor})$$

Results of the formula in the example below are shown in the accompanying table for some values of C1 from 0 to 120 in regular increments of 12.

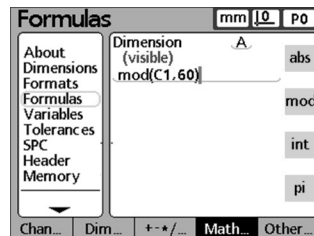
$$A = \text{mod}(C1,60)$$

C1	mod(C1,60)
0	0
12	12
24	24
36	36
48	48
60	0
72	12
84	24
96	36
108	48
120	0

In another example:

$$A = \text{mod}(C1,90)$$

$$A = 25.0039 \text{ degrees} \quad \text{when } C1 = 385.0039 \text{ degrees}$$



Seq function

The Sequence function (seq) is used to control the order of measurement steps.

Normally, dimension formulas are continuously evaluated and the results entered into the database simultaneously when the Enter key is pressed or a Trip occurs. However, the sequence function allows database record entries to be made individually in a user-defined sequence. The user defines the sequence by numbering the steps. The steps are then executed one at a time in ascending order each time the Enter key is pressed or a Trip occurs.

Dimensions calculated from sequence steps are stored in sequence as the Enter key is pressed. During operation, a blue line appears under the dimension label of the current sequence step. Each time the Enter key is pressed or a Trip occurs the current step function is stored, and the blue line advances to the next step.

This separation of steps makes it possible to conduct a series of different measurements using the same channel input if desired, and is necessary for the development of applications requiring sequential logic.

Press the Other softkey to display the Sequence function. The syntax of the Sequence function is:

$$A = seq(\text{Step number}, \text{function})$$

In this example the volume of a rectangular solid calculated from a sequence of 3 measurements using a single channel based on the equation:

$$\text{Volume} = \text{Height} * \text{Width} * \text{Length}$$

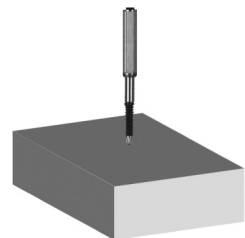
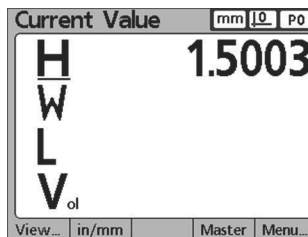
Where and the dimension formulas are:

H = height	H = <i>seq</i> (1, C1)
W = width	W = <i>seq</i> (2, C1)
L = length	L = <i>seq</i> (3, C1)
Vol = volume	Vol = H*W*L

To accomplish this sequence of measurements using only one channel, the operator performs the following steps from the beginning of the sequence:

The operator positions the block and channel input to measure height, and then presses the Enter key to store the channel value.

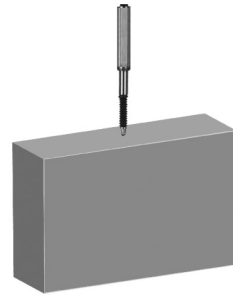
$$H = seq(1, C1)$$



The P-400 DRO advances to the next step in the sequence and waits for the operator to press the Enter key again. The operator positions the block and channel input to measure width, and presses the Enter key to store the new channel value.

$$W = \text{seq}(2, C1)$$

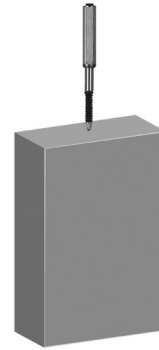
Current Value		mm	10	P0
H		1.5003		
W		2.0013		
L				
V _{ol}				
View...	in/mm		Master	Menu...



The P-400 DRO advances to the next step in the sequence and waits for the operator to press the Enter key again. The operator positions the block and channel input to measure length and presses the Enter key to store the final channel value.

$$L = \text{seq}(3, C1)$$

Current Value		mm	10	P0
H		1.5003		
W		2.0013		
L		2.7263		
V _{ol}		8.1859		
View...	in/mm		Master	Menu...



This last step in the sequence also stores the calculation of volume based on the values of T, W and L.

$$\text{Vol} = H * W * L$$

Upon completion of the last step, the P-400 DRO returns to the first step in the sequence to begin a new series of measurements.

This example of volume measurement illustrates that many dimensions can be calculated from a single channel input.

Performing operations within a sequence

Operations such as sending data and engaging relay contacts can be performed within a sequence by appending the operation using a semicolon. The syntax is:

$$A = \text{seq}(\text{Step number}, \text{function}); \text{seq}(\text{Step number}, \text{operation})$$

For example:

$$A = \text{seq}(3, C1); \text{seq}(3, \text{ClrTrig4})$$

Clears event trigger 4 when step 3 of the sequence is executed

Reinitialing a sequence

The syntax for prematurely ending the sequence before its completion and initiating a new sequence is:

seq(reinitialization step number)

This syntax is used in conjunction with an If or Case statement, and reinitiation of the sequence is performed as a result of a logical decision.

**NOTE**

The reinitializing step cannot be embedded in another sequence step.

In the example below, hidden dimension 1 is used to continually evaluate C2, and the sequence is reinitiated at step 1 if the value of C2 exceeds 1.

A = seq(1,C1)
B = seq(2,C2)
C = seq(3,C1 + C2)
H1 = if(C2>1mm,seq(2),0)

Trip function and measurement automation

The Trip function automates the data entry (storage) process. Normally, dimension formula calculations are stored in the database only when the Enter key is pressed. The trip function duplicates pressing the Enter key by automatically storing formula calculations when a changing value passes through user-defined thresholds.

By automatically storing formula calculations, the trip function allows the operator to conduct a series of identical measurements by simply loading and unloading parts into and out of a gage.



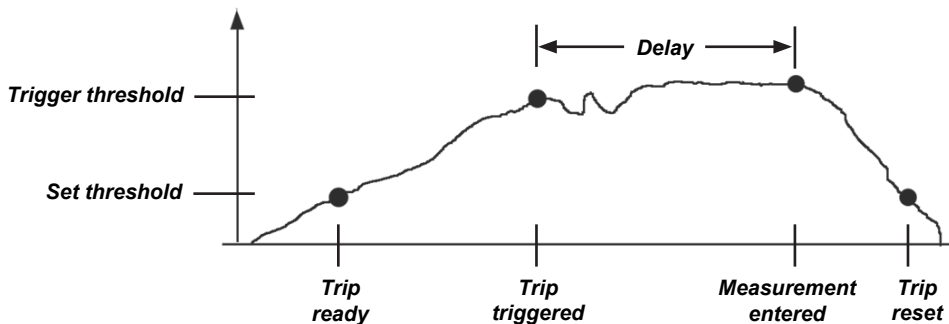
NOTE

Measurement automation (the Trip function) can be toggled on and off from the front panel using the hot key Auto function. Refer to the Hot Keys section of [Chapter 3: Setup](#) for details regarding hot keys.

The trip function is set and triggered by a value passing through predefined threshold levels. A delay can be included in the trip function to eliminate the effects of hardware noise and settling times.

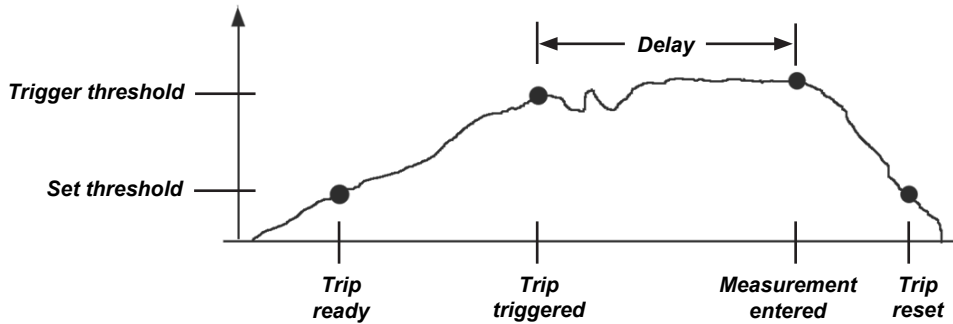
The trip function thresholds and delay are diagrammed here for a positive-going value. Trip functions can accommodate positive-going and negative-going values. Positive-going and negative-going values are conceptually identical except for direction and polarity of the input.

Once the Trip function has entered a value, it must be reset before it can be used again. The trip function is reset when the monitored value reverses direction and passes back through the set threshold as shown below.



NOTE

The trip function delay can be set to 0 if hardware settling is not a problem.



The trip function can be used by itself, included in if statements or case statements as the logical result of either passing or failing a conditional test, or included in a sequence function step.

Press the Other softkey to insert the Trip function. The syntax for using the Trip function is:

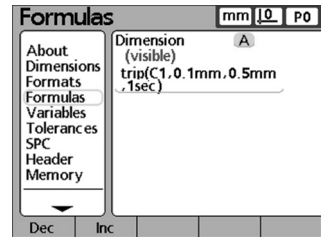
$$A = \text{trip}(\text{Value}, \text{set}, \text{trigger}, \text{delay})$$

Where the value can be a term or collection of terms

For example:

$$A = \text{trip}(C1, 0.1\text{mm}, 0.5\text{mm}, 1.0\text{sec})$$

A = C1 will be stored in the database after the value of C1 has passed through 0.1mm, then 0.5mm and then 1 second has passed



NOTE

The examples shown for the Trip function used channel functions. However, any term or collection of terms that have numeric value could as easily have been used.

Continuous sampling using the Trip function

Typical applications using the Trip function include the use of set and trigger thresholds as discussed above. However, some applications are configured with the input channel devices in constant contact with the surface(s) to be measured, and require continuous input sampling.

Continuous input sampling can be achieved by omitting the set and trigger thresholds from the standard Trip function syntax, as shown below.

$$A = \text{trip}(\text{Value}, , , \text{Delay})$$

The rate of continuous sampling is determined by the Delay parameter and the system refresh time. System refresh time typically varies between 0.03 and 0.10 seconds depending on the number and type of channels used and the complexity of formulas. The resulting sample rate becomes:

$$\begin{aligned}\text{Sample rate} &= 1/(\text{Total trip function time}) \\ &\sim 1/(\text{System refresh time} + \text{Delay time})\end{aligned}$$

Assuming the maximum system refresh time, and no sample Delay, the maximum sample rate is approximately:

$$\begin{aligned}\text{Max sample rate} &= 1/(0.10 + 0) \\ &= 10 \text{ samples/second}\end{aligned}$$

Generally applications that require continuous sampling employ slower rates, with seconds, minutes or even more time between samples. For these applications the sample rate can simply be expressed as the inverse of the user-specified delay as shown below.

$$\text{Sample rate} \sim 1/\text{Delay}$$

Application developers generally know the sample rate requirement and need to find the delay parameter to enter into the Trip function. Since sample rate and delay are inversely related, for sample rates less than 10 per second, delay can be expressed as:

$$\text{Delay} \sim 1/\text{sample rate}$$

For example, a sample rate of 1 sample per minute requires a delay of 60 seconds, resulting in the formula parameters shown below.

$$A = \text{trip}(C1, , , 60\text{sec})$$

Continuous samples can be accumulated in the P-400 DRO database, transmitted over the RS-232 port or sent to a USB drive.

$$A = \text{trip}(C1, , , 60\text{sec});\text{Send}$$



NOTE

The Auto hot key function toggles the Trip function on and off. Assign the Auto function to the desired front panel key prior to configuring the Trip function for continuous sampling. Refer to the Hot Keys section of [Chapter 3: Setup](#) for details.

dmin and dmax functions

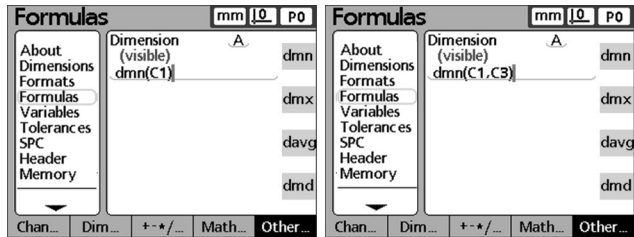
The dynamic minimum (dmin) and dynamic maximum (dmax) functions assign values to dimensions based on the minimum or maximum values of dynamically sampled channels or dimensions. The sampled values can be assigned directly, or can be used as triggers to assign a value from a second source.

P-400 DRO channel inputs are sampled many times per second and the system updates and retains the minimum and maximum values encountered in the sampling process. Minimum and maximum values are evaluated simultaneously during sampling. Dynamic minimum and maximum values can be calculated for any term or collection of terms. Pressing the Enter button or the Trip function stores the minimum and maximum values.

Press the Other softkey to insert the dynamic minimum or dynamic maximum functions. The syntaxes of the dmin and dmax functions are identical, so only the dmin function is shown here.

$A = dmin(\text{Sampled value})$
 Assigns the sampled minimum value

$A = dmin(\text{Sampled value, second source})$
 Assigns the second source value when the sampled value is at the minimum



Assigning the sampled value **Assigning a second value**



CAUTION

Due to the relatively low sample rates of the dmin and dmax functions, surfaces must be moved slowly during the sampling process to insure that all points are evaluated. Applications that require faster sample rates and have appropriate input devices should use the HwDmn or HwDmx function described on the next page.

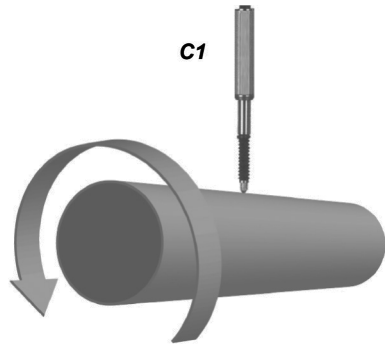
In this example, the runout of a shaft is determined by spinning the shaft, dynamically measuring the shaft's minimum and maximum diameters and then subtracting the minimum diameter from the maximum diameter.

$R = dmax(C1) - dmin(C1)$



NOTE

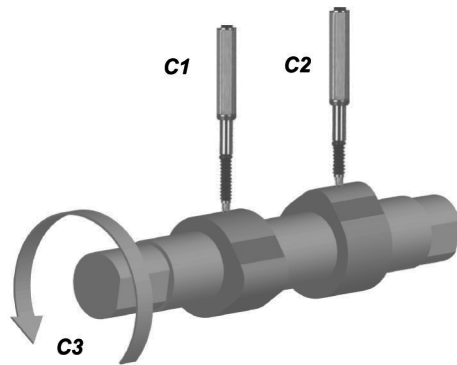
The RsetDyn function discussed later in this chapter must be used to clear existing samples before using the dmin and dmax functions.



In another example, the angle between high points of two cams is determined by spinning the cam shaft, dynamically measuring the rotational angle at each cam minimum, and subtracting the smaller angle from the larger angle.

Encoder C1 measures cam 1, encoder C2 measures cam 2, and the rotary encoder C3 measures the rotational angle of the cam shaft as it spins.

$$A = dmax(C2,C3) - dmax(C1,C3)$$

**CAUTION**

The Reset Dynamic function (RsetDyn) must be initiated prior to the use of the dmin and dmax functions to clear previous minimum and maximum values.

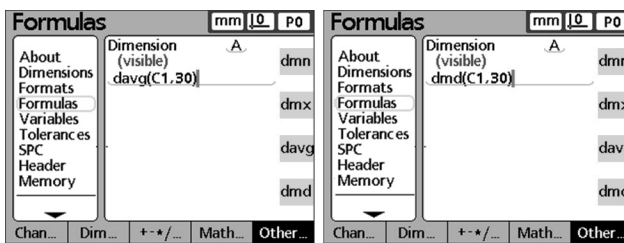
davg and dmd functions

The dynamic average (davg) and dynamic median (dmd) functions assign values to dimensions based on the average or median values of dynamically sampled channels or dimensions. The sampled values are assigned directly. Dynamic averages are useful when measuring rough surfaces. Dynamic medians are useful when measuring in the presence of noise.

P-400 DRO channel inputs are sampled many times per second and the system updates and retains the average and median values encountered in the sampling process. Average and median values are evaluated simultaneously during sampling. The number of samples used to calculate the average or median is specified as an argument by the user. Smaller numbers of samples have little impact on system performance but result in rapidly changing averages and medians. Larger numbers of samples result in more stable averages and medians but slow system performance.

Dynamic average and median values can be calculated for any term or collection of terms. Pressing the Enter button stores the average and median values.

Press the Other softkey to insert the dynamic average or dynamic median functions. The syntaxes of the davg and dmd functions are identical.



A = **davg**(Sampled value, sample size)
 Assigns the average value of the samples
 The minimum sample size for averages is 2

A = **dmd**(Sampled value, sample size)
 Assigns the median value of the samples
 The minimum sample size for medians is 3



NOTES

The sample size must be specified using a dimensionless constant.

The RsetDyn function discussed later in this chapter must be used to clear existing samples before using the davg and dmd functions.



CAUTION

Due to the relatively low sample rates of the davg and dmd functions, surfaces must be moved slowly during the sampling process to insure that all points are evaluated.

Fail function

The fail function tests the current pass/fail tolerance status of any dimension, list of dimensions provided as the fail argument or of all dimensions. The fail function returns a logic level 0 or 1, indicating the pass or fail status of specified dimensions. The value of 0 or 1 can be assigned to a dimension or can be included in a dimension formula as a logic or dimensionless variable.

Press the Other softkey to insert the fail function. The syntaxes of the fail function are:

$A = \mathbf{Fail}()$

Assigns a logic 1 to A if any dimension fails a tolerance test

Assigns a logic 0 to A if all dimensions pass a tolerance test

$A = \mathbf{Fail}(\text{Dim } X)$

Assigns a logic 1 to A if the specified dimension (X) fails a tolerance test

Assigns a logic 0 to A if the specified dimension (X) passes a tolerance test

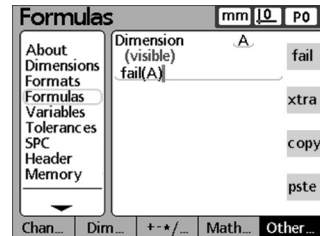
$A = \mathbf{Fail}(\text{Dim } 1, \text{Dim } 2, \dots, \text{Dim } n)$

Assigns a logic 1 to A if any of the specified dimensions fail a tolerance test

Assigns a logic 0 to A if all of the specified dimensions pass a tolerance test

The Fail function can also be assigned to a hidden dimension as shown in this example that operates Relay 1 if any tolerance fails:

$H1 = \text{if}(\mathbf{Fail}(), \text{Relay}(1,1), \text{Relay}(1,0))$



Xtra menu formula functions

Xtra menu functions are accessed by pressing the Other softkey and then pressing the Xtra softkey. Xtra menu functions include:

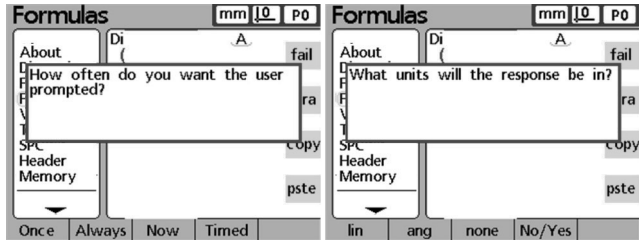
- Ask
Display a message or prompt the user for keyboard entry, then return the entered value
- Beep
Makes a beep sound
- ClrAllD (Clear all data)
Clears data across all parts
- ClrData (Clear data)
Clears data for this part
- ClrTrig (Clear trigger)
Part of the OnEvent function. Clears the specified event trigger
- DateStr (Date string)
Returns the current system date
- Din (Data in)
Returns logic levels from the primary parallel port input pins
- DinBin (Data in binary)
Returns a base 10 number equivalent to the logic levels from the primary parallel port input pins
- Display
Sets the current graph display starting at a dimension, with a number a axes
- Dout (Data out)
Applies individually-defined logic levels to the primary parallel port output pins
- DoutBin (Data out binary)
Applies binary logic levels to the primary parallel port output pins equivalent to a base 10 number
- FnCall (Function call)
Calls a user-defined custom P-400 DRO function which returns a value based on arguments passed in the calling statement
- FnDefine (Function define)
Defines a function and includes parameter placeholders for arguments
- FnParam (Function parameters)
Defines up to 12 parameters to be passed to a custom P-400 DRO function
- FnReturn (Function return)
Returns immediately from a custom P-400 DRO function without returning a value
- Global
Returns the value of a global variable that is available across all parts
- HwDmn (Hardware dynamic minimum)
Returns the minimum channel input value sampled at high speed by dedicated hardware
- HwDmx (Hardware dynamic maximum)
Returns the maximum channel input value sampled at high speed by dedicated hardware
- HwLx (Hardware latch)
Returns the value of one channel based on the incremental values of another channel
- Lookup
Returns one of a selection of several dimensions, part values or database values

xtra menu		
Ask	Global	Report
Beep	HwDmn	RsetDyn
ClrAllD	HwDmx	Scan
ClrData	HwLx	Send
ClrTrig	Lookup	SendMsg
DateStr	Loop	SendRec
Din	Master	SetColor
DinBin	MaxIndex	SetTrig
Display	MinIndex	Setup
Dout	OnEvent	Time
DoutBin	PartNo	TimeStr
FnCall	Preset	Var
FnDefine	Recall	Xlatch*
FnParam	Relay	
FnReturn	Remark	

- Loop
Loop control used to repeat a series of steps or functions
- Master
Presets channels to a numeric values contained in the Master screen
- OnEvent
Evaluate a formula term and return the value or perform a task when a specified event \ occurs
- Part number (PartNo)
Changes the part number, usually in conjunction with an OnEvent function
- Preset
Presets a dimension to a numeric value
- Recall
Recalls dimension values that were specified the last time the Preset function was used
- Relay
Operate dry-contact relay outputs
- Remark
Adds a comment to a formula, but has no effect on values or operation
- Report
Print report on the parallel or serial port
- Reset dynamic (RsetDyn)
Clear dmn, dmx, HwDmn and HwDmx sampled channel input values in preparation for new samples
- Scan
Collects all channel data at the maximum rate
- Send
Transmit specified dimension(s) to an output port
- Send message (SendMsg)
Transmit text or ASCII codes to the RS-232 port
- Send record (SendRec)
Transmit a specified dimension record(s) to an output port
- SetColor
Sets the color of a specified dimension displayed on the DRO
- Set trigger (SetTrig)
Part of the OnEvent function. Sets a user defined event trigger
- Setup
Performs a variety of setup functions for the specified dimension
- Time
Return elapsed time since startup or the amount a formula term has changed over an elapsed time
- TimeString (TimeStr)
Returns the current system time
- Variable (Var)
Returns or initializes the value of a local variable available for individual parts
- XLatch (Optional)
Return a channel input value when an external edge is detected

Ask function

The ask function displays messages that prompt the user for data or simply display instructions on the LCD. Messages can contain a mixture of up to 80 upper or lower case alphanumeric characters, and can be displayed *once* when the part is loaded, *always* when a data record is entered, immediately (*Now*) upon formula execution or for a *timed* interval specified by the user. The *Now* selection should only be used as the result of a OnEvent function to prevent continuous prompting. Numeric data entered by the user in response to a prompt can be interpreted as linear, angular or dimensionless.



The prompt message is displayed to the user in a pop-up box that provides a space for entering the requested data. Data is entered into the pop-up box from the numeric keypad, and stored by the system when the Enter key is pressed.

The user prompt messages are constructed on the Alpha Entry screen. Please refer to [Chapter 3: Setup](#) for details regarding entering data using the Alpha Entry screen.

Press the Other softkey, the xtra softkey, highlight Ask and then press the Enter key to insert the Ask function.

The syntax for using the Ask function to get data is:

$$A = ask(\text{user prompt})$$

For example:

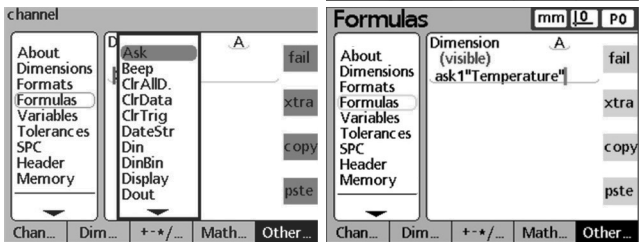
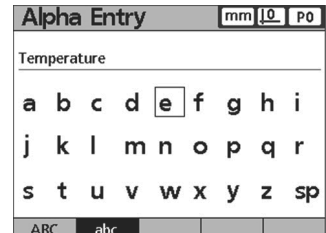
$$A = ask\text{''Temperature''}$$

The syntax for using the ask function to display a message without user data-entry is:

$$A = \text{Formula};ask(\text{user prompt})$$

For example:

$$A = C3;ask\text{''Part 11A10525''}$$

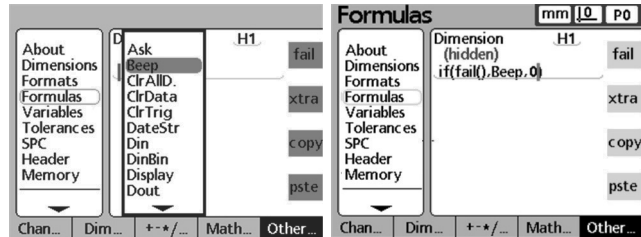


Beep function

The Beep function generates a beep sound. The volume of beep is determined by the Volume parameter specified in the Misc setup screen, described in [Chapter 3: Setup](#).

Press the Other softkey, the xtra softkey, highlight Beep and then press the Enter key to insert the beep function.

The syntax for including the beep function in a visible or hidden dimension formula is:



A = formula; **beep**

or

Hn = function (beep)

For example, in the formula:

A. = C1: **beep**

A = C1 and a beep sound is generated

Also, in the formula:

H1 = if (Fail (), **Beep**, 0)

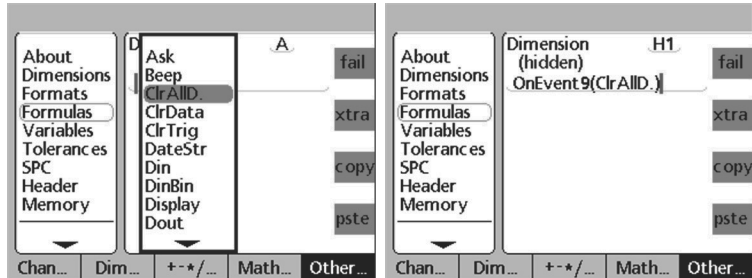
A beep sound is generated if any measurement fails or tolerance test.

ClrAllID and ClrData functions

The ClrAllID and ClrData functions clear data stored in the P-400 DRO database for either all parts, or for only the current part.

ClrAllID

The ClrAllID function clears all data for all parts. Press the Other softkey, the xtra softkey, highlight ClrAllID and then press the Enter key to insert the function.



The syntax for including the ClrAllID function in a hidden dimension formula is:

$$H_n = \mathit{ClrAllID}$$

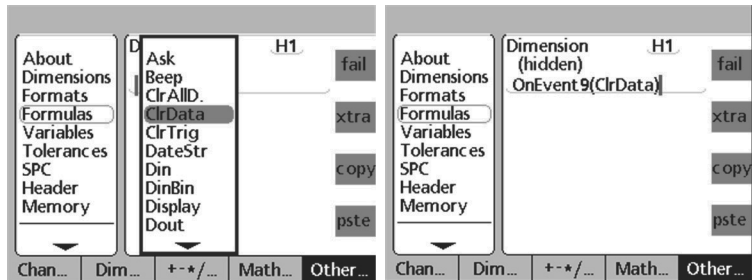
For example, in the formula:

$$H_1 = \text{OnEvent9}(\mathit{ClrAllID})$$

All database data is cleared when no numeric data is required and the 9 number key is pressed.

ClrData

The ClrData function clears all data for the current part. Press the Other softkey, the xtra softkey, highlight ClrData and then press the Enter key to insert the function.



The syntax for including the ClrData function in a hidden dimension formula is:

$$H_n = \mathit{ClrData}$$

For example, in the formula:

$$H_1 = \text{OnEvent9}(\mathit{ClrData})$$

All data for the current part is cleared when no numeric data is required and the 9 number key is pressed.

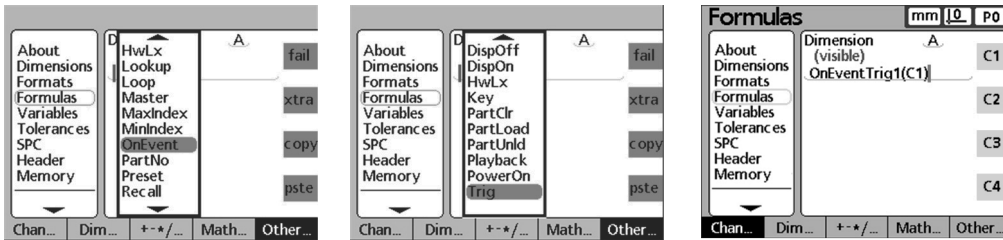
ClrTrig, SetTrig and user-defined events

User-defined trigger events cause OnEvent functions to execute once each time a trigger event happens. The trigger event must be set using the SetTrig function before it can cause an event to execute, and then must be cleared using the ClrTrig function before it can be used again.

In the following example, the value of channel input C1 is assigned to dimension visible A once when the value of C3 exceeds 3mm.

$A = \text{OnEventTrig1}(C1)$

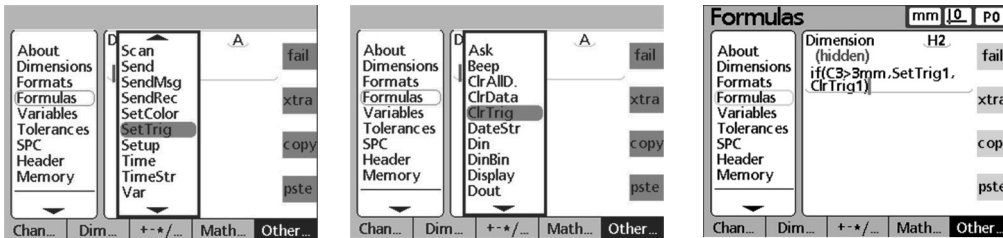
Defines the trigger event **Trig1**



An If function is used to set and clear the trigger event using the SetTrig and ClrTrig functions.

$H2 = \text{If}(C3 > 3\text{mm}, \text{SetTrig1}, \text{ClrTrig1})$ When $C3 > 3\text{mm}$, Trig1 is set and causes the OnEvent function shown above to execute once.

When $C3 \leq 3\text{mm}$, Trig1 is cleared so that the next time $C3 > 3\text{mm}$, the OnEvent function can execute again.

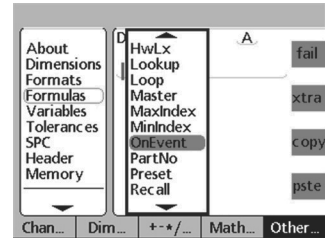


OnEvent function

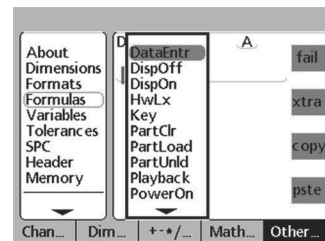
The OnEvent function is used to assign values to dimensions or to perform operations when triggered by a specified event. When the triggering event occurs, the value is assigned to the dimension and latched, or the specified operation is performed.

Press the Other softkey, the xtra softkey, highlight OnEvent and then press the Enter key to insert the OnEvent function. The syntax for the OnEvent function is:

$$A = \text{OnEvent} \underbrace{\text{Event}}_{\text{Triggering event}}(\text{Value or operation})$$



When the OnEvent function is inserted, a menu of triggering events is displayed. Highlight the desired triggering event and press the Enter key. Triggering events include a collection of system triggering events provided by the menu, and one triggering event that is user-defined:

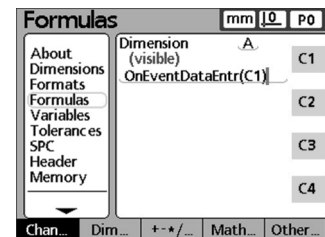


- DataEntr Occurs after a data record is entered into the database
- DispOff Occurs after the display is turned off using the red LCD ON/OFF button
- DispOn Occurs after the display is turned on using the red LCD ON/OFF button
- Edge1 Occurs after an (Optional) external edge event has happened on external edge line 1
- Edge2 Occurs after an (Optional) external edge event has happened on external edge line 2
- Edge3 Occurs after an (Optional) external edge event has happened on external edge line 3
- HwLx Occurs after the HwLx function has latched a new value
- Key Occurs after the specified front panel key has been pressed
- PartClr Occurs after the part database has been cleared
- PartLoad Occurs after a new part has been loaded
- PartUnld Occurs when a part is unloaded
- Playback Occurs after execution of the scan function, when scanned results are played back
- PowerOn Occurs at startup
- Trig User-defined triggering event.

System triggering events

System triggering events cause OnEvent functions to execute each and every time predetermined system events happen. In the following example, the value of channel input C1 is assigned to dimension A each time a record is entered into the database.

$$A = \text{OnEventDataEntr}(C1)$$



DateStr and TimeStr function

The DateStr and TimeStr functions display the current system date and time on the LCD screen in the formats shown here. Since the current date and time values will typically exceed tolerance limits, they are often displayed in the color specified for tolerance failures. The date and time values are updated during each formula evaluation cycle.

Current Value		mm	dd	po
A		8	28	06
B		15	05	40
C		0	000	
D		0	000	

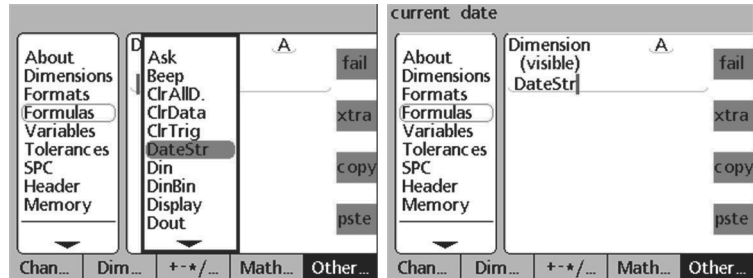
View... in/mm Master Menu...

DateStr

The DateStr function displays the current date. Press the Other softkey, the xtra softkey, highlight DateStr and then press the Enter key to insert the function.

The syntax for including the DateStr function in a visible dimension formula is:

$$A = \text{DateStr}$$

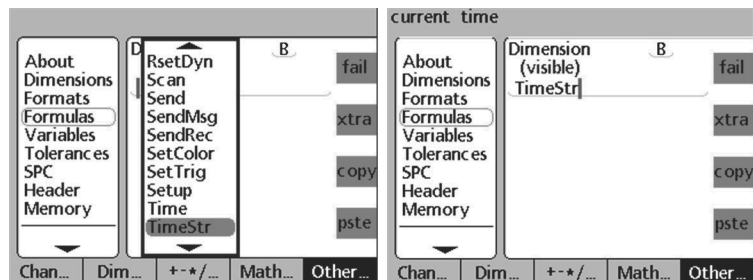


TimeStr

The TimeStr function displays the current time. Press the Other softkey, the xtra softkey, highlight TimeStr and then press the Enter key to insert the function.

The syntax for including the TimeStr function in a visible dimension formula is:

$$B = \text{TimeStr}$$



Time function

The Time function is used to:

- Assign the elapsed time in seconds since system startup using the syntax:
A = **Time**()
- Assign the elapsed time in seconds equal to, or closest to (but exceeding) the specified interval using the syntax:
A = **Time**(Interval)

**NOTE**

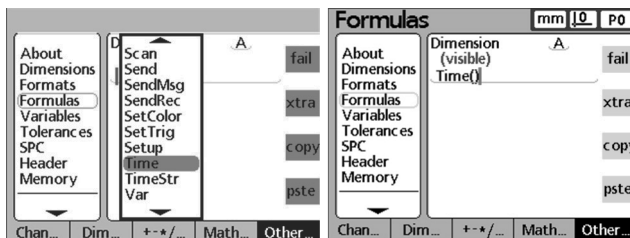
The approximation of specific time Intervals is necessary for the exact calculation of velocity and other time-related quantities because the system clock is not a precise timekeeping device. By returning a time interval that is known precisely, exact calculations of time-related quantities are possible.

The example below uses an elapsed time interval and a value change captured at channel input C1 over the same interval to calculate the exact velocity of the motion of C1.

$$V = \mathbf{Time}(1.0, C1) / \mathbf{Time}(1.0)$$

- Assign value changes over a specified time interval using the syntax:
A = **Time**(Interval,value)

Values can be channel inputs, dimensions or any collection of terms evaluated by the system. Press the Other softkey to display the xtra menu, then scroll to Time. Press the Enter key to insert the function into the formula.



Din and DinBin functions

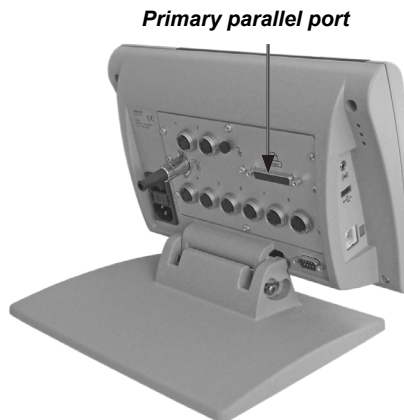
The primary parallel port is configured as a general-purpose data Input/Output (I/O) port, and does not support parallel printers.

The P-400 DRO uses 5 pins of the parallel port connector as the inputs shown below. Inputs support 5 volt TTL logic levels only.



NOTES

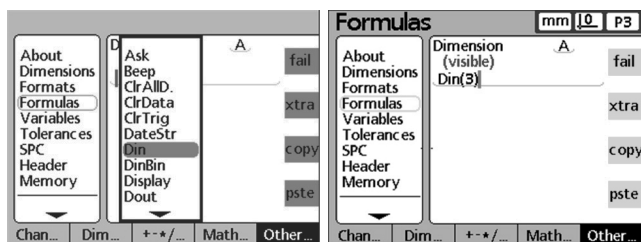
Electrical characteristics of the parallel port are contained in **Chapter 8: Reference Material**.



Din

Insert the Din function to read the logic level of a single parallel port input pin or range of parallel port pins. The logic level from a single pin can be used in a dimension formula, or the decimal equivalent of the binary values from a range of pins can be used.

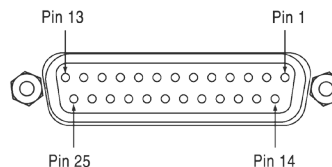
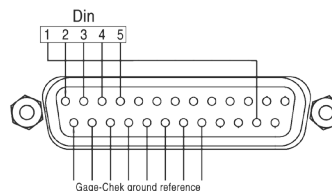
Press the Other softkey to display the xtra menu softkey, then scroll to Din. Press the Enter key to insert the function into the formula.



through 5 as shown here. Logic levels are referred to ground on pins 18 through 25.

The logic level at a single Din pin can be assigned to a dimension as a numeric 1 or 0 using the syntax:

$$A = \text{Din}(\text{Pin number})$$



Din	Parallel pin
1	15
2	13
3	12
4	11
5	10

The Din pins of the parallel port connector are numbered 1

For example,

$$A = \mathbf{Din}(3)$$

$$A = 1$$

When Din(3) = logic level 1

The decimal equivalent of the binary values from a range of pins can be assigned to a dimension as a numeric value using the syntax:

$$A = \mathbf{Din}(\text{Range of pin numbers})$$

For example,

$$A = \mathbf{Din}(3--5)$$

$$A = 20$$

When Din(3) = logic level 1

Din(4) = logic level 0

Din(5) = logic level 1

Din	Din(5)	Din(4)	Din(3)	Din(2)	Din(1)
Din logic level	1	0	1	0	1
Decimal equivalent	16	0	4	0	1



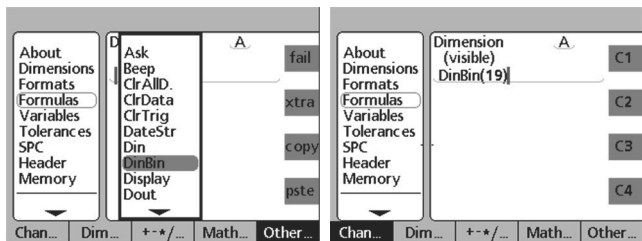
Specified range

DinBin

Insert the DinBin function to read the logic levels of multiple parallel port input pins simultaneously as a decimal equivalent. The decimal value can be included directly in a dimension formula as a variable, or can be tested in conditional if and case statements.

Press the Other softkey to display the xtra menu softkey, then scroll to DinBin. Press the Enter key to insert the function into the formula.

The logic levels at the Din pins can be assigned to a dimension as a decimal value using the syntax:



$$A = \mathbf{DinBin}(\text{Lines})$$

Where lines is a decimal value of the binary mask that specifies which input pins to read

For example,

$$A = \mathbf{DinBin}(19)$$

Includes a lines value of 19, which when converted to a binary mask of 10011, reads Din(1), Din(2) and Din(5). All unread pins are given a logical value of zero. The binary value of the input pins read at the parallel port are then returned as a decimal equivalent.

$$A = \mathbf{DinBin}(19)$$

$$A = 17$$

When the input pin logic levels are 10101

and the lines mask value is decimal 19 = 10011

The masked result is 10001 = decimal 17

Din	Din(5)	Din(4)	Din(3)	Din(2)	Din(1)
Din logic level	1	0	1	0	1
Lines mask (dec 19)	1	0	0	1	1
Masked value (dec 17)	1	0	0	0	1

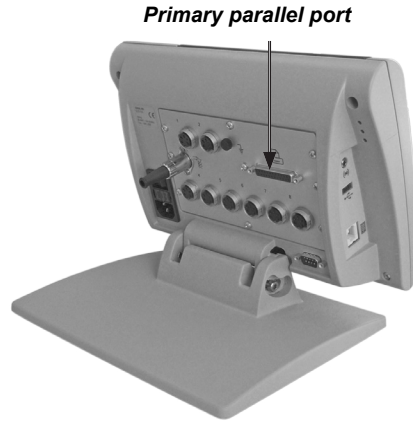
Dout and DoutBin functions

The primary parallel port is configured as a general-purpose data Input/Output (I/O) port, and does not support parallel printers.

The P-400 DRO uses 12 of the parallel port connector pins as the outputs shown below. Outputs are 5 volt TTL logic levels.



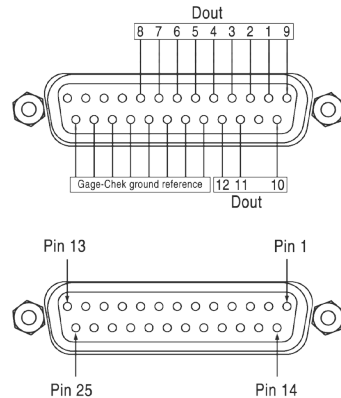
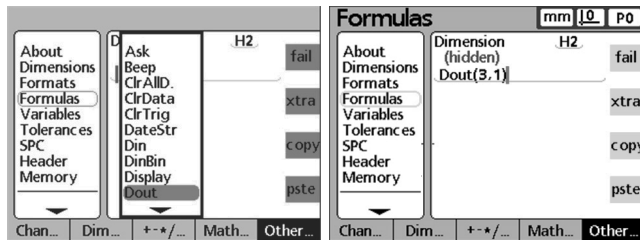
NOTES
Electrical characteristics of the parallel port are contained in Chapter 8: Reference Material.



Dout

Insert the Dout function to output a TTL logic level of 0 or 1 to a specific parallel port output pin or range of pins. Logic levels are referred to ground on pins 18 through 25. The logic level is presented to the pins specified, no other pins are affected. If a delay is also specified, the logic level will be presented for the delay period, and then the affected output pins will be changed to the opposite logic state.

Press the Other softkey to display the xtra menu softkey, then scroll to Dout. Press the Enter key to insert the function.



4 Formulas

Dout	Parallel pin	Dout	Parallel pin
1	2	7	8
2	3	8	9
3	4	9	1
4	5	10	14
5	6	11	16
6	7	12	17

The Dout pins of the parallel port connector are numbered 1 through 12 as shown above. The logic level at a Dout pin or range of pins can be assigned using the syntax:

$$H_n = \text{Dout}(\text{Pin number/range of pins, state, delay})$$

Where: Pin number/range of pins specifies which output pin or pins are used

State is the logic level to output to the specified pins

Delay is the output period in seconds - if a delay is not included, the output is continuous

For example,

H1 = **Dout**(3, 1)

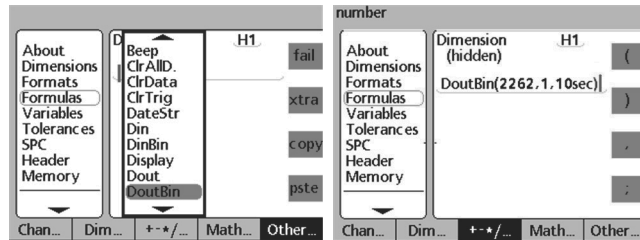
H1 = Sets Dout pin 3 to a logical 1 continuously

H1 = **Dout**(3--5, 1, 5sec)

H1 = Sets Dout pins 3 through 5 to a logical 1 for 5 seconds, then to zero

DoutBin

Insert the DoutBin function to output a specified logic level to multiple parallel port output pins simultaneously. The new logic level can be presented continuously or for a specified period.



The logic level is presented to the pins specified by the lines mask, no other pins are affected. If a delay is also specified, the logic level will be presented for the delay period, and then the affected output pins will be changed to the opposite logic state.

Press the Other softkey to display the xtra menu softkey, then scroll to DoutBin. Press the Enter key to insert the function into the formula.

The output pins, logic level and delay are specified using the syntax:

Hn = **DoutBin**(Lines, state, delay)

Where: Lines is a decimal value of the binary mask that specifies which output pins are used

State is the logic level to output to the specified pins

Delay is the output period in seconds - if a delay is not included, the output is continuous

For example,

H1 = **DoutBin**(2262, 1, 10sec)

Includes a lines value of 2262, which when converted to a binary mask of 100011010110, outputs a logic level of 1 for 10 seconds to lines Dout(2), Dout(3), Dout(5), Dout(7), Dout(8) and Dout(12). All pins not included in the mask are unaffected. After the 10 second delay period, the affected output pins are changed to a logical 0.

H1 = **DoutBin**(2262, 1, 10sec)

When the lines mask is decimal 2262 = 100011010110

and the state is logical 1

and the delay is 10 seconds

outputs a logical 1 for 10 seconds as shown in this table

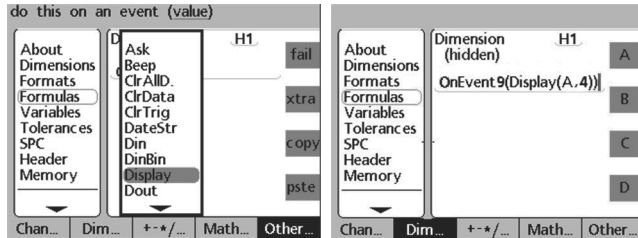
Dout	Dout(12)	Dout(11)	Dout(10)	Dout(9)	Dout(8)	Dout(7)	Dout(6)	Dout(5)
State	1	1	1	1	1	1	1	1
Lines mask (dec 2262)	1	0	0	0	1	1	0	1
Resulting output	1	Unaffected	Unaffected	Unaffected	1	1	Unaffected	1

Display function

The Display function sets the current graph display to a specified dimension and a specified number of axes. The display function should be used in other functions that are evaluated once, such as the OnEvent function.

Press the Other softkey, the xtra softkey, highlight Display and then press the Enter key to insert the function.

The syntax for including the Display function in an OnEvent function is:



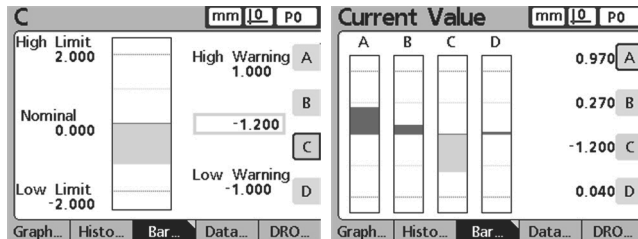
$$H1 = \text{OnEventX}(\text{Display}(\text{dim}, \text{axes}))$$

Where: dim = the dimension to display and
axes = the number of graph axes to display

For example, in the formula:

$$H1 = \text{OnEvent9}(\text{Display}(A,4))$$

The display of graphs will change to show dimension A and a total of 4 axes when no numeric data is required and the 9 number key is pressed.



FnDefine, FnParam, FnCall and FnReturn functions

A custom P-400 DRO function is a collection of formula operations that perform a specific task and is relatively independent of other formula operations. Calling a custom function in a formula returns a value calculated by the function.

Advantages to creating custom functions include:

- Reducing the duplication of formula operations in a part program
- Reuse of formula operations in multiple part program locations
- Compressing complex operations into short, simple statements that improve readability

P-400 DRO custom functions always include:

- A collection of formula operations to be executed when the function is called
- A value that is returned to the point where the call occurred

P-400 DRO custom functions can also include:

- Parameters that are passed to the function and will be used in the calculation of the returned value

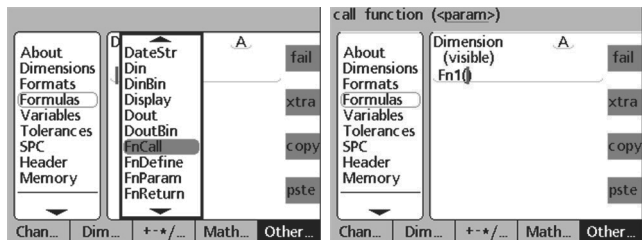
Custom functions are created using FnDefine. Custom functions that are passed parameters also use FnParam. Functions are executed when FnCall is included in a formula. Functions can be defined with or without input parameters and return the result of the included formula operations.

Functions must be defined on hidden dimension formula lines, but can be called from hidden or visible dimension formulas.

Defining and calling custom functions

Press the Other key to display the Xtra menu softkeys, then press the Enter key to insert the function.

The syntax for defining a custom function is:



$$Hn = \mathit{DefFn}\#(\mathit{action\ 1}, \mathit{action\ 2}, \dots \mathit{action\ n})$$

Where actions are combinations of P-400 DRO formula operations

The syntax for calling a custom function is:

$$A = \mathit{Fn}\#(\mathit{param1}, \mathit{param2}, \dots \mathit{param\ n})$$

Where parameters are passed to the function and used to calculate the result

In this example, a custom function is defined to change the logic state of parallel port output pins Dout(3) and Dout(4) to indicate four ranges of displacement of the channel 1 probe. The value ranges of C1 and the corresponding logic states of Dout(3) and Dout(4) are shown in this truth table.

C1 value range	Dout(4)	Dout(3)
<0mm	0	0
>=0mm AND <0.5mm	0	1
>=0.5mm AND <1.0mm	1	0
>=1.0mm AND <1.5mm	1	1

This custom function is defined in a hidden dimension and uses 2 parameters to set the logic states of Dout(3) and Dout(4).

H1 = **DefFn1**(Dout(4,*Param1*),Dout(3,*Param2*))

Later, the function is called in a Case operation and the 2 parameters are passed in the calling statement that correspond to the logic states of Dout(3) and Dout(4) shown in the truth table above.

H2 = Case((C1<0mm),**Fn1**(0,0)
 ((C1>=0mm)&&(C1<0.5mm)),**Fn1**(0,1),
 ((C1>=0.5mm)&&(C1<1.0mm)),**Fn1**(1,0)
 ((C1>=1.0mm)&&(C1<1.5mm)),**Fn1**(1,1)0)

Returning from functions

Normally, when a function is called, it executes some formula operations and returns a resulting value. However, when the function involves an IF test or a Case sort, it might become necessary to simply return from a function with a known, specified value. In this example, a custom P-400 DRO function performs an IF test of tolerance test results. If all tolerance tests pass, dimension A shows the value of channel 1. When any tolerance test fails, the function returns with a value of zero.

H3 = **DefFn1**(If(Fail, FnReturn(0), Param1))
 A = **Fn1**(C1)

Variable and Global functions

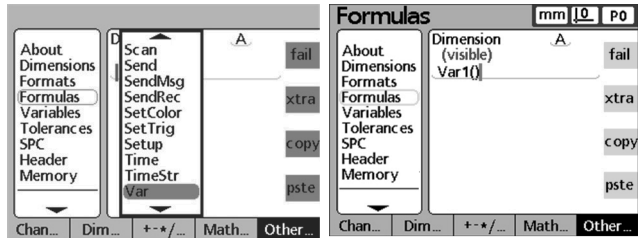
The Variables and Globals are used to:

- Assign a values to a dimensions or
- Create loops or event counters to control the flow of logic

Variables

Variables are local to parts. For example, a variable used in part 0 will not be available in Part 1. Up to 20 variables can be used in each part.

Press the Other softkey to display the xtra menu softkey, then press the xtra softkey and scroll to Var. Press the Enter key to insert the function into the formula.



Setting the value of a variable

The method of setting the value of a variable depends on the application. Regardless of the method, the syntax for setting the value of a variable is:

Var#(Value)

The examples below use different methods to set Var1 to a value:

Var1(ask"Number")

The value is entered by the user in response to a prompt

Var1(C1 + sqr(C2 + C3))

The value is calculated from the expression in parentheses

Var1(27)

The value is set directly to the constant 27

Reading the value of a variable

Variables can be tested by If and Case functions to count loop executions, indicate states and assign values to dimensions. The syntax for reading the value of a variable is:

Var#()

The example below assigns the value of Var1 to dimension A:

A = Var1()

Variables as loop or event counters

Variables can be incremented or decremented to serve as loop or event counters. Incrementing a variable increases its value by a specified amount at each increment. Typically, a variable is incremented or decremented each time a loop is executed or an event occurs, and its value is tested to determine if the required number of loops or events have taken place.

The syntax for incrementing a variable is:

$\text{Var\#}(\text{Var\#}() + \text{increment value})$

This example increments the value of variable **Var1** by one:

$\text{Var1}(\text{Var1}()+1)$

The syntax for decrementing a variable is:

$\text{Var\#}(\text{Var\#}() - \text{increment value})$

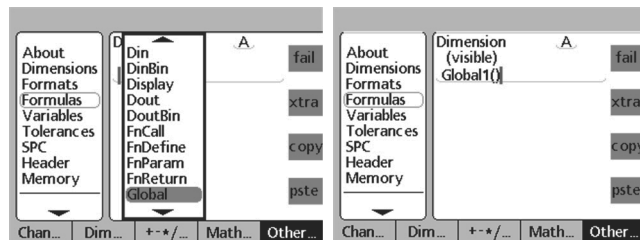
This example decrements the value of variable **Var1** by one:

$\text{Var1}(\text{Var1}()-1)$

Globals

Globals are variables that are available to all parts in the system. For example, a global used in part 0 will also be available in Part 1, or in any other part. Up to 20 globals can be used in the P-400 DRO system. The Global function is identical in use and function to the Variable function described on the previous page.

Press the Other softkey to display the xtra menu softkey, then press the xtra softkey and scroll to Global. Press the Enter key to insert the function into the formula.



Loop Function

The loop function performs an evaluation or operation repeatedly through a specified number of execution loops. The syntax of the loop function is:

Loop(number of loops, evaluation or operation)

This example accumulates the sum of C1 and C2 over 5 loops:

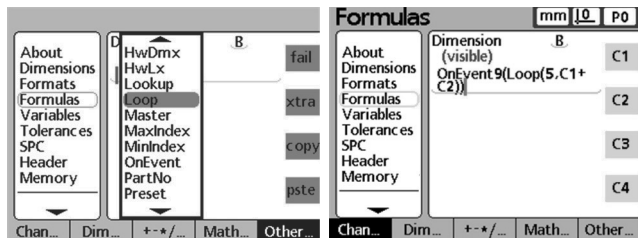
A = **Loop**(5, C1 + C2)

This seems straightforward enough, however, the loop function must be contained by an OnEvent, Sequence or some other function, to prevent the loop from being executed continually at the dimension evaluation rate. In the following example, the loop function is contained within an OnEvent function.

A = OnEvent 9(**Loop** (5, C1 + C2))

The loop execution is now constrained by the OnEvent function and will be executed only once when the number 9 key is pressed.

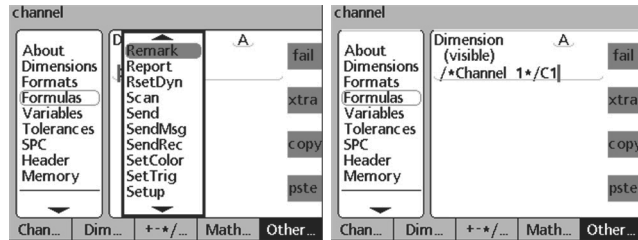
Press the Other softkey to display the xtra menu softkey, then press the xtra softkey and scroll to Loop. Press the Enter key to insert the function into the formula.



Remark Function

The Remark function adds a comment to a formula, but does not affect values or operation. The comment can be added before or after the formula operations in visible dimensions, hidden dimensions and custom P-400 DRO functions.

Press the Other softkey to display the xtra menu softkey, then press the xtra softkey and scroll to Remark. Press the Enter key to insert the function into the formula. The Alpha entry screen will be displayed for the remark.



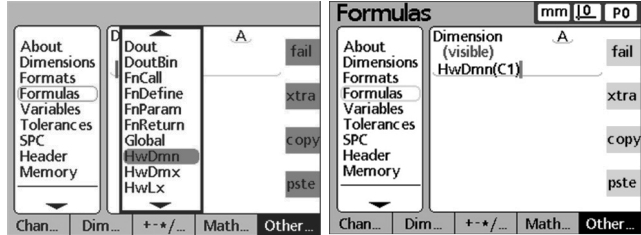
The syntax of the Remark function is:

$A = /*\textit{Remark text}*/\textit{formula}$ or $\textit{formula}/*\textit{Remark text}*/$

HwDmn and HwDmx functions

The HwDmn and HwDmx functions are identical to the dmin and dmax functions described earlier, except that only channel inputs are sampled, and the sample rates are very high.

Press the Other softkey to display the xtra menu softkey, then press the xtra softkey and scroll to HwDmn or HwDmx. Press the Enter key to insert the function into the formula. The syntaxes of the HwDmn and HwDmx functions are also identical to the dmin and dmax functions discussed earlier in this chapter.



NOTE

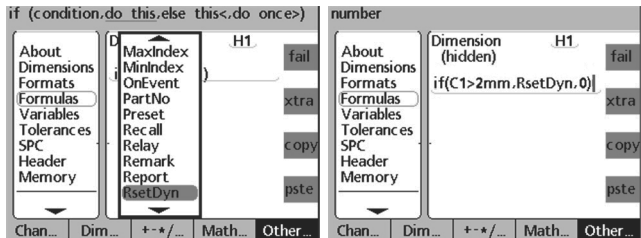
Only encoder and Solartron Orbit input channels can be used with the HwDmn and HwDmx functions.

RsetDyn function

The RsetDyn function clears any existing dmin and dmax values, and must be used before assigning values using the dmin and dmax functions. The left wide hotkey above the screen is assigned the Dynamic Reset by default, and pressing this hotkey prior to a dynamic measurement will clear previous minimum and maximum values.

The Reset Dynamic function is also available in the xtra menu for manual operation and for inclusion in formulas. Use of the Reset Dynamic function in formulas must be controlled by If, Case or OnEvent functions so that the reset only occurs when desired, and not repeatedly in every evaluation cycle.

Press the Other softkey to display the xtra menu softkey, then press the xtra softkey and scroll to RsetDyn. Press the Enter key to insert the function into the formula.



HwLx function

The hardware latch (HwLx) function is used to include the value of one channel when a second reference channel reaches a specified value.

Press the Other softkey to display the xtra menu softkey, then press the xtra softkey and scroll to HwLx. Press the Enter key to insert the function into the formula.

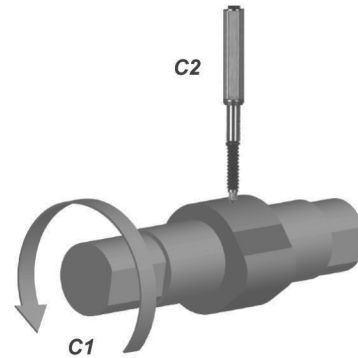
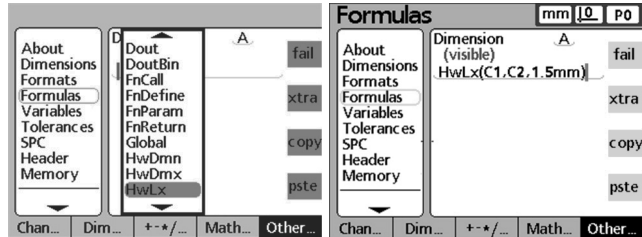
The syntax of the HwLx function is:

$$A = \mathbf{HwLx}(\text{Chan \#1}, \text{Chan \#2}, \text{value})$$

This function assigns the value of channel #2 when channel #1 reaches the specified value.

For example, the rotational angle of the cam (C2) will be latched and the value assigned to dimension A when the cam lift (C1) is 1.5 mm.

$$A = \mathbf{HwLx}(C1, C2, 1.5\text{mm})$$

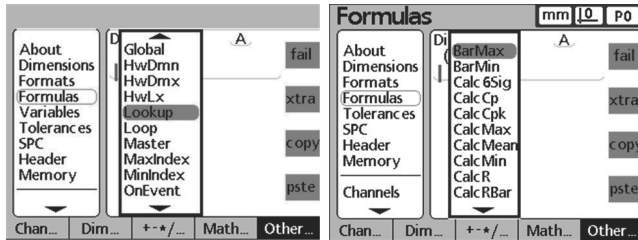


Lookup function

The Lookup function is used to include SPC, tolerance, database record and other information in formulas. The lookup function is used in If and Case functions to extend the system's tolerance capabilities. The information that can be included in formulas using the Lookup function includes:

- BarMax The Nom + Max value from the Tolerances screen
- BarMin The Nom - Min value from the Tolerances screen
- Calc6Sig The 6 Sigma value from the Data view screen
- CalcCp The Cp value from the Data view screen
- CalcCpk The Cpk value from the Data view screen
- CalcMax The Max value from the Data view screen
- CalcMean The Mean value from the Data view screen
- CalcMin The Min value from the Data view screen
- CalcPp The Pp value from the Data view screen
- CalcPpk The Ppk value from the Data view screen
- CalcR The r value from the Data view screen
- CalcRBar The rbar value from the Data view screen
- CalcSig The Sigma value from the Data view screen
- Datum The current datum status 0/1; absolute/incremental
- HiLimit The Nom + Limit value from the Tolerances screen
- HiWarn The Nom + Warn value from the Tolerances screen
- IsDD, IsDMS The current system angular units of measure
- IsInch, IsMM The current system linear units of measure
- MaxSGrp The Max Subgroups value from the SPC screen
- NextId The Next Record Id value from the SPC screen
- Nominal The Nominal value from the Tolerances screen
- NumRecs The number of records stored in the database for the current part
- LCL The LCL value from the SPC screen
- LoLimit The Nom - Limit value from the Tolerances screen
- LoWarn The Nom - Warn value from the Tolerances screen
- RecDate, RecTime The date and time that a specified record was stored in the P-400 DRO database
- RLCL The r Lcl value from the SPC screen
- RUCL The r Ucl value from the SPC screen
- SGrpSize The Subgroup size value from the SPC screen
- UCL The UCL value from the SPC screen
- XBarLCL The xbar Lcl value from the SPC screen
- XBarUCL The xbar Ucl value from the SPC screen

Press the Other softkey, then press the xtra softkey and scroll to Lookup. Press the Enter key to display the Lookup functions. Scroll to the desired function and press the Enter key to insert the function into the formula.



For example:

$$A = \text{Calc6Sig}(B)$$

A = 0.0345 when the 6 Sigma for dimension B is 0.0345 in the Data View screen

Data lookup function

The data lookup function is used to assign a value from the database of stored dimension values to a dimension, or to include it as the criterion of a comparison test. The data lookup function does not appear in any menu and must be constructed of a dimension label and parentheses containing record and part indexes as shown in the syntax example below:

$$C = A(\text{Record index}, \text{part index})$$

When no part index is specified, the current part records are used.

Database record elements are numbered starting with element 0 at the top of the list for each dimension. The most recently stored value is at the top. Value A(2) is the third element from the top of dimension A list (not the second) as shown below.

List indexes must be positive integers. An index that exceeds the range of a specified list results in an error message.

For example, using values from the screen at the right:

$$C = A(2)$$

$$C = 1.3013$$

Another example shows the syntax of a data lookup function that uses record and part indexes.

$$C = B(2,3)$$

$$C = 1.5710$$

The formula assigns the value of the third element of the data stored for dimension B of part 3 to dimension C.

Dimension A list

2:05:54 PM 8-15-03 mm [0] P0				
#242 / 1.3013				
A	B	C	D	
0.8013	0.9616	0.6218	-0.0193	A
0.8013	0.9616	0.6218	-0.0193	
1.3013	1.4616	1.1218	0.4808	B
1.3013	1.4616	1.1218	0.4808	
1.3013	1.4616	1.1218	0.4808	C
1.3013	1.4616	1.1218	0.4808	
1.3013	1.4616	1.1218	0.4808	D
1.3013	0.9616	1.1218	0.4808	
1.3013	0.9616	1.1218	0.4808	

Graph... Histo... Bar... Data... DRO...

2:10:31 PM 10-3-03 mm [0] P3				
#19 -0.0012				
A	B	C	D	
-0.0012	0.3010	1.6208	-1.1415	A
-0.0012	0.3010	1.6208	-1.1415	
-0.0012	0.3010	1.6208	-1.1415	B
-0.0012	0.3013	1.6214	-1.1411	
-0.0007	0.3012	1.6215	-1.1412	C
-0.0006	0.3012	1.6217	-1.1412	
-0.0006	0.3012	1.6217	-1.1412	D
-0.0006	0.3012	1.6217	-1.1412	
-0.0006	0.3012	1.6217	-1.1412	
-0.5006	0.8012	1.1217	-0.6412	

Graph... Histo... Bar... Data... DRO...

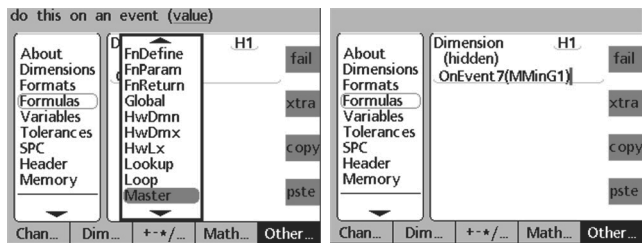
Master function

The Master function is used to perform a master calibration of input channel groups in response to remote I/O signals on the parallel port, key presses or, more rarely, tests performed in formulas. Mastering with remote I/O and key presses is implemented using the OnEvent function.

The input channel mastering uses values previously entered into master groups and the mastering type specified in the Master setup screen described in [Chapter 3: Setup](#); Mean or Min-Max. The Mean mastering type performs either a Min or Max channel preset at the current input probe position. Min-Max mastering performs a channel preset followed by a resolution calibration.

The order of Min-Max mastering operations can be Min preset followed by a Max to calibrate resolution, or a Max preset followed by a Min to calibrate resolution. In either case, the mastering type should be changed to Mean in the Master setup screen once the resolution is calibrated to prevent accidental recalibration when a new preset is performed.

Press the Other softkey, then press the xtra softkey and scroll to Master. Press the Enter key to insert the function into the formula. You will be prompted for the Min or Max preset type and the master group number.



MaxIndex and MinIndex functions

The MaxIndex and MinIndex functions return the position of either the minimum or maximum value in a list. The list can contain individual values, ranges of values or a mixture of both.

For example:

In the list (12, 34, 23, 67, 13) the position of the maximum value is 4

In the list (2, 45, 27, 41, 56) the position of the minimum value is 1

In the list (C1--C4, 7, A, 6, 4) the position of the maximum value is 1 when:

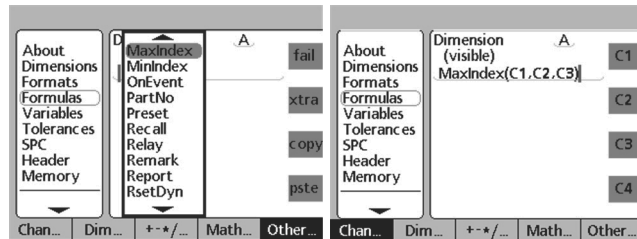
C1 = 2.0, C2 = 5.6, C3 = 2.1, C4 = 8.2

A = 3.8

Because one of the values in the range C1--C4 was the maximum in the list

Press the Other softkey to display the xtra menu softkey, scroll to MaxIndex or MinIndex. and then press the Enter key to insert the function into the formula. The syntax for MaxIndex or MinIndex is:

A = **MaxIndex**(List of values or ranges)



For example:

A = **MinIndex**(C1, C2, C3)

A = 2 when C1 = 2.5, C2 = 1.5, C3 = 3.7

PartNo function

The PartNo function is used to change part numbers from within a formula. The P-400 DRO database provides storage for up to 16 dimensions for each part. Applications involving more than one physical part or requiring greater than 16 dimensions can use multiple parts to provide additional database capacity.

Press the Other softkey to display the xtra menu softkey, scroll to PartNo, and then press the Enter key. The syntax for appending the PartNo function to a visible dimension formula is:

$$A = \text{Formula}; \mathbf{PartNo}$$

For example:

$$A = C4; \mathbf{Part2}$$

A = C4 and changes the current part to part number 2

The syntax for assigning the PartNo function to a hidden dimension is:

$$H1 = \mathbf{PartNo}$$

or

$$H1 = \text{Function}(\mathbf{PartNo})$$

For example:

$$H1 = \text{OnEvent Wide 1}(\mathbf{Part2})$$

Changes the current part to part number 2 when the left widekey is pressed

In this example, users are given access to parts in the P-400 DRO by password:

$$H2 = \text{Ask1}''\text{Pass}''$$

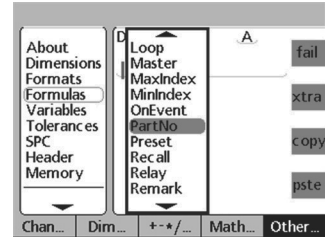
$$H3 = \text{Case}(H2 == 1234, \mathbf{Part1}, H2 == 5678, \mathbf{Part2}, \mathbf{Part3})$$

The user is prompted for a password

 Password 1234 causes part 1 to be active

 Password 5678 causes part 2 to be active

 Any other password causes part 3 to be active



Preset function

The Preset function is used to preset a dimension to a specified value.

Press the Other softkey to display the xtra menu softkey, scroll to Preset and then press the Enter key. The syntax for appending the Preset function to a visible dimension formula is:

$$A = \text{Formula}; \mathbf{Preset}(\text{Dimension}, \text{value})$$

For example:

$$A = C1; \mathbf{Preset}(B, 1.25\text{mm})$$

A = C1 and dimension B is preset to 1.25mm

The syntax for assigning the Preset function to a hidden dimension is:

$$H1 = \mathbf{Preset}(\text{Dimension}, \text{value})$$

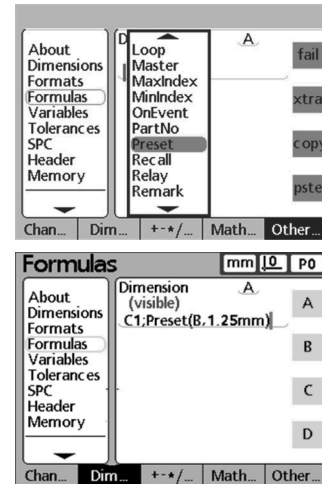
or

$$H1 = \text{Function}(\mathbf{Preset}(\text{Dimension}, \text{value}))$$

For example:

$$H1 = \text{OnEvent Wide 1}(\mathbf{Preset}(B, 1.25\text{mm}))$$

Presets dimension B to 1.25mm when the left widekey is pressed



Recall function

The Recall function is used to reestablish the last dimension preset value or values specified using the Preset function. All dimension presets last applied will be recalled. The Recall function is generally included in an OnEvent, If or Case function.

Press the Other softkey to display the xtra menu softkey, scroll to Recall and then press the Enter key. The syntax for appending the Recall function to a visible dimension formula is:

$$A = \text{Formula}; \textit{Recall}$$

For example:

$$A = C1; \textit{Recall}$$

A = C1 and all the latest dimension presets are recalled as current presets

The syntax for assigning the Recall function to a hidden dimension is:

$$H1 = \textit{Recall}$$

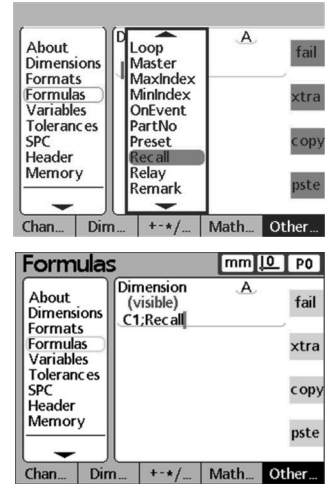
or

$$H1 = \text{Function}(\textit{Recall})$$

For example:

$$H1 = \text{OnEvent Wide 1}(\textit{Recall})$$

Recalls the most recent dimension presets when the left widekey is pressed

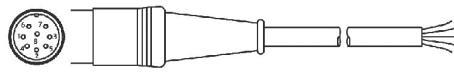
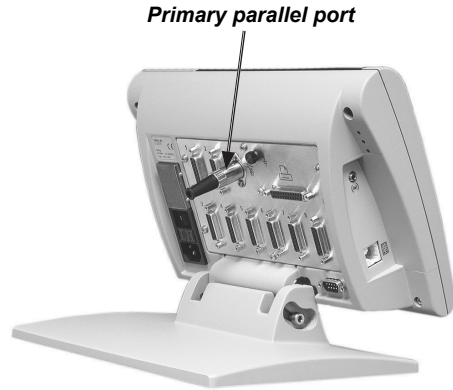
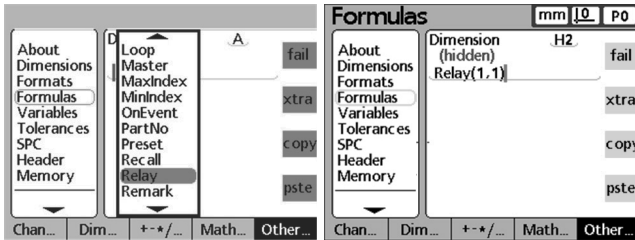


Relay output function

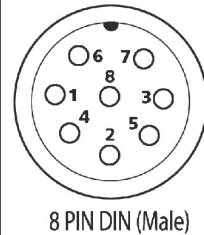
The Relay function provides formula control of electrical relay contact operation.

The contacts of two single-pole, double-throw dry-contact relays are accessible on the rear of the P-400 DRO for special applications requiring low-power electrical switching. The normally open and normally closed contacts of both relays are available for use in low-current, low-voltage applications. The electrical requirements of the relay and relay output jack are contained in [Chapter 8: Reference](#).

Press the Other softkey to display the xtra menu softkey, then scroll to Relay and press the Enter key to insert the function into the formula.



8 Pin Conn.	Signal
1	Relay 1 Input
2	Relay 1 Normally Closed
3	Relay 2 Normally Open
4	Relay 1 Normally Open
5	Relay 2 Normally Closed
6	Relay 2 Input
7	-
8	-



The relay function can be used by itself or included in if or case statements as the logical result of either passing or failing a comparison test.

The syntax for using the relay function appended to a formula is:

A = Formula;**Relay**(Relay number, state, delay)

Where:

Relay number = 1 or 2

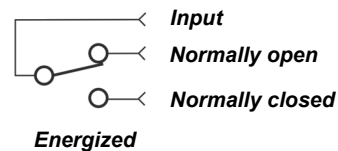
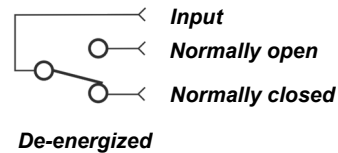
State = 0 (off/low/**de-energized**) or 1 (on/high/**energized**)

Delay = The time in seconds that the relay will be in the new state before returning to the previous state

For example:

A = C3;**Relay**(1,1,2)

A = C3 and Relay number 1 will be energized for 2 seconds



Report function

The Report function is used to print reports on the USB port. Contents can include a user-specified range, all new records (never before reported), all records or a record selected in the data view.

Press the Other softkey to display the xtra menu, then scroll to Report. Press the Enter key and select the desired report contents. The syntax for appending the Report function to a visible dimension formula is:

A = Formula;**Report**

For example:

A = C1;**ReportNew**

A = C1 and a report is printed of new records

The syntax for assigning the Report function to a hidden dimension is:

H1 = **Report**

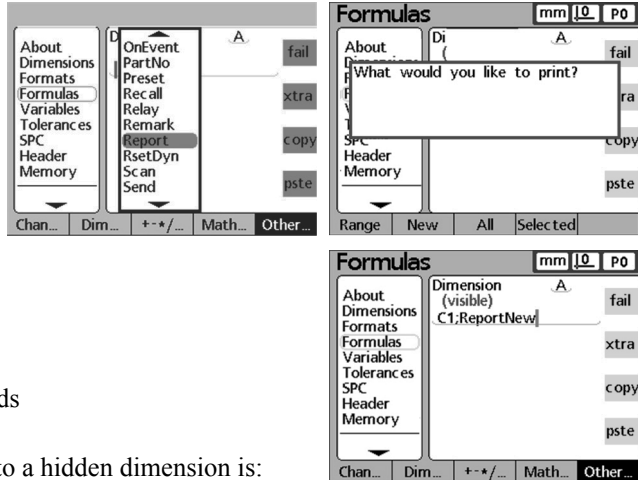
or

H1 = Function(**Report**)

For example:

H1 = OnEvent Wide 1(**ReportNew**)

Prints a report of new records when the left widekey is pressed



Scan function

The scan function rapidly collects potentially large quantities of measurement data from all input channels simultaneously. When the scan function is initiated, all channel inputs are collected in a series of data records that are stored in a temporary memory buffer. No data are displayed on the DRO and no formulas are evaluated during the scanning period. This process is explained in detail below and shown by the flowchart on the next page.

The basic syntax of the scan function is:

```
Scan (ch, st, inc, dp, to)
```

Parameters specified for the scan function include:

ch (Reference channel)

Scans of all channels are collected at predetermined intervals that are measured by the reference channel

st (Starting value)

Scans begin when the reference channel measurement reaches this value

inc (Scanning increment)

A new scan is performed each time the reference channel value increases (or decreases) by this increment value. The scans continue only when the increments progress in the same direction (+ or -) over the scanning cycle.

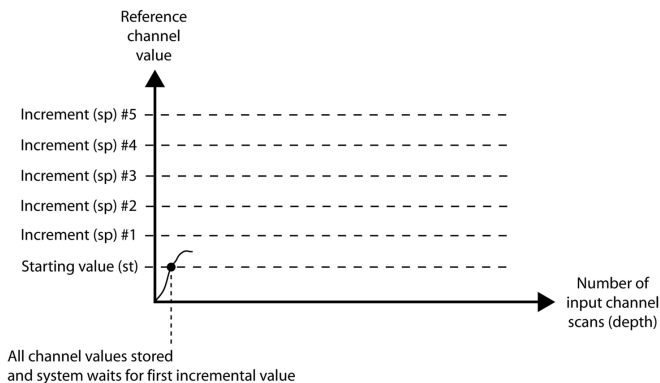
dp (Depth of scans)

Scans are accumulated in a temporary buffer memory until the specified depth (number) of scans has been collected, or until the timeout interval has elapsed.

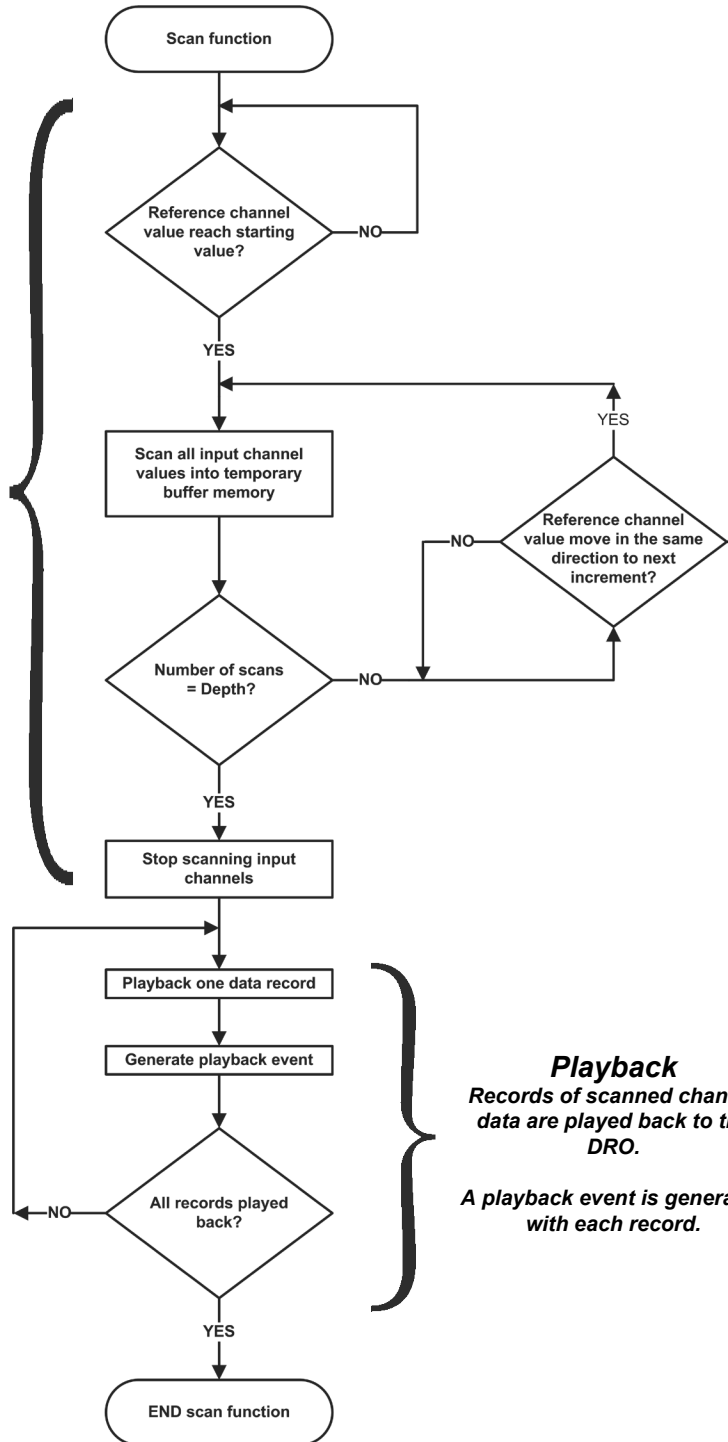
to (Timeout interval)

Scanning is aborted if the timeout interval expires before the specified depth of scans have been collected. A RsetDyn function must be performed before the Scan function can be used again.

When scanning begins, the reference channel value (ch) is compared to the Starting value (st) parameter. When the reference channel value reaches the starting value, all channel inputs are scanned once and stored in a temporary memory buffer. The system then waits for the reference channel value to cross the first increment above (or below) the starting value.



Scanning
 All input channel values are scanned into a buffer memory.
 The scan function is aborted if a timeout occurs before the specified depth of scans has been collected.
 A RsetDyn function must occur before using the scan function

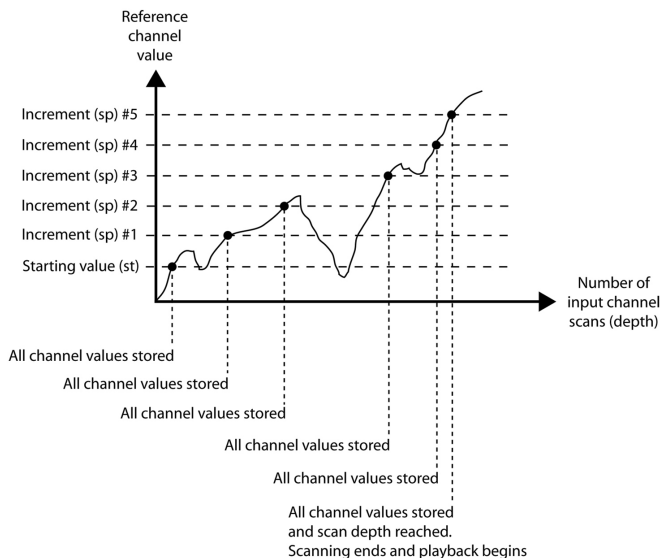


Playback
 Records of scanned channel data are played back to the DRO.
 A playback event is generated with each record.

Each time the value of the reference channel increases or decreases by the specified increment (inc), another scan of all input channels is collected and stored in the temporary buffer. Input channel scanning continues in this manner at each new increment until the specified depth of scans (dp) is collected.

Reference channel values between increments are irrelevant to the process as long as the values pass through increments in one direction.

The scan function is aborted if the timeout interval (to) elapses before the specified depth of scans is collected.



When the specified depth of scans has been collected, the channel data are immediately played back and displayed on the DRO in the order they were scanned. A playback event is generated each time a record is played back. This playback event is used in conjunction with the onevent function to enter the scanned data into the P-400 DRO database, include the data in the formulas or send the data to a computer. A RsetDyn function must be performed to clear the buffer before the Scan function can be used again.

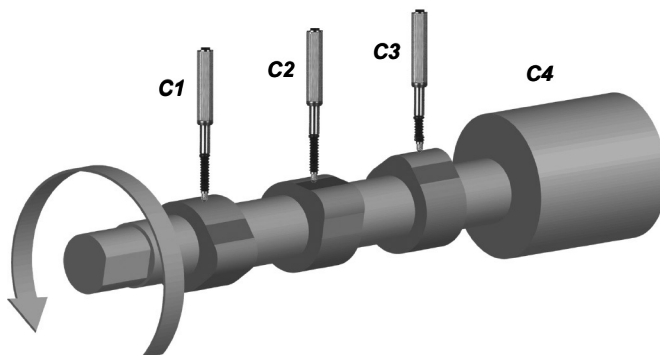
Scanning input channels

The scan function is generally included in another function as an operation to be performed in response to a condition or an event. The syntax for including the scan function in this manner is:

H1 = Function(Scan (ch, st, inc, dp, to))

In the following two examples, camshaft lift profiles will be measured at 1 degree intervals over 360 degrees of rotation using a reference channel rotary encoder and three cam encoders.

In these examples, the number 5 key is pressed to generate an event that initiates scanning.



The method of playing back scanned data is unique to each of the two examples. However, in both cases, the OnEvent function is used to route the data.

Example 1: Scanning data to the P-400 DRO database

The channels are scanned and then entered into the database using the Trip function and Playback event. Scanning is initiated by pressing the number 5 key, and then 360 scans are collected at 1 degree increments. If all the specified scans are not complete within the timeout period of 60 seconds, the scan function is aborted. During playback, each time a Playback event occurs, a record of dimension values is entered into the P-400 DRO database.

H1 = OnEvent 5(Scan (C4,0 Deg,1Deg,360,60 sec))

A = C1

B = C2

C = C3

D = C4

H2 = OnEvent Playback (Trip (,,))

Example 2: Scanning data to the RS-232 serial port

The channels are scanned and then transmitted to the RS-232 serial port using the SendRec function and Playback event. Scanning is initiated by pressing the number 5 key, and then 360 scans are collected at 1 degree increments. If all the specified scans are not complete within the timeout period of 60 seconds, the scan function is aborted. During playback, each time a Playback event occurs, a record of dimension values is transmitted to the RS-232 serial port.

H1 = OnEvent 5(Scan (C4,0 Deg,1Deg,360,60 sec))

A = C1

B = C2

C = C3

D = C4

H2 = OnEvent Playback (SendNewRec)

Send function

The Send function is used to transmit the current value of the formula's dimension or other numeric data over the parallel or RS-232 serial port. Parallel and serial ports are configured for transmissions in the Parallel and RS-232 setup screens. The Send function cannot be used on the parallel port when the parallel port is configured as a general purpose data I/O port in the Parallel setup screen.

Press the Other softkey to display the xtra menu softkey, then scroll to Send. Press the Enter key to include the function. The syntax for appending the Send function to a visible dimension formula is:

A = Formula;*Send*

For example,

A = C4;*Send*

A = C4, and dimension A data is transmitted to a port

The syntax of the Send function can be extended to transmit the value of a number (constant) or any expression that can be evaluated as number, and can also include display resolution formatting.

A = Formula;*Send(number,display resolution)* or A = Formula;*Send(expression,display resolution)*

For example:

A = C1;*Send((B+D),0.001)*

A = C1 and the value of the expression (B+D) is transmitted to a port with 3 decimal places

The syntax for assigning the Send function to a hidden dimension is:

H1 = *Send*

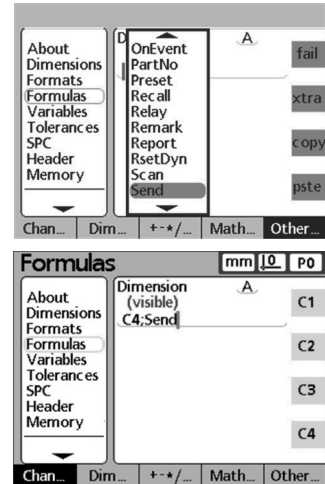
or

H1 = Function(*Send*)

For example:

H1 = OnEvent Wide 1(*Send*)

Transmits data to a port when the left widekey is pressed

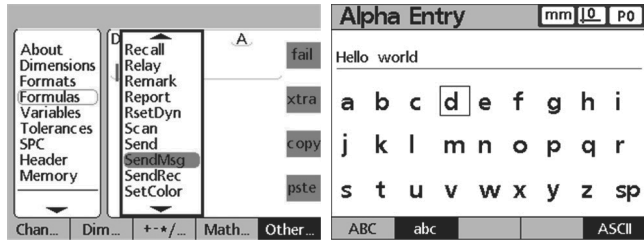


SendMsg function

The Send Msg function is used to transmit text or ASCII codes over the RS-232 port.

Press the Other softkey, the xtra dimension softkey, scroll to SendMsg and press the Enter key to display the Alpha Entry screen.

Text messages and ASCII codes are entered into the Alpha Entry screen.

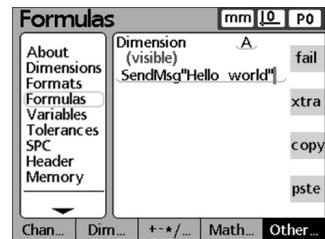


Text characters

Press a softkey to select the desired upper or lower case, use the cursor keys to highlight the desired text character, and then press the Enter key to include the character in the message.

ASCII codes

ASCII codes can precede or follow text characters or text strings. Press the ASCII softkey prior to entering the ASCII code from the numeric keypad. The < symbol will appear on the message line. No separation is allowed between ASCII codes and text.



The syntax for appending the SendMsg function to a visible dimension formula is:

A = Formula;*SendMsg*

For example:

A = C1;*SendMsg*"Hello world"

A = C1 and the message "Hello world" is transmitted to the RS-232 port

The syntax for assigning the SendMsg function to a hidden dimension is:

H1 = *SendMsg*

or

H1 = Function(*SendMsg*)

For example:

H1 = OnEvent Wide 1(*SendMsg*)

Transmits a message when the left widekey is pressed

SendRec function

The SendRec function is used to send records over the parallel or RS-232 (serial) ports.



NOTE

Parallel and serial ports are configured for transmissions in the Parallel and RS-232 setup screens. The SendRec function cannot be used on the parallel port when the parallel port is configured as a general purpose data I/O port in the Parallel setup screen.

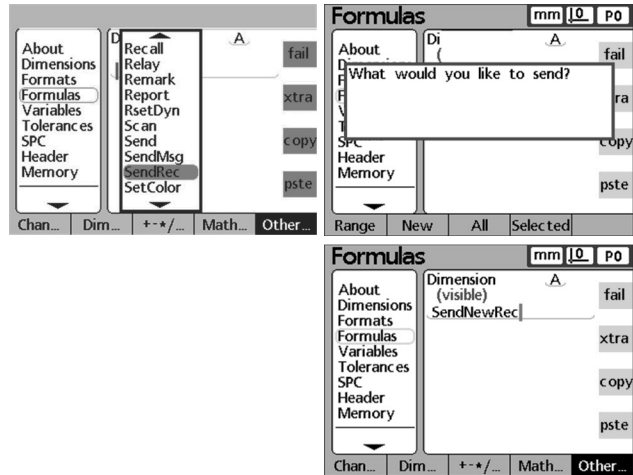
Press the Other softkey to display the xtra menu softkey, then scroll to SendRec. Press the Enter key and select the desired transmission contents. The syntax for appending the SendRec function to a visible dimension formula is:

A = Formula;*SendRec*

For example:

A = C4;*SendRec*

A = C4 and record data is transmitted



The syntax for assigning the SendRec function to a hidden dimension is:

H1 = *SendRec*

or

H1 = Function(*SendRec*)

For example:

H1 = OnEvent Wide 1(*SendRec*)

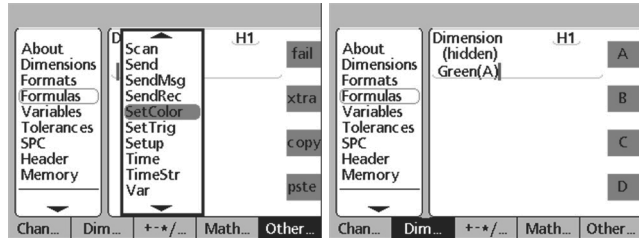
Transmits record data when the left widekey is pressed

SetColor function

The SetColor function is used to set the DRO display color of a single dimension. The SetColor function only changes colors in the DRO screen, and has no affect on other screens. The color of a dimension can be changed to highlight the result of an If test or Case sort, or to emphasize some other state or condition.

Press the Other softkey to display the xtra menu softkey, then scroll to SetColor. Press the Enter key and select the desired color and dimension. The syntax for using the SetColor function is:

$H_n = \text{SetColor}(\text{Dimension})$



For example:

$H1 = \text{SetColor}(A)$

Select green in response to prompt, then

$H1 = \text{Green}(A)$

and dimension A is displayed in green on the DRO

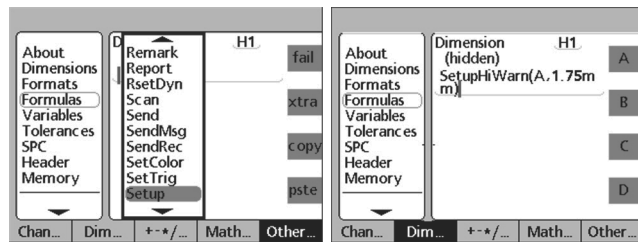
Setup function

The Setup function is used to specify bar graph parameters for the current part including:

- Max value (BarMax)
- Min value (BarMin)
- High limit (HiLimit)
- High warning (HiWarn)
- Low limit (LoLimit)
- Low warning (LoWarn)
- Nominal value (Nominal)

Press the Other softkey to display the xtra menu softkey, then scroll to Setup. Press the Enter key and specify the bar graph parameter, value and dimension. The syntax for using the Setup function is:

Hn = **Setup**Parameter(Dimension,value)



For example:

H1 = **Setup**HiWarn(A,1.75mm)

H1 = **Setup**HiWarn(B,2.00mm)

H1 = **Setup**HiWarn(C,2.25mm)

H1 = **Setup**HiWarn(D,2.50mm)

Sets the Bar graph high warning parameters of dimensions A through D to different values.

Xlatch function

The XLatch function is used to latch and assign the value of a channel to a dimension when an edge is detected on an optional edge-detection input.



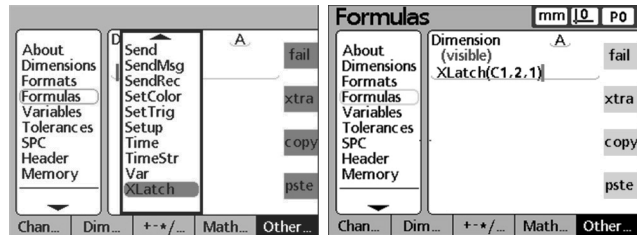
NOTES

The XLatch function is available only when the edge detection option is specified for the P-400 DRO at the time of purchase. This option cannot be installed in the field.

Edge detection and relay functions alternately use the same connector located on the P-400 DRO rear panel. When the edge detection option is included, relay output functions are not available.

Press the Other softkey, then press the xtra softkey and scroll to XLatch. Press the Enter key to insert the function into the formula.

The syntax of the XLatch function is:



$A = \text{XLatch}(\text{Channel, edge line \#, auto trip})$

Edge lines numbers are:

- 1 = Single edge option
- 2 = First of two for double edge option
- 3 = Second of two for double edge option

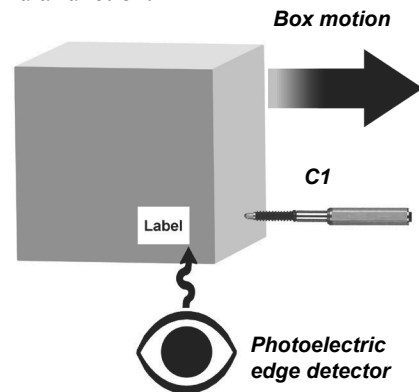
Auto trip numbers are:

- 1 = Auto trip enabled
- 0 = Auto trip disabled

A Trip function event can be initiated to automatically enter the latched channel value into the P-400 DRO database when an edge is detected by enabling auto trip in the formula function.

In this example, the horizontal position of a label on a box will be measured by latching the value of C1 when the label edge is recognized by a photoelectric sensor C2 connected to edge line # 2. When the edge of the label is detected, dimension A is automatically entered into the P-400 DRO database by an auto trip event.

$A = \text{XLatch}(C1,2,1)$



Chapter 5: Operation

The P-400 DRO can be operated as a digital readout for manual measurements conducted completely under operator control, or as a semi-automated multipoint measurement system in conjunction with a fixtured gage. In either case, operation of the P-400 DRO is very straightforward, requiring only a basic understanding of the available panel controls and LCD screens.

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Front Panel Keys and LCD Screens

The P-400 DRO combines front panel keys and color LCD screens to provide a simple, intuitive operator interface for setting up and conducting measurements, and for reviewing measurement data and SPC information.

The P-400 DRO front panel keys and LCD screens are explained in the following pages. Please read this portion of the guide carefully as subsequent operating instructions depend on a familiarity with the key functions, screen content and screen hierarchy descriptions.

Front panel keys

Front panel keys include:

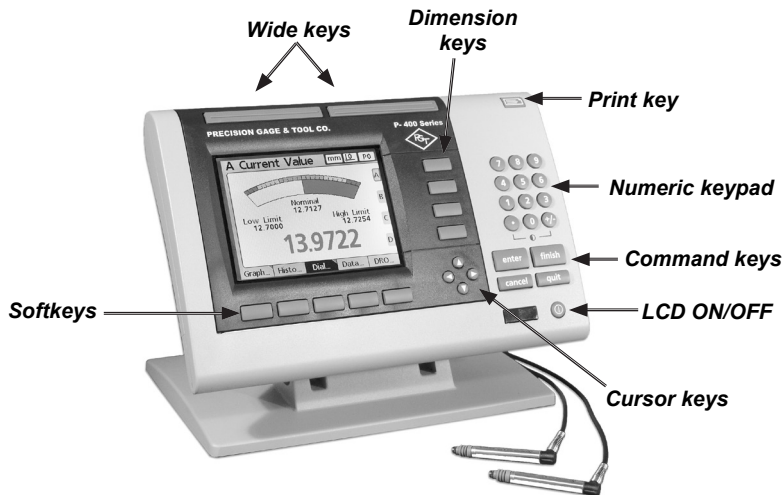
- Command keys
- Cursor keys
- Print key
- Wide keys
- Numeric keypad
- LCD ON/OFF
- Dimension keys
- Softkeys

Command keys

The command keys are used to enter individual data points, finish a data entry session, cancel (or delete) the last data entry, or quit the current activity and return to the DRO screen.

Enter key

Enters data for a measurement. Information on the LCD is stored as measurement or configuration data. This information includes current dimension values or alphanumeric data for a configuration or user-prompt data field.



Finish key

In general, the Finish key is used to exit a screen saving any changes that were made. The Finish key may also be used to return from the display of measurement or SPC data to the current DRO screen.

Cancel key

Erases the last data value entered into the system from the numeric keypad. The Cancel key can also be used to delete any highlighted alphanumeric characters from data fields shown on the screen.

Quit key

The Quit key aborts the current task and returns to the previous screen. The Quit key can also be used to exit the current menu.

Cursor keys

The 4 cursor keys are used to scroll menu lists and to navigate through the hierarchy of screens.

Print key

Pressing the Print key transmits data corresponding to the screen contents to the USB printer port.

Screen displayed

DRO Screen:

Data View:

Graph Views:

Setup Menu:

Data Transmitted

Currently displayed dimension values

Stored dimension data as specified by the user in response to a prompt message.

Currently displayed graph, including:

- Dimension values or histogram for subgroups of 1
- or
- xbar and r for subgroups greater than 1.

A list of all P-400 DRO setup parameters.

Wide keys

The wide keys can be configured as hot keys to initiate frequently used functions in the Hot Keys setup screen. Refer to [Chapter 3: Setup](#) for details regarding Hot Key setup.

The keypad is used primarily for numeric data entry. The decimal point key and +/- key can also be used to increase or decrease the LCD screen contrast when a decimal point or +/- input are not expected by the system as part of a data entry process. The screen contrast setting will be saved when the system is powered down and used as the default contrast setting the next time the system is turned on.

LCD on/off

The LCD on/off key toggles the LCD display on and off without removing power from the instrument. The LCD on/off key can also be used to clear channel calibrations, delete data stored for a single part or delete data stored for all parts.

Dimension keys

Dimension keys can be assigned one of six hotkey functions for use when the DRO screen is displayed. When graph, bar value and data screens are displayed, the dimension keys are used to display values for single dimensions or a smaller group of dimensions.

When Viewing...

Pressing the dimension Softkey...

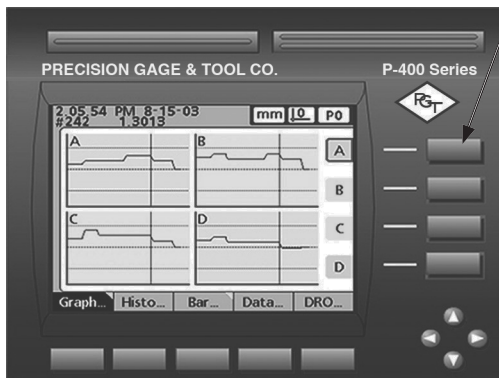
DRO screen:	Performs the function assigned in the Hotkey setup screen. By default, no hotkey function is assigned until the user makes the assignment.
Graph screens:	Displays a single graph for the corresponding dimension.
Bar screens:	Displays a single bar showing current values for the corresponding dimension.
Data screens:	Displays a single data table of stored values for the corresponding dimension.



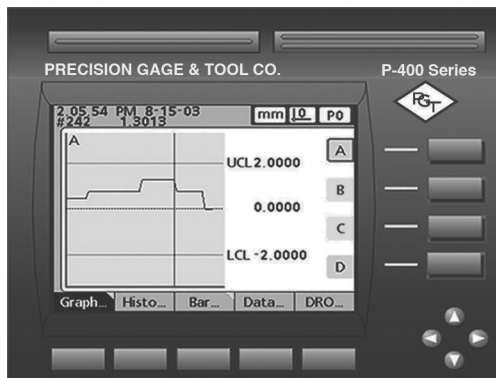
NOTE

Hotkey assignments are discussed in detail in [Chapter 3: Setup](#).

Dimension A key



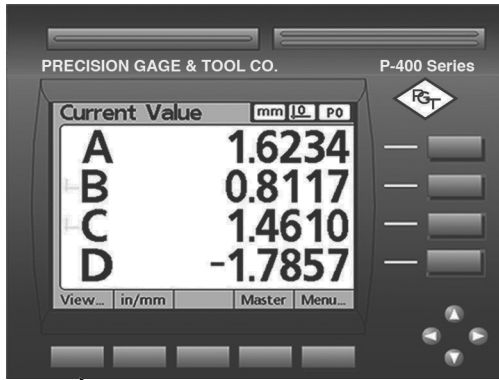
Pressing the dimension A key in a graph screen...



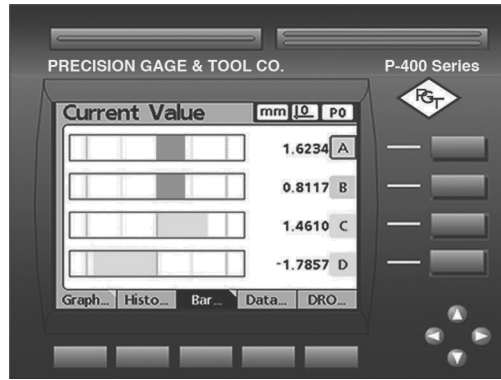
selects the dimension A graph for display

Softkeys

The softkeys initiate functions that are labeled above the keys at the bottom of the LCD screen. As different system functions are selected, the softkey labels change in support.



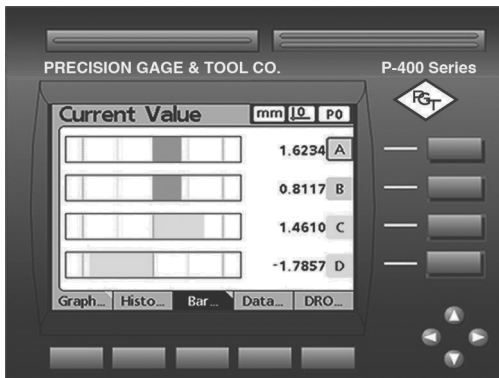
Pressing the View softkey...



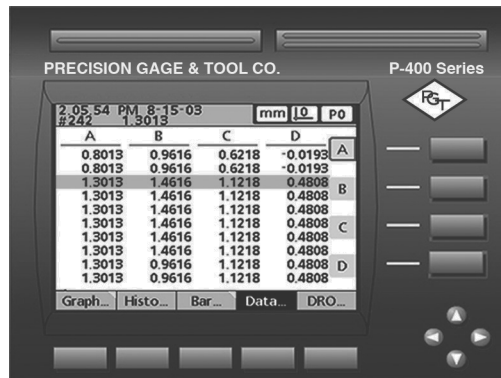
causes softkey labels to change in support, offering 5 options for viewing data

In the example above, pressing the View softkey of the left screen changes softkey labels to those at the bottom of the right screen. The new softkeys offer 5 options for viewing current and stored data.

When viewing graphs of stored data, current value bars or tables of stored data, pressing a different softkey changes to the view indicated by the softkey label.

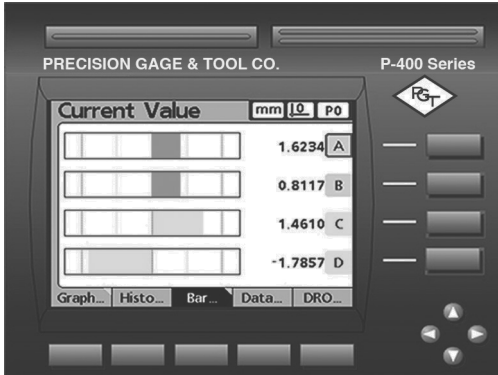


Pressing the Data softkey when viewing bars...



causes the dimension data table to be displayed

Pressing the currently highlighted softkey alternates between single-dimension and multiple-dimension displays.



Pressing the Bar softkey when viewing multiple-dimensions...



causes the currently selected dimension to be displayed by itself

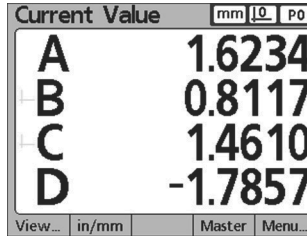
The leftmost 4 softkeys can be designated as hot keys to provide quick access to commonly used functions when the DRO screen is displayed. More about hot keys is contained in [Chapter 3: Setup](#).

LCD Screens and menus

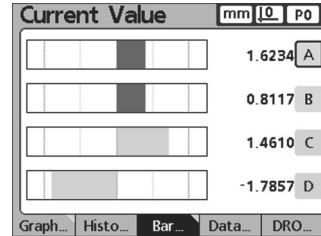
The large-character color LCD presents a variety of screens and menus selected by the user to display current dimension values, pass/fail test results, dimension value graphs, statistical process control graphs and data tables, and setup and part configuration options.

Screen navigation

As suggested by the diagrams shown on subsequent pages, navigation from one screen to another is very straightforward. For example, to display a bar graph of current values from the DRO screen, press the View softkey and then the Bar softkey.



Press the View softkey...



then the Bar key

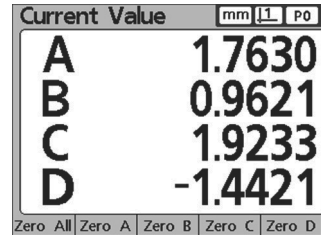
Home screen

The home screen is displayed after the startup screen when power is applied to the P-400 DRO, and is displayed after the Finish key is pressed to complete a measurement or screen evaluation. The default home screen is the DRO, but can be reassigned to another screen in the Display setup screen. The assignment of the home screen is discussed in detail in [Chapter 3: Setup](#).

DRO screen

The DRO screen is the default home screen displayed after power is applied and the startup screen is shown. The DRO screen provides numeric displays of the current values of up to 4 dimensions. The unit of measure, current datum and current part number or part name are displayed in the upper right corner of the screen.

Use the cursor keys to scroll dimensions when more than 4 dimensions are active.



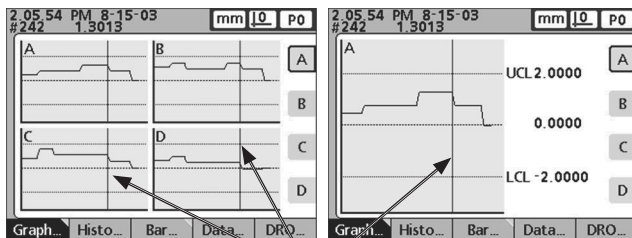
View screens

The screens accessed by pressing the View softkey are shown on the next page.

Dimension graphs for SPC subgroups of one

The dimension graph screen is displayed for SPC subgroups of 1, and displays graphs for up to 16 dimensions.

Press the Graph softkey to change the number of graphs presented on the screen. Press a dimension softkey to display a graph of the dimension and the minimum additional dimensions. Use the cursor keys to scroll the graphs when more data is stored than will fit on the screen.



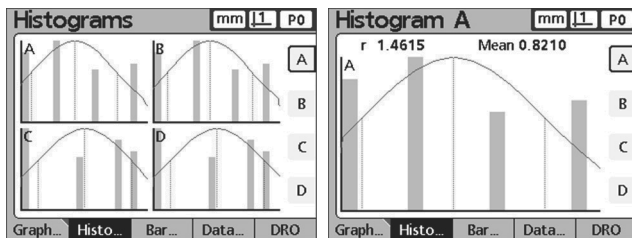
Vertical selection lines

Individual samples are selected by a vertical line on the graph. Move the vertical line left and right through the stored data using the cursor keys. The time and date that the selected sample was stored are shown in the upper left corner of the screen. The ID number of the sample for the dimension and the value of the data are also shown in the upper left corner. Displays of a single dimension also show the nominal and control limit values.

Dimension histograms for SPC subgroups of one

The dimension histogram screen displays histograms of values for up to 16 dimensions. The dimension histogram screens are displayed for SPC subgroups of one.

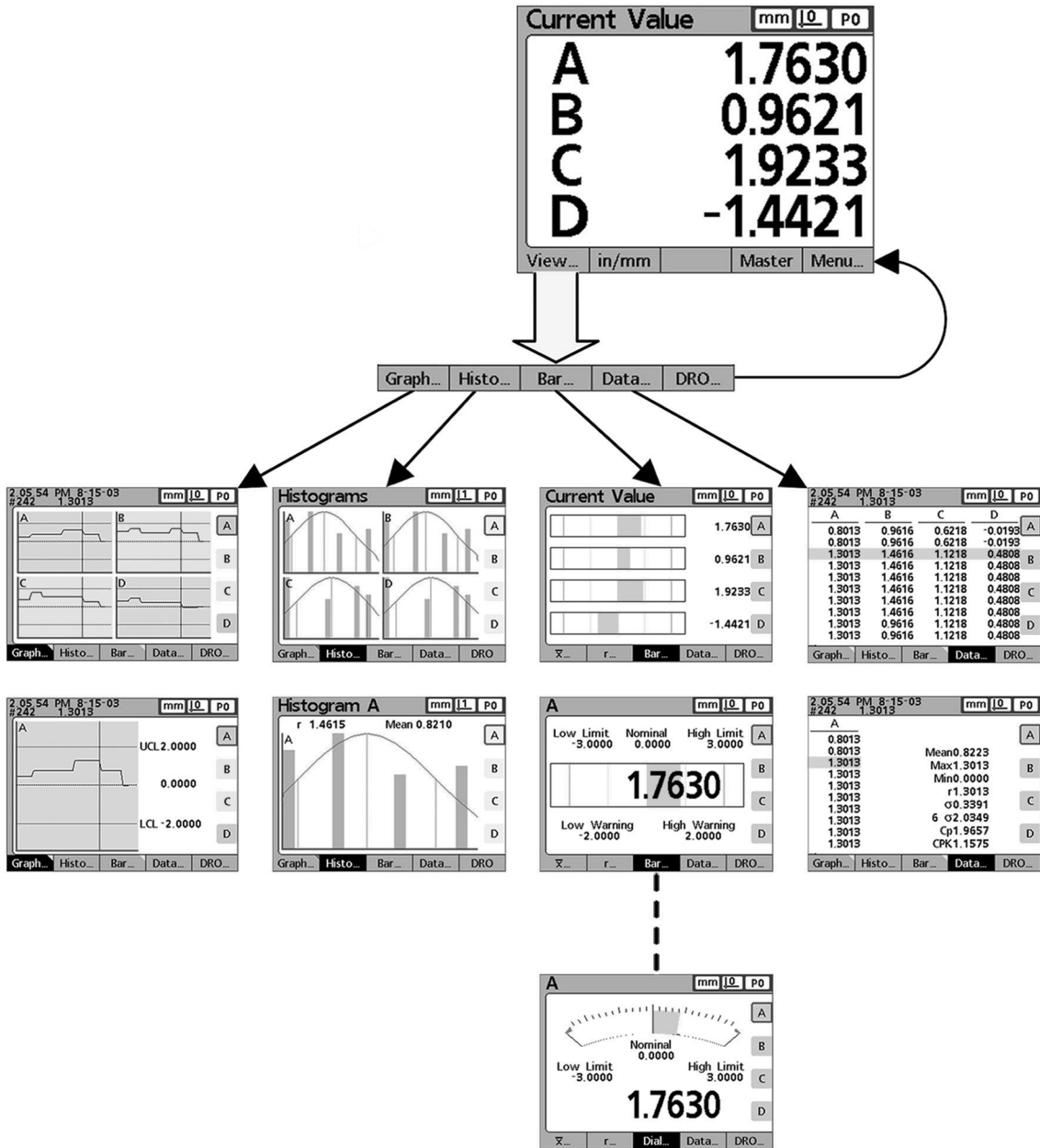
Press the Histo softkey to change the number of histograms presented on the screen. Press a dimension softkey to display the histogram of a single dimension.



The display of a single dimension also shows the total range and mean of the values.

Bar and dial current value displays

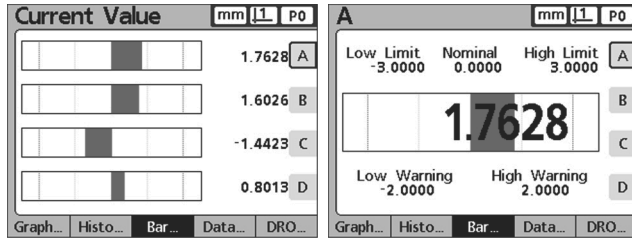
The bar and dial screens provide graphic displays of the current values of up to 16 dimensions. The default bar screen can be configured to display current value bars in horizontal or vertical orientation using the Display setup screen.



5 Operation

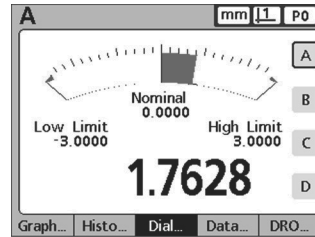
View screens displayed for SPC subgroups of one

Bar displays of multiple dimensions show current values. Bar displays of single dimensions include the current value, nominal value, and high and low warning and limit values.



Press the Bar softkey to change the number of bars presented on the screen. Press a dimension softkey to display a bar for a single dimension.

The display can be configured in the Display setup screen to include a dial in addition to the bars. When the dial display is also available, press the Bar softkey to toggle between the bars and the dial.



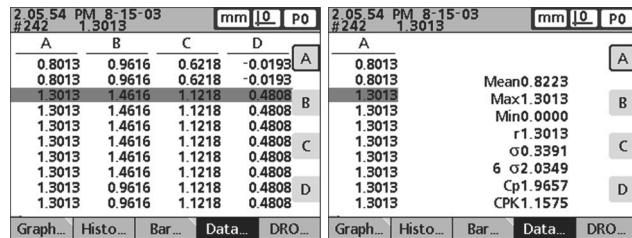
NOTE

The display of a single dimension can be configured to be a bar or a dial, but cannot be toggled between a single bar and a single dial.

Dimension data tables for SPC subgroups of one

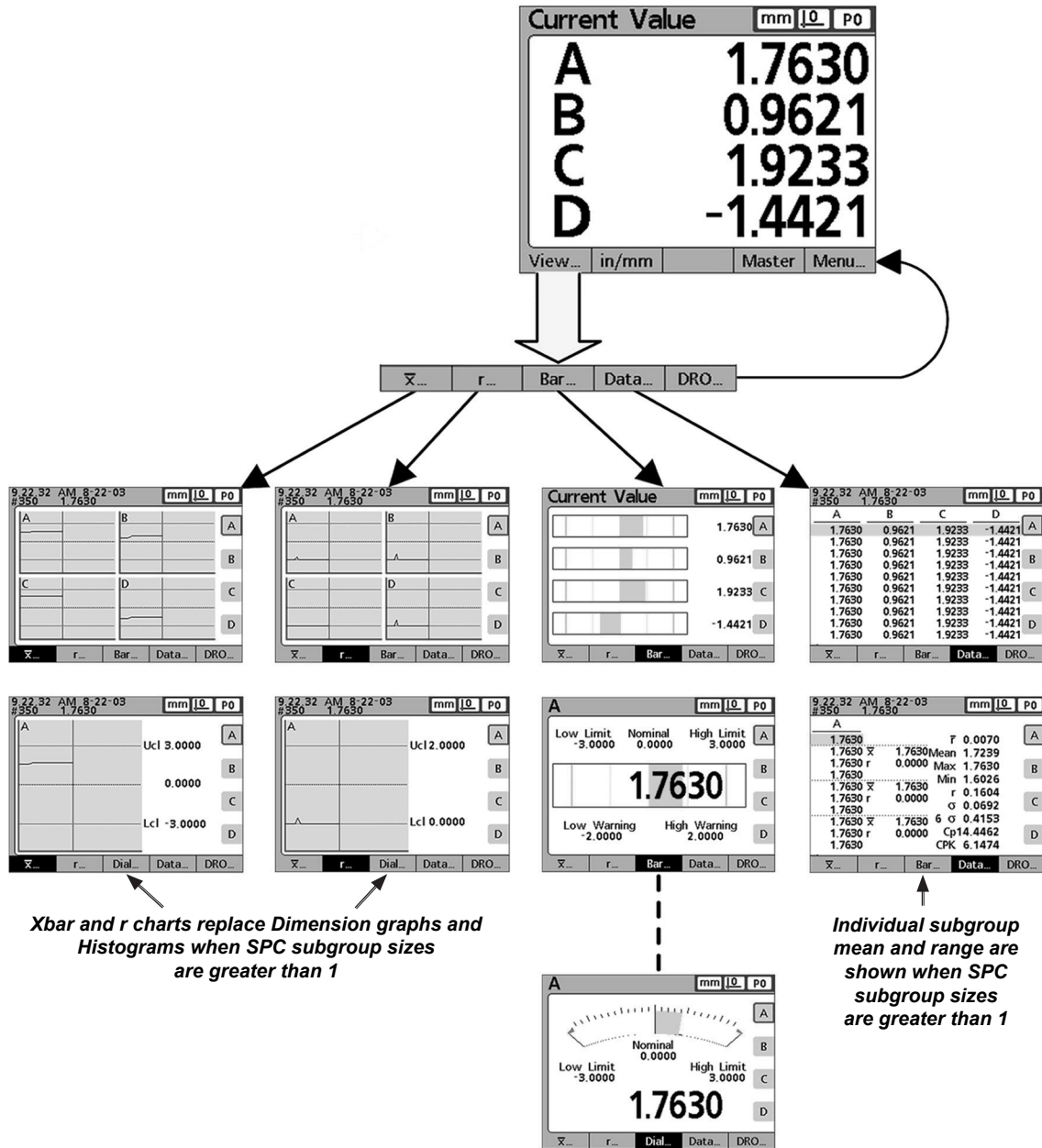
Dimension data screens contain measurement data stored for up to 4 dimensions. Press the Data softkey to toggle between views of data for all dimensions and data for a single dimension that includes SPC statistics.

Press a dimension softkey to display data for a single dimension. Use the cursor keys to scroll the tables when more data is stored than will fit on the screen.



Dimension Xbar charts for subgroups greater than one

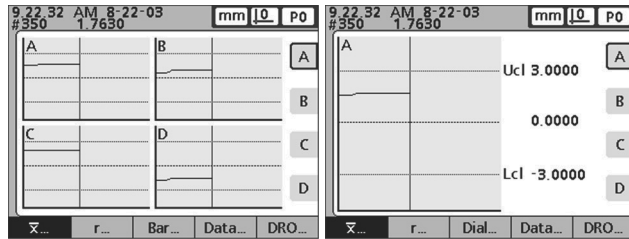
The Dimension Xbar screen is displayed in place of the Value Graph screen discussed earlier for SPC subgroups greater than 1, as shown on the next page. The Dimension Xbar screen graphs the mean (\bar{X}) of each subgroup for up to 16 dimensions.



View screens displayed for SPC subgroups greater than one

Press the \bar{x} softkey to change the number of graphs presented on the screen. Press a dimension softkey to display a graph of a single dimension.

Use the cursor keys to scroll the graphs when more data is stored than will fit on the screen.



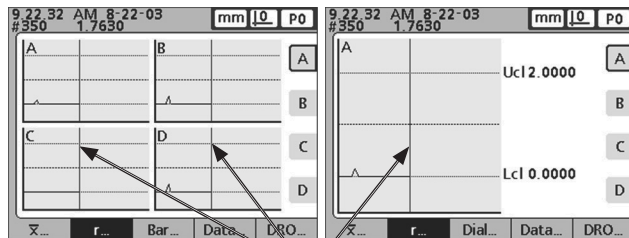
Individual subgroups are selected by a vertical line on the graph. Move the vertical line left and right through the stored data using the cursor keys. The time and date when the selected subgroup data was stored are shown in the upper left corner of the screen. The ID number of the subgroup and the value of the data for the dimension are also shown in the upper left corner. Displays of single dimensions also show the control limits.

Dimension r charts for subgroups greater than one

The dimension r screen is displayed in place of the Histogram screen discussed earlier for SPC subgroups greater than 1, as shown on the previous page. The dimension r screen graphs the range (r) of each subgroup for up to 16 dimensions. The range is not recalculated for each measurement, but is recalculated each time a subgroup is completed. Refer to the SPC information contained in [Chapter 8: Reference material](#) for details.

Use the cursor keys to scroll the graphs when more data is stored than will fit on the screen.

Individual subgroups are selected by a vertical line on the graph. Move the vertical line left and right through the stored data using the cursor keys. The time and date when the selected subgroup data was stored are shown in the upper left corner of the screen. The ID number of the subgroup and the value of the data for the dimension are also shown in the upper left corner. Displays of single dimensions also show the range control limits.



Vertical selection lines

Dimension data tables for subgroups greater than one

Dimension data screens display measurement data for up to 4 dimensions. The Data screen for a single dimension is slightly different for SPC subgroups > 1 than those for SPC subgroups of 1. Individual subgroups are indicated by a horizontal line in tables for single dimensions. The data table for multiple dimensions remains unchanged for SPC subgroups > 1.

Press the Data softkey to toggle between views of data for all dimensions and data for a single dimension that includes SPC statistics. Press a dimension softkey to display data for a single dimension.

9:22:32 AM 8-22-03 #350 1.7630 mm [0] P0					9:22:32 AM 8-22-03 #350 1.7630 mm [0] P0					
A	B	C	D		A					
1.7630	0.9621	1.9233	-1.4421	A	1.7630	\bar{x}	1.7630	Mean	1.7239	A
1.7630	0.9621	1.9233	-1.4421	B	1.7630	r	0.0000	Max	1.7630	B
1.7630	0.9621	1.9233	-1.4421	C	1.7630	\bar{x}	1.7630	Min	1.6026	C
1.7630	0.9621	1.9233	-1.4421	D	1.7630	r	0.0000	r	0.1604	D
1.7630	0.9621	1.9233	-1.4421		1.7630	\bar{x}	1.7630	σ	0.0692	
1.7630	0.9621	1.9233	-1.4421		1.7630	\bar{x}	1.7630	6 σ	0.4153	
1.7630	0.9621	1.9233	-1.4421		1.7630	r	0.0000	Cp	14.4462	
1.7630	0.9621	1.9233	-1.4421		1.7630			CPK	6.1474	
\bar{x} ...	r...	Bar...	Data...	DRO...	\bar{x} ...	r...	Bar...	Data...	DRO...	

Use the cursor keys to scroll the tables when more data is stored than will fit on the screen.

The time and date when the highlighted subgroup data was stored are shown in the upper left corner of the screen. The ID number of the subgroup and the value of the data for the dimension are also shown in the upper left corner.

in/mm menu item

Pressing the in/mm menu softkey toggles the display of distance between inch and millimeter units of measure. This does not alter the channel configurations in the Channel setup screen. The P-400 DRO simply calculates the conversion from one unit of measure to another as a convenience to the user.

Current Value		mm [0] P0
A	1.7630	
B	0.9621	
C	1.9233	
D	-1.4421	
View...	in/mm	Master Menu...

Converts units of measure for display purposes only

Master menu item and screens

Master screens are used to calibrate the encoder datums or transducer input channel ranges. The Master function is configured in the Master setup screen to either calibrate datum D0 for encoders, or calibrate datum D0 and the entire channel range for transducers.



NOTE

Prior to applying, and after clearing a mastered channel value, the P-400 DRO machine zero is used as the absolute datum.

Master screen for calibrating encoder datums

When the Master setup screen is configured to calibrate encoder channel datums (Master type set to Mean), the absolute datum (D0) of any channel can be calibrated at any time using the Master function. Up to 18 mastered datum values can be stored for each P-400 DRO input encoder channel. Any of these groups can be quickly recalled and applied later.



NOTE

Instructions for calibrating channel datums are provided later in this chapter.

Current Value		mm	0	P0
A	1.7630			
B	0.9621			
C	1.9233			
D	-1.4421			
View...	in/mm	Master	Menu...	

Channel Master 1		mm	0	P0
	Master Value	Actual		
C1	<input type="text"/>	0.1602500		
C2	<input type="text"/>	0.9615500		
C3	<input type="text"/>	0.6410500		
C4	<input type="text"/>	0.1602500		
		G1	G2	G3

Channel Master screen for calibrating encoder datums

Master screens for calibrating transducer ranges

When the Master setup screen is configured to perform full calibrations of transducer input channels (Master type set to Min-Max), the full range of any channel input can be calibrated at any time using the Master function Min and Max screens. Up to 18 range calibration values can be stored for each P-400 DRO transducer input channel. Any of these groups can be quickly recalled and applied later.

Current Value		mm	0	P0
A	1.7630			
B	0.9621			
C	1.9233			
D	-1.4421			
View...	in/mm	Master	Menu...	

Master Min 1				mm	11	P0
Master Value	Actual	Mn	Mx			
C1 =	0.1602500					
C2 =	-0.9615500					
C3 =	0.6410500					
C4 =	-0.1602500					
Min	Max	G1	G2	G3		

Master Max 1				mm	11	P0
Master Value	Actual	Mn	Mx			
C1 =	0.1602500					
C2 =	-0.9615500					
C3 =	0.6410500					
C4 =	-0.1602500					
Min	Max	G1	G2	G3		

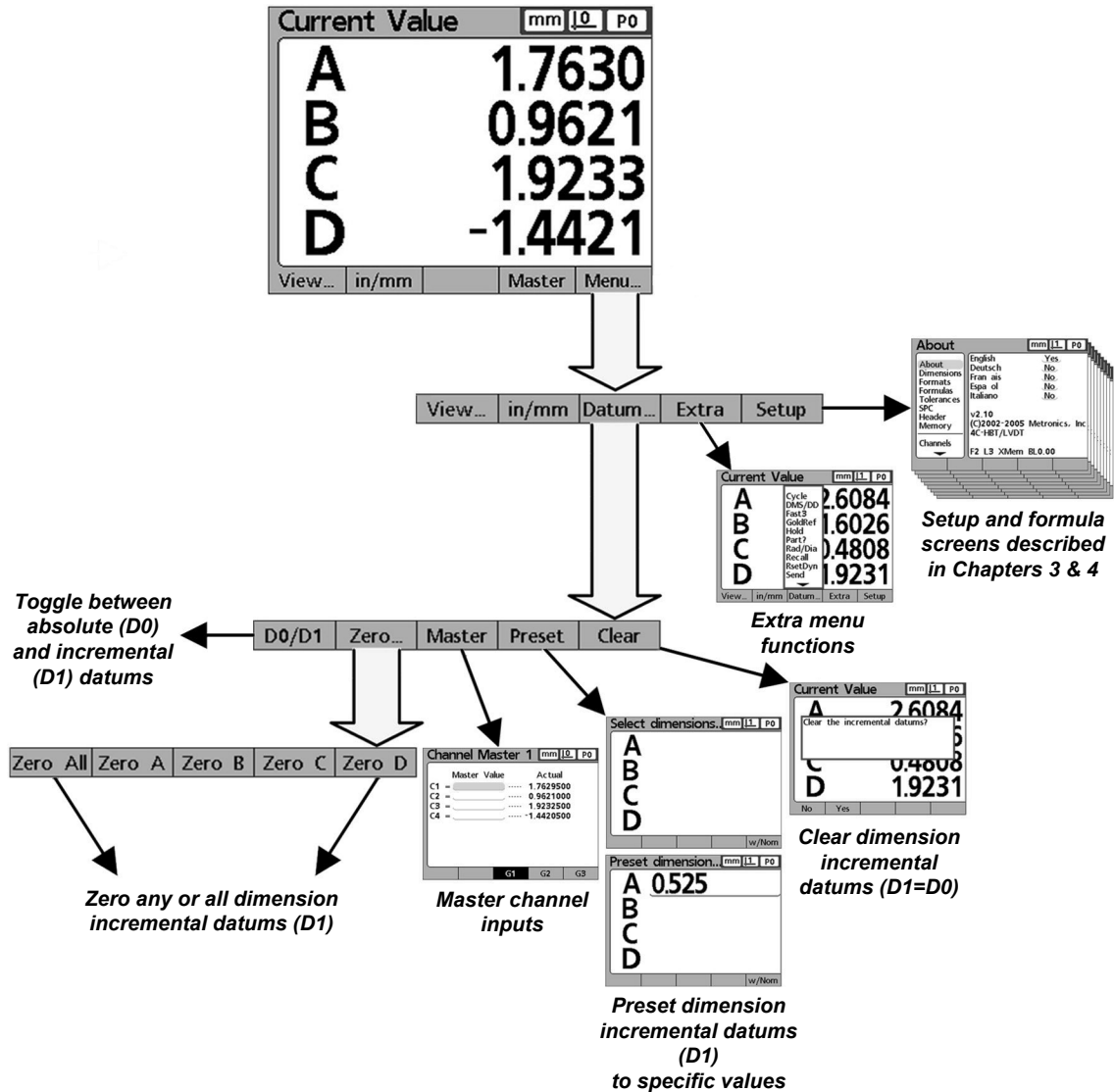
Master Min and Max screens for calibrating transducer range



NOTE
Instructions for calibrating transducer input channels Min and Max range values are provided later in this chapter.

Menu softkey screens

The screens accessed by pressing the Menu softkey are shown below.



Menu softkey screens

The Datum menu functions

The datum functions provide the means to zero, preset, clear and toggle between measurement reference datums.

Toggle between datums (D0/D1)

Pressing the D0/D1 key toggles between the absolute datum (D0) and the incremental datum (D1).

Zero datum functions

The Zero menu function can be used at any time to simultaneously zero all incremental datums, or to zero any specific incremental datum.

Master functions

The Master functions are used to calibrate the encoder datums or transducer input channel ranges.

Preset function

The Dimension Preset screen is used to preset incremental datums.

The incremental datum of a dimension can be preset to a specific value at any time by pressing the Preset softkey, pressing a dimension softkey and entering the desired value.

Clear function

The Clear menu function can be used at any time to simultaneously clear all incremental datums. Cleared incremental datums (D1) are made equal to absolute datums (D0).

The Extra menu functions

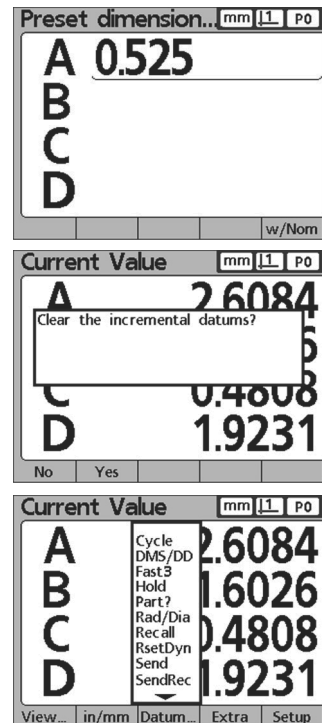
The extra menu provides quick access to a variety of display and other system functions. To use any Extra menu function, highlight the desired function, and then press the Enter key.

Cycle

Advances to the next defined part. Part numbers are cycled in a continuous loop.

DMS/DD

Toggles the display of angles between Degrees, Minutes, Seconds (DMS) and Decimal Degrees (DD).



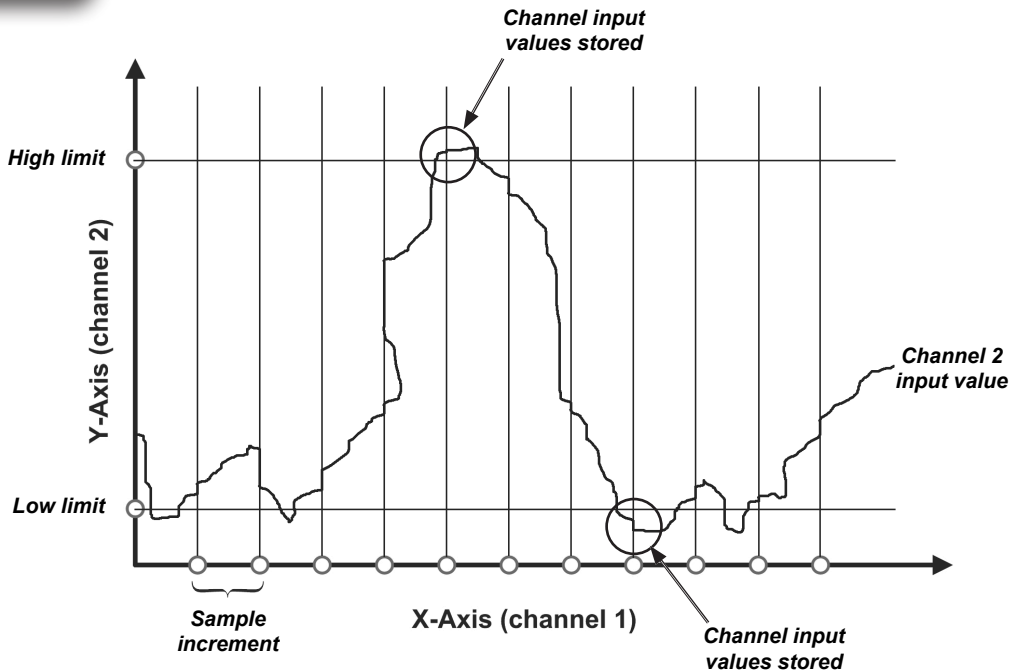
Fast3

The Fast3 function samples the channel 2 input each time the channel 1 input changes a specified sample increment. If the sampled value of channel 2 falls outside a specified range, all base-channel (first 1, 4 or 8 channels) input values will be stored in a dedicated memory array, otherwise samples will not be stored. This sampling process continues until:

- 1) The user aborts the process by pressing the Quit or the Cancel key
- 2) The user clears memory and restarts the process by pressing the Enter key
- 3) The user successfully completes the process by pressing the Finish key
- 4) The process is automatically completed after 50,000 sets of channel positions have been stored

**NOTE**

For the duration of the Fast3 function process, the P-400 DRO adopts an X-Y axis paradigm. Channel 1 is referred to as the X-axis, and channel 2 as the Y-axis.



In the example shown above, the channel 2 (Y-axis) input values exceed the user-specified limits five times, but channel input values are stored only twice when the channel 2 value exceeds the limits at a sample point between intervals.

When the Fast3 function is successfully completed, the stored sets of channel input values are processed by the P-400 DRO dimension formulas in the order that they were collected. The formula results are then

stored in the P-400 DRO database. During the processing of formulas, a percentage of completion will be displayed. Since up to 50,000 sets of channel input values can be collected and processed by formulas, considerable time could be required to complete the processing.

**NOTE**

Since the values processed by formulas after Fast3 data collection are contained in memory storage, no user interaction is possible. For this reason functions that require user interaction such as the Ask function must be avoided in formulas when the Fast3 Extra menu function is used.

**CAUTION**

If any key is pressed while the P-400 DRO is processing formulas, the remaining channel input values will be deleted from memory and formula processing will be aborted.

Press the Menu button, the Extra button and then highlight Fast3 and press Enter to initiate the Fast3 function. You will then be prompted to:

- 1) Enter an Y axis (channel 2) upper limit
- 2) Enter an Y axis (channel 2) lower limit
- 3) Enter an X axis (channel 1) capture increment
- 4) Enter an X axis (channel 1) resolution factor (this is a multiplier of scale resolution)

Current Value		mm	10	P0
A	Cycle	1.6055		
B	DMS/DD			
C	fast 3	1.5975		
D	Hold	0.0080		
	Part?			
	Rad/Dia			
	Recall			
	RsetDyn			
	Send			
	SendRec	0.0030		
View...		in/mm	Datum...	Extra Setup

Once these parameters are entered, the Fast3 function will begin to read the input values for channels 1 and 2.

Hold

Toggle function that holds (freezes) or releases the current value of a single dimension when a dimension softkey is pressed, or of all dimensions when the All softkey is pressed.

Part?

Displays a pop-up screen that allows the user to specify a new part number.

Rad/Dia

Toggles between the radius and diameter measurement types on the DRO screen, if radius or diameter was specified earlier in the Formats setup screen.

Recall

Applies the last-used incremental datum (D1) preset that was entered by the user.

RsetDyn

Resets the minimum and maximum values accumulated during dynamic measurements. This function must be initiated prior to new dynamic measurements.

Send

Sends the specified current dimension values, or all current dimension values to the RS-232 serial port for transmission to a computer. The user is prompted to send one or all.

SendRec

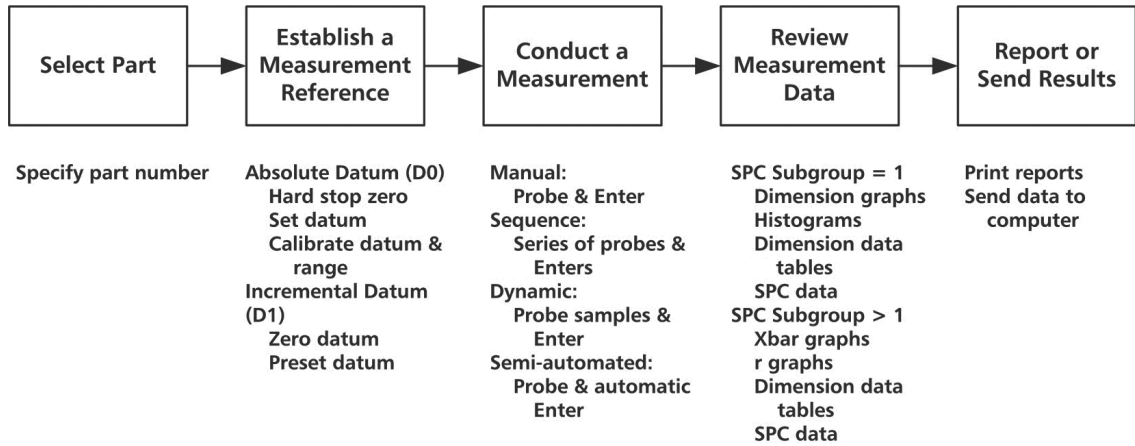
Sends stored records to the RS-232 serial port for transmission to a computer. Refer to [Chapter 3: Setup](#) for details regarding the setup screens.

Setup menu functions

P-400 DRO operating parameters and formulas that define dimension values are entered into the system from Setup menu screens. Setup menu functions and formulas are discussed in [Chapter 3: Setup](#) and [Chapter 4: Formulas](#).

Operating Instructions

Basic operation of the P-400 DRO is extremely simple, as shown by the typical process steps below.



Measurement steps and the resulting data collected depend entirely on setup parameters and dimension formulas defined earlier to satisfy a specific application.



NOTE

Examples used in this chapter use encoder probes to emphasize concepts. However, the concepts apply equally well to all types of input devices.

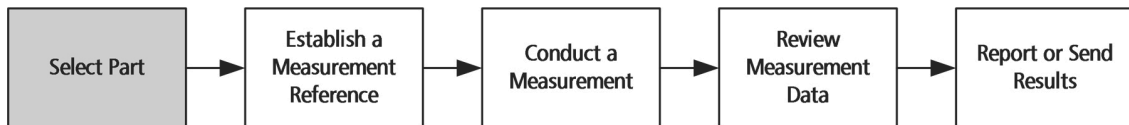
Often the measurement process simply consists of selecting a part number, establishing a measurement reference, manually probing the part and pressing the Enter key to store the data.



At other times, the P-400 DRO is used in conjunction with a fixtured gage to conduct sequential, dynamic or semi-automated measurements. In all cases, the fundamental operating steps are the same.

Select a part to begin a measurement

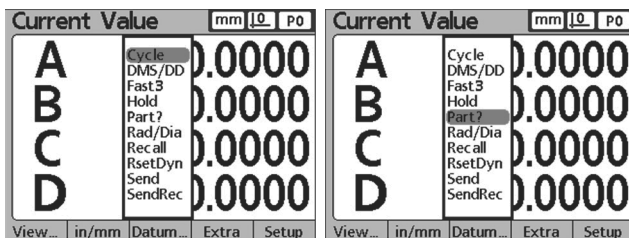
The correct part (number) must be selected prior to conducting measurements.



One hundred part configurations can be stored in the P-400 DRO. Each part configuration includes all the P-400 DRO settings and dimension formulas required to conduct measurements and report results for the part.

To select a part:

1 Press the Menu softkey, the Extra softkey and use the cursor keys to highlight Cycle or Part?

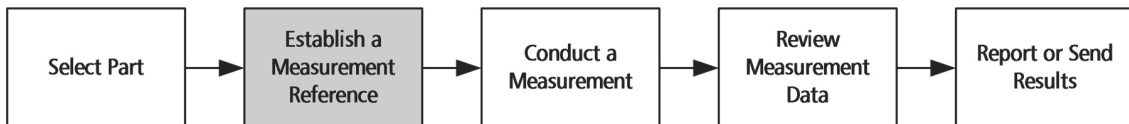


2 Press Enter. If Part? was highlighted, you will be prompted for a part number. Use the Numeric Keypad to specify the part and press the Enter key.

If Cycle was highlighted, the part number will be incremented. Continue incrementing to select the desired part number.

Establish a reference for the measurement

A measurement reference must be established prior to conducting measurements. Measurement references



can be established by calibrating channels or presetting dimensions.



NOTE

An input calibration is applied to any parts that use that channel in a formula. For example, a channel calibration performed for channel 1 and part number 0 will also apply to any other parts using channel 1.

Calibrating channels using the Master function

Channel calibrations are performed using the Master function. A single-point calibration defines the reference value of the absolute datum (D0) of an input channel. A full calibration defines the reference value of the absolute datum, and the resolution of the channel input.

Since encoders have fixed resolutions based on etched scales or some other permanent device characteristic, typically only a single point is calibrated to define a reference position. Transducers such as LVDT and Half-bridge devices do not have fixed resolutions. The use of these devices requires calibrating both ends of the transducer's measurement range to derive resolution. Once a full calibration has been performed, single-point calibrations can be performed as required to define new measurement reference positions.

Calibration of a single reference point

A single measurement reference point can be calibrated for encoders and fully-calibrated transducers.

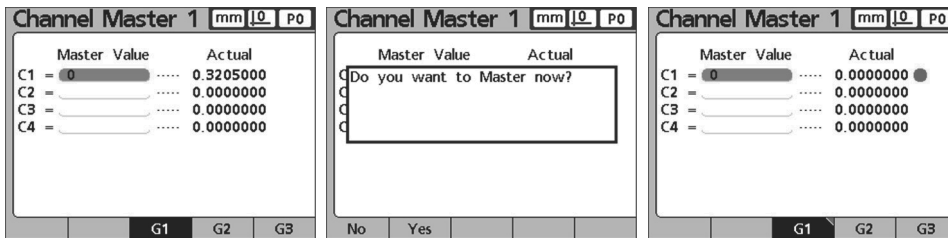


NOTE

The Master type should be set to Mean in the Master setup screen to perform a calibration of a single encoder point. Refer to [Chapter 3: Setup](#) for details.

To calibrate a single reference point:

- 1 Press the Master softkey. Use the cursor keys to select the desired channel if necessary.
- 2 Position the probe against the measurement reference surface.
- 3 Use the Numeric Keypad to enter the reference value (zero or the desired offset) into the Master Value data field. Press the Enter key, then press the Yes softkey to calibrate the measurement reference.

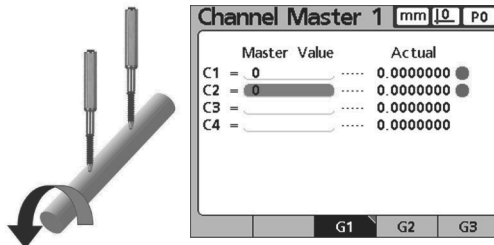


A green dot will appear next to the actual value indicating that the reference point is calibrated.

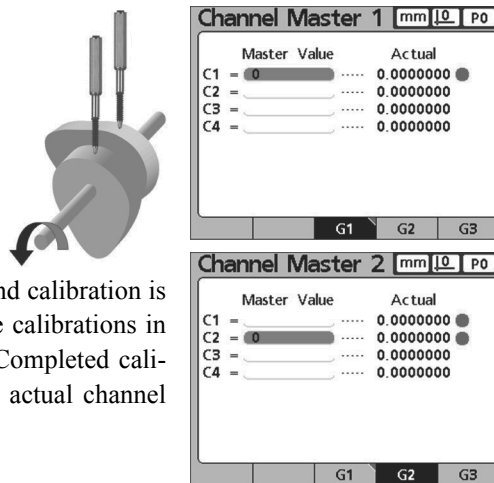
Calibration groups (G1, G2, G3...G18)

All calibration values shown on the screen are simultaneously applied when the Enter key is pressed. While this is acceptable in most cases, some applications require entering a series of calibrations at different times. The example shown here illustrates this difference.

When measuring runout at two points on a rod, both channels are measuring a common surface and can be calibrated simultaneously. In this example, both channels are calibrated to zero on the rod surface in calibration group 1 (G1). Completed calibrations are indicated by filled circles at the right of the actual channel values.



When measuring the low and high lifts of two offset cams, simultaneous calibration on the offset surfaces is not possible. First one channel must be calibrated to zero on the low surface of one cam, then after turning the cam shaft 90 degrees, the second channel must be calibrated to zero on the low surface of the second cam.



The first calibration is performed in calibration group 1 (G1), then the camshaft is turned 90 degrees, and the second calibration is performed in calibration group 2 (G2). By performing the calibrations in different groups, the calibrations are made independent. Completed calibrations are indicated by filled circles at the right of the actual channel values.

Calibrations of transducer resolution (Min-Max calibrations)

Transducers such as LVDT and half bridge devices do not have fixed resolutions based on etched scales or other permanent device characteristics. The use of these devices requires calibrating both ends of the transducer range of measurement to derive transducer resolution. Full transducer calibrations are performed periodically on a schedule determined by your application using the Master function. Full calibrations are performed only after performing the transducer gain and null setup steps described in [Chapter 3: Setup](#).



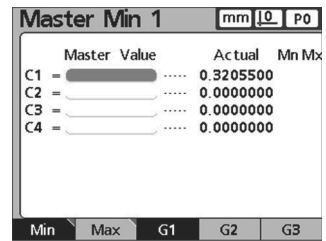
NOTE

The Master type should be set to Min-Max in the Master setup screen to perform a full transducer calibration. Refer to [Chapter 3: Setup](#) for details.

To perform a full transducer calibration:

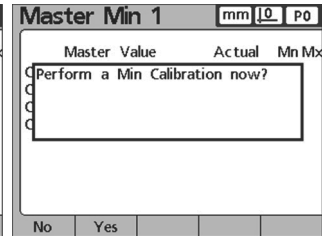
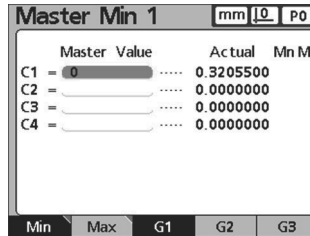
- 1 Press the Master softkey, then press the Master Min softkey to display the Master Min screen.

Use the cursor keys to select the desired channel, then press the G1, G2... G18 softkey to select a group to store the calibration data in. Refer to the discussion of groups on the previous page if necessary.

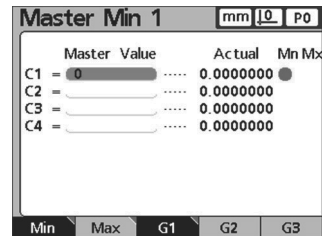


- 2 Position the channel's probe against the measurement Min reference surface.

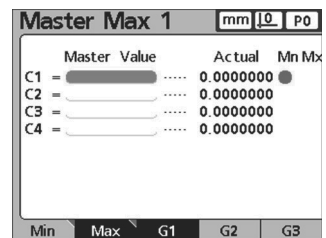
- 3 Use the Numeric Keypad to enter the Min reference value into the Master Value data field for the channel. Press the Enter key, then press the Yes softkey to set the Min value or offset the absolute datum (D0) for the channel. This calibrates the low end of the channel measurement range.



The completed minimum level calibration will be indicated by a filled green circle in the Mn column at the right of the Actual channel value.

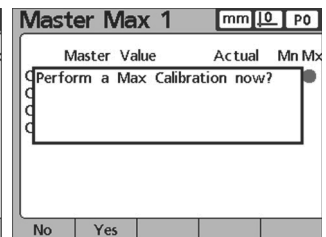
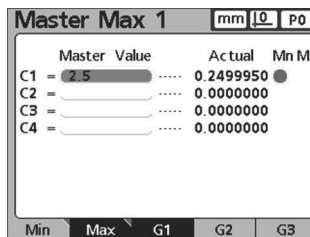


- 4 Press the Master Max softkey and use the cursor keys to select the same channel as in step 1 if necessary.



- 5 Position the channel probe against the measurement Max reference surface for the maximum end of the channel calibration range.

- 6 Use the Numeric Keypad to enter the Max value into the Master Value data field for the channel. Press the Enter key, then press the Yes softkey to calibrate the maximum value for the channel input.



The completed maximum level calibration will be indicated by a filled green circle in the Mx column at the right of the Actual channel value.

Master Max 1		mm	L0	P0
	Master Value	Actual	Mn	Mx
C1	2.5	2.500000	●	●
C2		0.000000		
C3		0.000000		
C4		0.000000		

Min Max G1 G2 G3

Establishing a temporary dimension reference

Establishing a temporary dimension reference is useful when quick point to point measurements are desired. The temporary reference is only applied to the associated dimension, and only to the current part. For example, a temporary reference established for dimension A and part number 0 will not apply to any dimensions or to any other parts that might include their own dimension A.

Temporary dimension references can be established for encoders and transducers. Since only one point is used as a reference, transducer resolution remains unchanged.

Dimension references can be zeroed or preset to specific values.

Zeroing a dimension reference

Dimensions can be zeroed at any time using the Datum/Zero function. The zero reference is temporary in the sense that it uses the incremental datum D1, and has no effect on the absolute datum D0.

To zero a dimension:

- 1 Press the Menu softkey, the Datum softkey and the Zero softkey. The softkeys across the bottom of the screen will be labeled to support zeroing specific or all dimensions. Use the left and right cursor keys to scroll through dimensions when there are more dimensions defined than P-400 DRO softkeys.
- 2 Press the desired Zero key to zero the corresponding dimension.

Current Value		mm	L1	P0
A	0.3205			
B	-0.5000			
C	0.8013			
D	0.4808			

Zero All Zero A Zero B Zero C Zero D

Current Value		mm	L1	P0
A	0.0000			
B	-0.5000			
C	0.8013			
D	0.4808			

Zero All Zero A Zero B Zero C Zero D

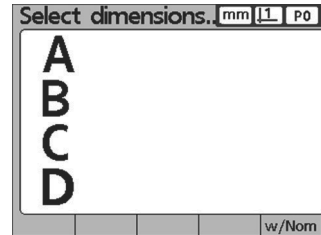
Pressing Zero A zeros the A dimension

Presetting a dimension reference to a specific value

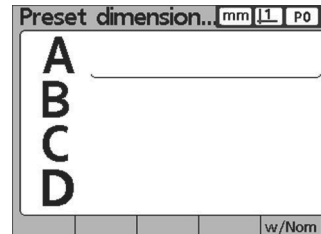
Dimensions can be preset to a user-specified value at any time using the Datum/Preset function. The reference is temporary in the sense that it uses the incremental datum D1, and has no effect on the absolute datum D0.

To preset a dimension reference:

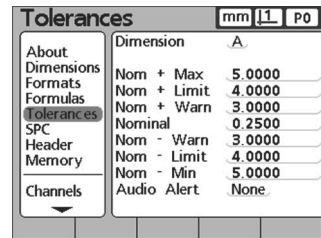
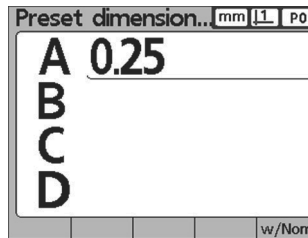
1 Press the Menu softkey, the Datum softkey and the Preset softkey. The Select dimensions screen will be displayed.



2 Press the dimension key associated with the dimension you wish to preset. A text line will be displayed.

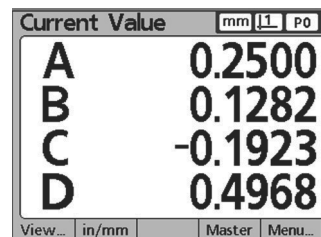


3 Use the Numeric Keypad to enter the reference value (preset) of the new reference. Press the w/Nom softkey to change the Nominal value in the Tolerance setup screen to the new preset reference value if desired.



The Nominal tolerance value can be changed to the preset value by pressing the w/Nom softkey

4 Press the Enter key to preset the dimension measurement reference.

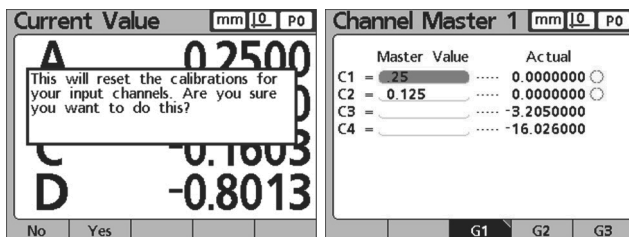


Clearing channel calibrations

The reference calibrations and full calibrations of all channels can be cleared using the LCD ON/OFF key.

To clear calibrations:

- 1 Press the LCD ON/OFF key, then press the Clr Cal softkey. You will be asked to confirm your intention. Press the Yes softkey to clear channel mastered values and full calibrations.



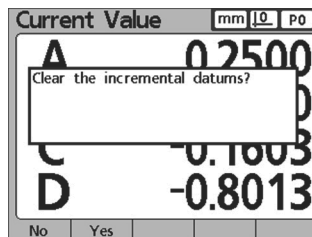
Channel mastered values and full calibrations will be cleared, as indicated by the empty circles at the right of the screen. However, the values will be retained in the Master values fields, and can be reactivated at any time by pressing the Enter key.

Clearing dimension references (presets)

Dimension references can be cleared at any time using the Datum/Clear function.

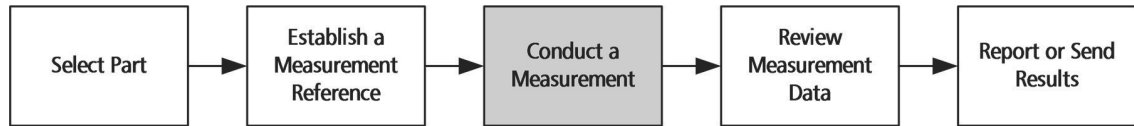
To clear dimension references:

- 1 Press the Menu softkey, press the Datum softkey and then press Clear. You will be asked to confirm your intention.
- 2 Press the Yes softkey to clear dimension preset references. When a preset reference is cleared, D0 becomes the new reference.



Conducting measurements

Once a part number is selected and a reference is established, measurements can be conducted.



Measurements can:

- Be conducted manually, completely under the control of the operator
- Follow a predetermined sequence of steps shown on the screen
- Be based on dynamic samples of changing input data
- Be semi-automated to increase the throughput of repetitive measurements

Typically a setup person will configure the P-400 DRO for operation in the Setup screens described in [Chapter 3: Setup](#), and then will construct formulas defining dimensions in the Formula screens described in [Chapter 4: Formulas](#).

Once the P-400 DRO is configured and dimension formulas are constructed, measurement instructions are usually given to the operator that reflect the specific measurement requirements and gage equipment setup. Instructions provided in this guide are generic and meant to be used as guidelines when applying the P-400 DRO to specific measuring applications.

Manual measurements

Manual measurements are performed completely under the control of an operator. Measurement results can be displayed as current values, in graphs or in data tables using the screens described earlier in this chapter. Please refer to the descriptions of graph and data table screens for details.

Measurements can also be printed or transmitted to a computer. The data printed or transmitted are specified and formatted in the setup screens described in [Chapter 3: Setup](#).

To conduct manual measurements:

- 1 Probe a single point with one channel, or multiple points simultaneously with multiple channels.
- 2 When the measurement data are displayed on the LCD, press the Enter key to store the data.

Sequential measurements

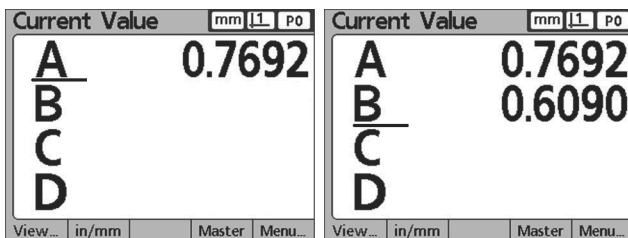
The P-400 DRO can be configured in the Formula setup screen to direct the user through a sequence of predetermined measurement steps. Typically a setup person will provide instructions describing how to conduct the measurements. However, the P-400 DRO operation is fundamentally the same for all sequential measurements.

Measurement results can be displayed as current values, in graphs or in data tables using the screens described earlier in this chapter. Please refer to the descriptions of graph and data table screens for details.

Measurements results can also be printed or transmitted to a computer. The data printed or transmitted are specified and formatted in the setup screens described in [Chapter 3: Setup](#).

To perform a sequential measurement:

1 Probe the dimension underlined on the DRO screen and press the Enter key to store the data. The underline will advance to highlight the next dimension in the measurement sequence.



2 Continue probing the underlined dimensions and pressing the Enter key as described above, following the sequence of underlined steps on the LCD.

When measurements specified for the part are complete, the P-400 DRO will return to underline the first dimension in the series to indicate the beginning of a new sequence.

Dynamically sampled measurements

The P-400 DRO can be configured in the Formula setup screen to sample input channels and retain the minimum and maximum values of all samples for each channel. Typically a setup person specifies dynamic measurements to evaluate rotational or curved surfaces and will provide instructions describing how to conduct the measurements. The P-400 DRO operation is essentially the same for all dynamic measurements.

Measurement results can be displayed as current values, in graphs or in data tables using the screens described earlier in this chapter. Please refer to the descriptions of graph and data table screens for details.

Measurement results can also be printed or transmitted to a computer. The data printed or transmitted is specified and formatted in the setup screens described in [Chapter 3: Setup](#).

In the example shown here, the runout of a shaft is measured. The minimum and maximum values are sampled as the shaft is turned.

To perform a dynamic measurement:

- 1 Perform a dynamic reset by pressing the left Wide key (factory default), or by highlighting RsetDyn in the Extra menu, and pressing the Enter key. This clears old dynamic measurement data prior to a new measurement.
- 2 Position the probe(s) against the surface to be measured and repeatedly rotate or move the surface slowly while observing the resulting dimension value(s).



CAUTION

The sampling rate for LVDT, HBT (Half-bridge) and serial transducers will be slower than for encoders. If your system includes these input devices, the part must be rotated or moved slowly to ensure that all points on the surface are sampled.

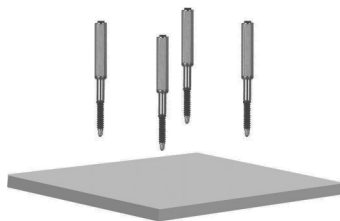
- 3 Repeat the rotation or movement until the dimension values that reflect minimum or maximum values no longer change.
- 4 Press the Enter key to store the measurement data.

Semi-automated measurements

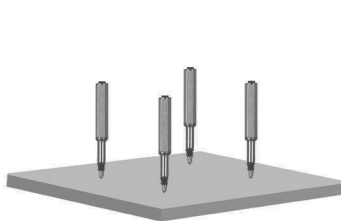
Normally, measurements shown on the DRO screen are not stored in the P-400 DRO database until the user presses the Enter key. However, the P-400 DRO can be configured in the Formula setup screen to perform and store measurements automatically when the gage is loaded with a new part.

Measurement results can also be printed or transmitted to a computer. The data printed or transmitted is specified and formatted in the setup screens described in Chapter 3: Setup.

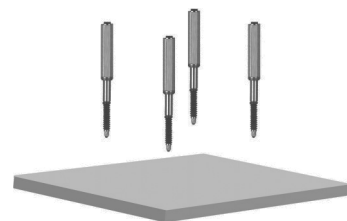
In the example shown here, the flatness of a sheet is measured. The measurement is performed and entered into the database a short time after the gage is lowered to position the probes against the surface of the sheet. The channels are reset for a new measurement when the probes are lifted away from the sheet.



Load part: Channels ready



Gage closed: Channels measure



Unload part: Channels reset

Typically, a setup person specifies semi-automated measurements to increase the throughput of repetitive measurements, and will provide instructions describing how to conduct the measurements, and load and unload the gage.

Measurement results can be displayed as current values, in graphs or in data tables using the screens described earlier in this chapter. Please refer to the descriptions of graph and data table screens for details if necessary.

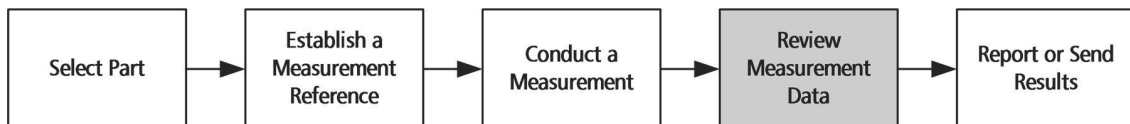
The instructions for performing semi-automated measurements depend entirely on the measurement application and equipment setup, and must be provided by the setup person. Please refer to the description of the Trip function in [Chapter 4: Formulas](#) for more details regarding semi-automated measurements.

Reviewing measurement results

Measurement results can be reviewed in graphs or in data tables using the screens described earlier in this chapter. Please refer to the descriptions of graph and data table screens earlier in this chapter for details.

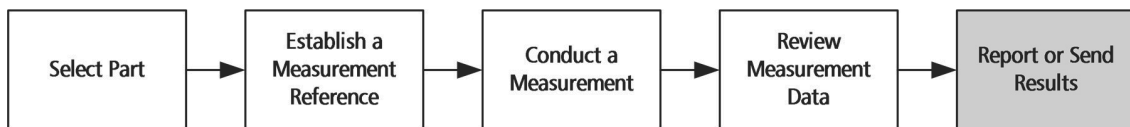
Printing reports or sending results to a computer

Measurement data can be printed or transmitted to a computer. The report and data transmission formats are prepared in the Header, Report, Send, Parallel and RS-232 setup screens described in [Chapter 3: Setup](#).



Printing reports

Reports of current dimension values, stored measurement results or P-400 DRO setup parameters can be printed by displaying the desired screen and pressing the Print key. In some cases, the user will be prompted to provide additional information.

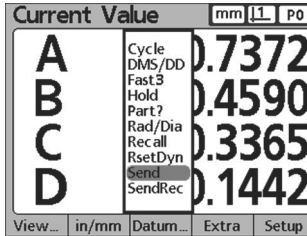


Sending data to a computer

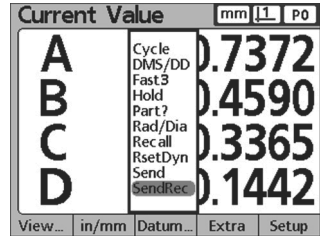
Current dimension values, or a collection of stored dimension measurement results can be transmitted to a computer using the Send and SendRec functions in the Extra menu. Please refer to the Extra menu descriptions provided earlier in this chapter for more details regarding the Extra menu.

To send current dimension values:

Press the Extra softkey, use the cursor keys to highlight Send and press the Enter key to send the current dimension values to a computer.



Use Send to send current values



Use SendRec to send stored measurement values

To send stored measurement results:

Press the Extra softkey, use the cursor keys to highlight SendRec and press the Enter key to send a file of stored measurement results.

Report type	Screen	User actions
Current dimensions (Numeric display)	DRO	Press Print key
Graphs of dimension values (SPC subgroups = 1)	Graph...	Press Print key
Histograms of dimension values (SPC subgroups = 1)	Histo...	Press Print key
xbar chart of subgroup mean values (SPC subgroups > 1)	xbar chart	Press Print key
r chart of subgroup range values (SPC subgroups > 1)	r chart	Press Print key
Current dimension values (Bar display)	Bar...	Press Print key
Current dimension values (Dial display)	Dial...	Press Print key
Data table multiple-dimensions	Data...	Press Print key, respond to prompt
Data table single-dimensions	Data...	Press dimension softkey, press Print key, respond to prompt

Clearing stored measurement data

Stored measurement data can be cleared for a single part, or for all parts by pressing the LCD ON/OFF key.



CAUTION
Erased data cannot be restored.

Clearing data stored for a single part

Select the desired part, press the LCD ON/OFF key and press the Clr Prt softkey to erase stored data for the part.

Clearing data stored for all parts

Select the desired part, press the LCD ON/OFF key and press the Clr All softkey to erase stored data for all parts.

Chapter 6: Communication

This chapter explains how to use ASCII control characters, HyperTerminal programs and QC-Wedge.

Printing reports

Instructions for connecting and testing a printer are provided in [Chapter 2: Installation](#). Instructions for formatting reports are included in [Chapter 3: Setup](#). Instructions for printing reports are included in [Chapter 5: Operation](#).

ASCII codes

The table shown on the next pages list ASCII codes that can be used to format data for printed reports and data transmissions to a computer.

Insert the desired ASCII character codes in the Rep Chars or Send Chars setup screen. For example, use ASCII character codes to insert a line feed and carriage return command as shown here.

Rep Chars		Send Chars	
mm | 10 | P0		mm | 10 | P0	
S Labels	Pre Line	Globals	+Snd
S Formulas	Post Line 10 13	-Lbl	+Snd 10 13
Globals	Pre Form	Channels	-Lbl 32
Channels	Post Form 12	Master	+Dim 32
Master	+Dim 32	SLEC	+Dim 32
SLEC	+Unt 32	Display	-Unt
Display		Report	+Unt 32
Report		Rep Chars	
Rep Chars		Send	
		Send Chars	

In the example Rep Chars screen shown on the last page, ASCII character codes 10 (line feed) and 13 (carriage return) are included in the post line field. This instructs a printer to perform a line feed and carriage return after each line of print.

Use the decimal key on the numeric keypad to space ASCII character codes in the fields.

Controlling the P-400 DRO using ASCII command codes

Nearly all P-400 DRO functions can be controlled over an RS-232 serial connection using the ASCII command codes shown below.

ASCII code	P-400 DRO function	ASCII code	P-400 DRO function
@E	Enter	@S1	Soft key #1
@F	Finish	@S2	Soft key #2
@C	Cancel	@S3	Soft key #3
@Q	Quit	@S4	Soft key #4
@U	Up Arrow	@S5	Soft key #5
@D	Down Arrow	@D1	Dimension key #1
@L	Left Arrow	@D2	Dimension key #2
@R	Right Arrow	@D3	Dimension key #3
@P	Print	@D4	Dimension key #4
@W1	The left most "wide" key	@0 to @9	Numeric keys
@W2	The right most "wide" key	@-, @+, @.	Plus, minus & decimal keys
		@!	LCD on/off key
Zero (argument):	Zeros		
	Dimension label	Zeros a specific dimension	
	All	Zeros all visible dimensions	
Send (argument):	Sends		
	Dimension label	Sends a specific dimension	
	All	Sends all dimensions shown on screen	

Commands can be transmitted from a file, or keyed in manually using MS Windows HyperTerminal or an equivalent communications application. The use of HyperTerminal is explained later in this section. Use a carriage return or line feed to separate commands included in command strings.

ASCII Codes

8	backspace	46	.	84	T
9	horizontal tab	47	/	85	U
10	line feed	48	0	86	V
11	vertical tab	49	1	87	W
12	form feed	50	2	88	X
13	carriage return	51	3	89	Y
14	so	52	4	90	Z
15	si	53	5	91	[
16	dle	54	6	92	\
17	dcl	55	7	93]
18	dc2	56	8	94	^
19	dc3	57	9	95	~
20	dc4	58	:	96	:
21	nak	59	;	97	a
22	syn	60	<	98	b
23	etb	61	=	99	c
24	can	62	>	100	d
25	em	63	?	101	e
26	sub	64	@	102	f
27	esc	65	A	103	g
28	fs	66	B	104	h
29	gs	67	C	105	i
30	rs	68	D	106	j
31	us	69	E	107	k
32	space	70	F	108	l
33	!	71	G	109	m
34	"	72	H	110	n
35	#	73	I	111	o
36	\$	74	J	112	p
37	%	75	K	113	q
38	&	76	L	114	r
39	'	77	M	115	s
40	(	78	N	116	t
41	)	79	O	117	u
42	*	80	P	118	v
43	+	81	Q	119	w
44	comma (,)	82	R	120	x
45	-	83	S	121	y
				122	z

Using HyperTerminal

Microsoft Windows HyperTerminal can easily be configured to transfer data between the P-400 DRO and your Windows computer using the RS-232 serial port.

Communication with a computer running HyperTerminal relies on a serial RS-232 connection between the P-400 DRO and your computer using a cable that does not include crossed receive and transmit wires. Instructions for connecting and testing a computer are provided in [Chapter 2: Installation](#).

Connecting to a computer using HyperTerminal

The following steps describe how to connect the P-400 DRO to a computer running HyperTerminal.

1 Launch the HyperTerminal application by clicking the following sequence:

- Start button
- Programs
- Accessories
- Communications
- HyperTerminal

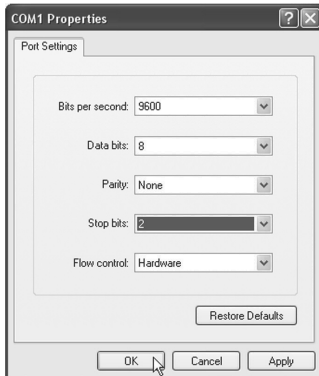
2 Enter the desired connection name into the Connection Description dialog box, click OK and then select the desired serial port and click OK.



3 Enter the following COM properties:

- Bits/second: 9600
- Data bits: 8
- Parity: None
- Stop bits: 2
- Flow control: Hardware

4 Click OK.



5 Click on the File menu and then click Properties to display the Properties dialog box. Click on the Settings tab and configure the settings as shown below.

Function, arrow and cut keys act as: Terminal
 Backspace key sends: Ctrl + H
 Emulation: Auto detect
 Telnet terminal ID: ANSI
 Backscroll buffer lines: 500

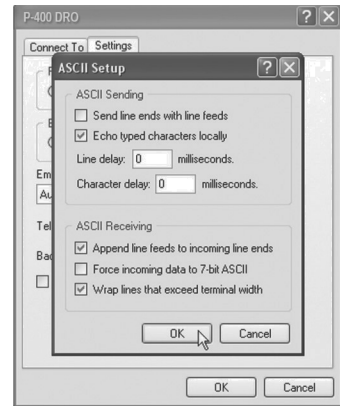


6 Click on the ASCII button and configure the ASCII setup as shown below and click OK.

Check only the following boxes:

- Echo typed characters locally
- Append line feeds to incoming line ends
- Wrap lines that exceed terminal width

7 Click OK in the Properties dialog box to return to the main HyperTerminal screen.

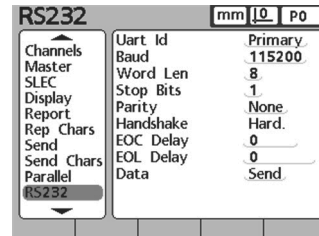
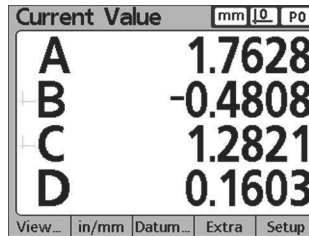
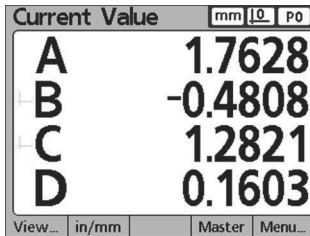


8 Click the File menu and then click Save. The HyperTerminal program is now ready to exchange data with the P-400 DRO.

Preparing to exchange serial data with HyperTerminal

The following steps describe how to connect the P-400 DRO to a computer running HyperTerminal.

9 Press the Menu softkey, press the Setup softkey and then highlight the RS-232 menu item.



10 Enter the following:

- | | | | |
|----------------|------|--------------|------|
| • Baud: | 9600 | • EOL Delay: | 0 |
| • Word length: | 8 | • Parity: | None |
| • Stop bits: | 2 | • Data: | Send |
| • EOC Delay: | 330 | | |

RS232		mm | 10 | P0
Channels	Uart Id	Primary
Master	Baud	115200
SLEC	Word Len	8
Display	Stop Bits	1
Report	Parity	None
Rep Chars	Handshake	Hard
Send	EOC Delay	0
Send Chars	EOL Delay	0
Parallel	Data	Send
RS232		
None		Send
		Report
		Both

11 Press the Finish key twice. The P-400 DRO is now setup to send data to and receive data from the HyperTerminal application.

Using QC-Wedge

QC-Wedge is software that can be purchased from Precision Gage & Tool Co. and communicates between your PG&T digital readout and a Microsoft Windows-based PC. Measurement data is sent from your P-400 DRO over the RS-232 serial connection to a Microsoft Excel file in your PC. The data can then be edited, saved on your PC or printed. The QC-Wedge package includes the RS-232 serial communication cable required for use with PG&T digital readouts.



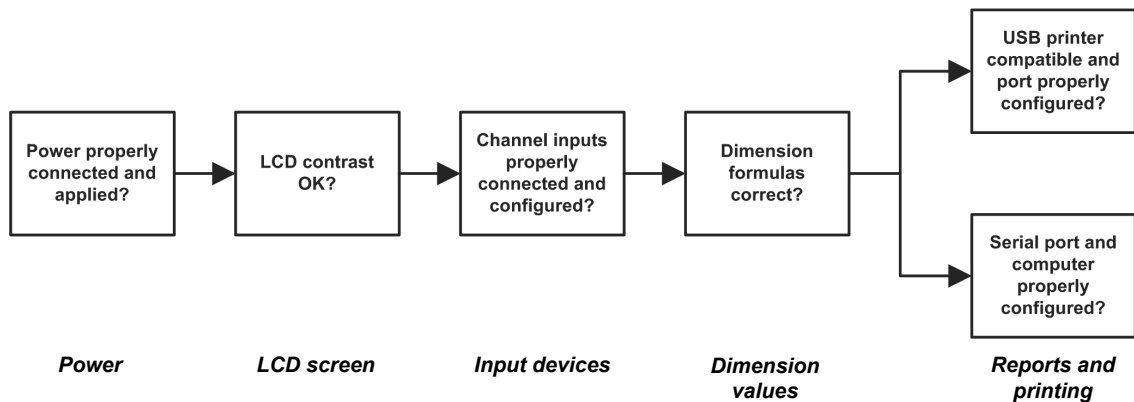
Instructions for using QC-Wedge are included in the QC-Wedge software Help file.

Chapter 7:

Problem solving

The P-400 DRO is based on a hardware platform common to the Metronics QC-100 and QC-200 products. Years of continuous improvement of this hardware have resulted in extremely reliable operation and few, if any hardware problems. Problems experienced with the operation of the P-400 DRO are likely to be the result of printer or cable incompatibilities, configuration or setup errors or encoder/transducer incompatibilities or malfunctions.

The steps recommended for initial troubleshooting are shown below. These are typically the same initial steps that would be taken by a distributor or factory product support technician. Since most problems



experienced in the field will have simple causes, and equally simple solutions, substantial time and expense can be saved by performing some straightforward troubleshooting of configuration settings and hardware connections prior to calling the distributor or factory for assistance.

As you're troubleshooting, list the steps that you use to identify and solve your problem. Should problems persist in spite of your efforts, gather the necessary product information listed at the end of this chapter, and your list of troubleshooting steps, and contact your distributor for assistance.

Symptoms, probable causes and solutions

Some common symptoms of problems are listed in the following pages with probable causes and possible solutions.

No image is visible on the LCD screen

Probable cause 1: Power is not applied to the P-400 DRO

Possible solutions:

- 1 Activate the main power source.
- 2 Connect the power cord or turn the power ON.
- 3 Replace the fuse.

Probable cause 2: LCD ON/OFF toggle switch is in the OFF mode

Possible solution:

- 1 Press the LCD ON/OFF button to toggle the LCD ON.

Probable cause 3: LCD contrast or backlighting is out of adjustment

Possible solution:

- 1 Perform the following procedure to reset the LCD contrast and backlighting parameters to factory defaults.:
 - Turn the power OFF
 - Press and hold the 0 numeric keypad key and turn the power back ON while continuing to hold the numeric 0 key down until beeps are heard
 - Release the 0 numeric keypad key
 - Press the left-most softkey under the LCD screen

Dashes are displayed across the LCD screen

Probable cause 1: The wrong encoder or transducer is connected

Possible solution:

- 1 Connect the input device specified in the Channels setup screen.

Probable cause 2: The wrong input device is specified in the Channels setup screen

Possible solution:

- 1 Change the Channels setup screen parameters to reflect the correct input device.

Dimension values displayed on the LCD screen are incorrect

Probable cause 1: *The channel input device is not connected or is malfunctioning*

Possible solutions:

- 1 *Connect the input device cable firmly to the P-400 DRO.*
- 2 *Replace the input device.*

Probable cause 2: *The Channels setup screen specifies the wrong input device resolution*

Possible solution:

- 1 *Specify the correct resolution in the Channels setup screen.*

Probable cause 3: *The wrong input device count polarity is specified in the Channels setup screen*

Possible solution:

- 1 *Specify the correct count polarity in the Channels setup screen.*

Probable cause 4: *The wrong encoder or transducer is connected*

Possible solutions:

- 1 *Connect the input device specified in the Channels setup screen.*
- 2 *Confirm that the each probe is connected to the correct channel input.*

Probable cause 5: *The wrong in/mm unit of measure is specified*

Possible solution:

- 1 *Specify the correct units of measure in the Channels setup screen.*

Probable cause 6: *The wrong Rad/Diam measurement type is specified*

Possible solution:

- 1 *Specify the correct Rad/Diam measurement type in the Formats setup screen.*

Probable cause 7: *The dimension formula specifies the wrong calculation*

Possible solution:

- 1 *Correct the dimension formula in the Formula setup screen.*

Dimension values displayed on the LCD screen are incorrect**Probable cause 8: The wrong datum is being used****Possible solution:**

- 1 Confirm that the correct datum number (D0/D1) is being displayed in the top-right corner of the Current Value screen.

Probable cause 9: The wrong part is being used**Possible solution:**

- 1 Confirm that the correct part number is being displayed in the top-right corner of the Current Value screen.

Reports are not printed or are incomplete**Probable cause 1: The channel input device is not connected or is malfunctioning****Possible solution:**

- 1 The printer is not supported by the P-400 DRO . Most HP inkjet USB printers using HP2 printer pack are supported.

Probable cause 2: The USB printer cable is not firmly connected or is damaged**Possible solution:**

- 1 Connect or replace the USB printer cable.

Probable cause 3: The USB port configuration is incorrect**Possible solution:**

- 1 Correct the USB port configuration in the Parallel setup screen.

Reports are printed incorrectly

Probable cause 1: *The wrong report configuration is specified*

Possible solution:

- 1 *Correct the report configuration in the Report setup screen.*

Probable cause 2: *The wrong control characters are specified*

Possible solution:

- 1 *Correct the control character configurations in the Rep Chars setup screen.*

Data cannot be transmitted to a computer

Probable cause 1: *The wrong serial cable (or no cable) is connected between the computer and the P-400 DRO*

Possible solution:

- 1 *Connect the computer to the P-400 DRO using an RS-232 serial cable that does not include crossed transmit and receive wires. The correct cable can be ordered from PG&T Co. by specifying part number 62596652.*

Probable cause 2: *The wrong computer serial port is used*

Possible solution:

- 1 *Connect the serial cable to the serial port specified by the computer port settings.*

Probable cause 3: *The wrong RS-232 port settings are specified*

Possible solution:

- 1 *Correct the RS-232 port settings to match the computer's serial port settings in the Send setup screen.*

Probable cause 4: *The wrong control characters are specified*

Possible solution:

- 1 *Correct the control characters to reflect the requirements of the receiving software in the Send Chars setup screen*

Error (ERR) or asterisks appear in the LCD display

Probable cause 1: *Errors are contained in formulas or settings*

Solution:

- 1 *Check the DRO display for diagnostic messages.*

Battery low message displayed

Cause: *The data backup battery voltage is low*

Solution:

- 1 *Contact Precision Tool & Gage Co. and arrange a backup battery replacement.*



CAUTION

Arrange to have the battery replaced immediately. All data and formulas will be permanently lost if the battery is allowed to fail.

Getting help

Performing the simple troubleshooting listed on the previous pages solves most problems experienced with the P-400 DRO. If a problem persists after performing this troubleshooting, follow the steps listed below and contact Precision Gage & Tool Co. for assistance.

- 1 Be prepared to discuss your troubleshooting steps.
- 2 Gather the following P-400 DRO information:
 - Model number
 - Serial number
 - Approximate purchase date
 - Software version number and other information from front of User's Guide and the About setup screen

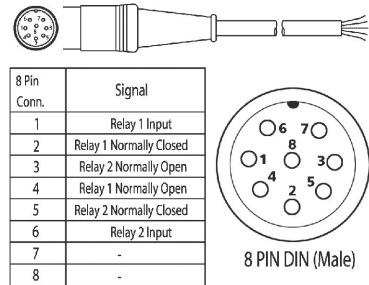
Chapter 8: Reference material


This chapter contains technical information regarding:

- Output relay contact specifications
- Parallel port specifications
- Footswitch wiring specifications
- RS-232 serial measurement input device configuration
- SPC formulas used by the P-400 DRO
- P-400 DRO product specifications

Output relay specifications

These tables show the electrical connections and specifications of the output relay contacts controlled by formulas created in the Formula setup screen.



 **CAUTION**
Be careful to limit voltage and current to the maximum ratings shown in this table. Exceeding the maximum ratings can cause serious damage the P-400 DRO and void the product warranty.

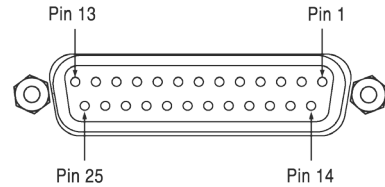
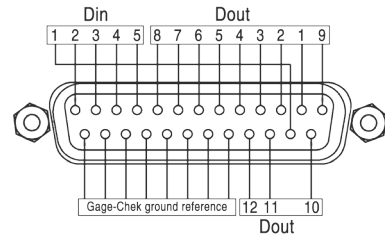
CONTACT RATINGS			
Switching Voltage	Max DC/Peak AC Resist.	Volts	100
Switching Current	Max DC/Peak AC Resist.	Amps	0.25
Carry Current	Max DC/Peak AC Resist.	Amps	0.5
Contact Rating	Max DC/Peak AC Resist.	Watts	3
Life Expectancy-Typical ¹	Signal Level 1.0V,10mA	x 10 ⁶ Ops.	100
Static Contact Resistance (max. init.)	50mV, 10mA	Ω	0.200
Dynamic Contact Resistance (max. init.)	0.5V, 50mA at 100 Hz, 1.5 msec	Ω	N/A
RELAY SPECIFICATIONS			
Insulation Resistance (minimum)	Between all Isolated Pins at 100V, 25°C, 40% RH	Ω	10 ⁹
Dielectric Strength (minimum)	Between Contacts	VDC/peak AC	250
	Contacts to Shield	VDC/peak AC	1500
	Contacts/Shield to Coil	VDC/peak AC	1500
Operate Time - including bounce - Typical	At Nominal Coil Voltage, 30 Hz Square Wave	msec.	1.0
Release Time - Typical	No Suppression	msec.	1.0
	Diode Suppression	msec.	1.5

Parallel port pin assignments

The parallel port can be configured in the Parallel setup screen as a standard printer port, or as a general purpose data input/output (I/O) port. Refer to [Chapter 3: Setup](#) for details.

This drawing shows parallel port pins that can be used as logic level data I/O connections. When used as logic level I/O, the parallel port pins are controlled by formulas created in the Formula set up screen. Refer to [Chapter 4: Formulas](#) for details.

The logic ground reference is connected to pins 18 through 25.



Footswitch wiring

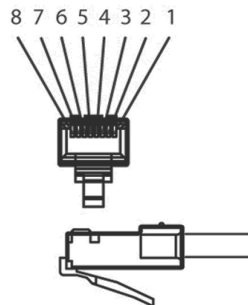
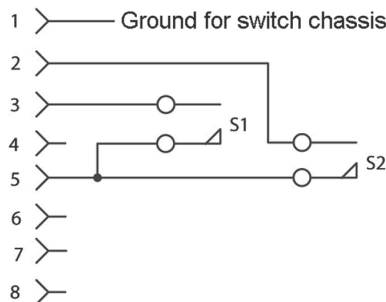
The optional foot switch is connected to the RJ-45 connector on the left side of the P-400 DRO.

The wiring of the footswitch is sometimes duplicated by other external switching devices to facilitate remote operation in conjunction with other devices in a larger semi-automated system.



CAUTION

Never apply power to the footswitch wires. Applying power to the connector wires or wiring the switch connector in any way other than shown by this diagram can cause serious damage the P-400 DRO and void the product warranty.



RS-232 serial input device configuration

Currently, three serial devices can be configured as input channels using the RS-232 serial port. These include:

- DGH D1311 thermocouple
- D5451 thermocouple
- Albion Gage Comp

RS-232 communication setup

The RS-232 communication parameters for all serial input devices are the same except for baud rate, which depends on the device. Serial communication settings are configured in the RS-232 setup screen and are shown below. Refer to [Chapter 3: Setup](#) for details.

- Baud: 9600 (changed to suit input)
- Word Length: 8
- Stop bits: 1
- Parity: None
- EOC Delay: 330
- EOL Delay: 0
- Data: None

Port configurations for serial devices

The input channel configuration parameters for serial input devices are entered into the Channel setup screen and are shown here. Refer to [Chapter 3: Setup](#) for details.

	D1311	D5451	Albion
Resolution	0.01	0.01	0.01
Units	Celcius	Celcius	mm
Reversed	No	No	No
Reference	None	None	None
M.Z. counts	0	0	0
Notify errors	Yes	Yes	Yes
Type	D1311	D5451	Albion
Interpolation	X5	X5	X5

Serial port pin assignments

The RS-232 serial port pin assignments are shown here.

QC Conn	Signal Name QC	PC CONNECTOR	Signal Name PC
1			
2	Transmit (TX)	2	Receive (RX)
3	Receive (RX)	3	Transmit (TX)
4			
5	Ground	5	Ground
6			
7	Clear to send (CTS)	7	Ready to send (RTS)
8	Ready to send (RTS)	8	Clear to send (CTS)
9			

SPC formulas used in the P-400 DRO

The following SPC formulas are used in the P-400 DRO:

- \bar{X} Mean of a single subgroup's values (only a completed subgroup)
- $\bar{\bar{X}}$ Mean of all subgroup mean values (only completed subgroups)
- Mean Mean of all sample values (total population)
- \mathbf{r} Range of a single subgroup's values (only a completed subgroup)
- Range Range of all sample values (total population)
- $\bar{\mathbf{r}}$ Mean of all subgroup range values (only completed subgroups)
- ULC/LCL Upper and lower control limits (UCL & LCL)
- Max Maximum of all sample values (total population)
- Min Minimum of all sample values (total population)
- $\sigma/6\sigma$ Standard deviation and 6 X standard deviation of all samples (total population)
- Cp/CpK Capability indices of all samples (total population)

$\bar{X}()$

Xbar is the mean (average) of the samples that makes up each subgroup. The Xbar chart is a graph of the Xbars of all complete subgroups.

$\bar{\bar{X}}()$

Xdoublebar is the mean of all the Xbars and is equal to the mean of all the samples (except those of an incomplete subgroup). It is only updated when the recalc function is used in the SPC setup page to recalculate xbar UCL and LCL.

Mean

Mean is the average of all the samples. It is the same as Xdoublebar except that it includes the samples of any incomplete subgroup.

$\mathbf{r}()$

r is the range of a subgroup (max of subgroup minus min of subgroup). The r chart is a graph of the ranges of all complete subgroups.

Range

Range is the overall range (Max – Min) of all the samples taken.

$\bar{\mathbf{r}}()$

rbar is the average of the ranges of all the completed subgroups.

UCL and LCL

The Upper Control Limit (UCL) and Lower Control Limit (LCL) are horizontal lines in the Xbar chart, representing the likely limits of the values of the Xbar of future subgroups. The values of these limits may be entered by the user, or if there is sufficient data, the system can calculate values for UCL and LCL:

The value of the UCL of the Xbar chart is: $\bar{X} + A_2 \text{ times } \bar{R}$
 (A2 is shown in the factor table)

The value of the LCL of the Xbar chart is: $\bar{X} - A_2 \text{ times } \bar{R}$

The Upper Control Limit (UCL) and Lower Control Limit (LCL) are horizontal lines also found in the r chart, representing the likely limits of the values of the range. These may be entered by the user or calculated by the system:

The value of the UCL of the r chart is: $D_4 \text{ times } \bar{R}$
 (D4 is shown in the factor table)

The value of the LCL of the r chart is: $D_3 \text{ times } \bar{R}$
 (D3 is shown in the factor table)

The statistics display (in the View display when only one dimension is shown) shows a list of values on the right. These values are statistics that are derived from all the samples taken so far. These are calculated as follows:

Subgroup size	2	3	4	5	6	7	8	9	10
A2	1.88	1.02	0.73	0.58	0.48	0.42	0.37	0.34	0.31
D3	0	0	0	0	0	0.08	0.14	0.18	0.22
D4	3.27	2.57	2.28	2.11	2.00	1.92	1.86	1.82	1.78

SPC Factor table

Max

Max is the Maximum value of all the samples taken.

Min

Min is the Minimum value of all the samples taken.

$\sigma/6 \sigma$

Sigma (σ) is the standard deviation of all the samples taken. The formula for sigma is:

$$\sqrt{\frac{\sum(X_i - \text{mean})^2}{n - 1}}$$

6σ is 6 times the standard deviation.

Cp/CpK

Cp is a capability index. The formula for Cp is:

$$Cp = (USL - LSL) / 6 \sigma$$

Where USL and LSL are the max and min tolerance values. They stand for Upper and Lower Specification limits. In this system, the σ in the denominator is not an estimate based on Sigmabar (the average sigma). This system does not calculate sigma for each subgroup. The sigma for all samples is used instead.

CpK is another capability index. The formula for CpK is:

$$CpK = \text{Min of } (USL - \bar{\bar{X}}, \bar{\bar{X}} - LSL) / 3 \sigma$$

Product specifications

Electrical

Input Voltage Range: 85 VAC to 264 VAC. 1.0 Amp maximum (Auto switchable)

Fuse: 1.6 Amp 250V Slow Blow 5X20mm

Input Frequency: 43Hz to 63Hz



CAUTION

For continued protection against fire, use only replacement fuses with the specified voltage and current ratings.

Environmental

Temperature: 0°C to 45°C (32°F TO 113°F) non-condensing

Humidity: 90% rh

Altitude: 2000 meters (6,562 ft)

Installation: Category: II

Dimensions

Enclosure (WxHxD): 29.2 cm X 19.1 cm X 7.0 cm (11.5" X 7.5" X 2.75")

Base (WxHxD): 25.4 cm X 5.1 cm X 19.8 cm (10" X 2" X 7.8")

Enclosure weight: 1.6 kg (3.5 lbs.)

Base weight: 3.2 kg (7 lbs.)

LCD

Size/color: 14.5 cm (5.7 inch) color

Display digit size: 1.27 cm (0.5 inch)

Resolution: 0.000 1 mm (0.000004 inch)

Chapter 9: Options

Available options are listed and shown here and on the next page with PG&T Co. part numbers:

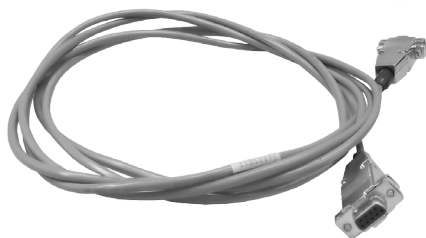
- Foot switch for remote operation
- Keypad for remote operation
- RS-232 cable without crossed cable wiring for communication with computers
- Arm-mounting bracket and bracket adapter for mounting the P-400 DRO on vertical surfaces (must be ordered together)
- QC-Wedge for communicating serial data directly from the P-400 DRO to PC applications



Foot switch w/8 ft cable
62596482



Remote keypad
w/15 ft cable 62596483



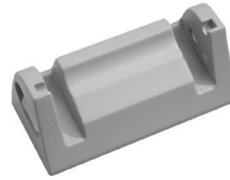
Serial cable
62596652



QC-Wedge software
62596653



QC arm-mounting bracket
62596654



QC arm-mounting bracket adapter
62596655



NOTE

The arm mounting bracket and arm mounting bracket adapter must be ordered as a pair.

Contact the Precision Gage & Tool Co. by phone at 937.866.9666 or by e-mail at info@pgtgage.com to order P-400 DRO options.

Chapter 10:

Air-Electronic Converter Connection & Set-Up

With air supply shut-off valve closed, and the restrictor valve Closed (fully Clockwise) connect Air Source to the rear of the Converter (Shop Air Pressure of at least 60 PSI is sufficient). The regulator on back of A/E converter has been Factory preset to 15 PSI (Open-Jet and leaf-jet tooling);



NOTE: If Special Tooling is being used then the Regulator must be adjusted to 20 PSI for elongated jets or 25 PSI for Ball –jets.

Connect interface cable from the rear of the Converter to the correct Channel Input Connector (located on the back of the P-400 unit).

Connect the Air line for the Tooling to the front of the converter.

The Shut-off valve, on the rear of the converter may now be opened.

The Restrictor valve, on the front of the converter should be turned approx. 2 1/4 turns counter-clockwise, your Spans are now set and you are ready to set up the P-400.

To Configure P-421, P-424 or P-428

Turn on switch on back of unit – Current Value (DRO) Screen should be displayed

At this Screen, select either Inch or MM by Pressing the **IN/MM** SoftKey (Second key from the lower Left)

- 1 Press: **MENU** Softkey
- 2 Press: **SETUP** Softkey, the About Screen will appear.
- 3 Scroll up to the **SUPERVISOR** Screen
- 4 Scroll right to highlight the Password Entry Line & Enter the generic Password **070583**, then press **Enter**.
- 5 Scroll down and unlock each of the Selections below the password by using the Softkey at the lowerleft hand corner. (DO NOT UNLOCK DATUMING)

- 6 Scroll left and highlight **SUPERVISOR**
- 7 Scroll down to **DIMENSIONS**
- 8 Scroll right to highlight Part 0.
- 9 If more than one part is to be configured, Press INC button to change part 0 to part 1 and so on.
- 10 Press DEC to return to part 0.
- 11 Scroll down to activate the amount of channels that are to be used. Switch D1 from **NONE** to desired Label name (example "A") by Pressing **LABEL** softkey to designate dimension label name. This screen will allow up to three characters (using Lower or Upper case letters and/or Numerical symbols).
- 12 Press **ENTER** after highlighting the desired label.
- 13 Continue to Scroll down and change D2, D3 etc. until the desired amount of channels have been turned on and labeled.
- 14 Press **FINISH** when complete; **DIMENSIONS** will again be highlighted

- 1 Scroll down to **FORMATS**
- 2 Scroll over & down to observe default resolution. Change resolution if necessary.
- 3 Press **FINISH** when complete, **FORMATS** will again be highlighted

- 1 Scroll down to **FORMULAS**
- 2 Scroll over and Highlight Dimension A
- 3 Scroll down to Formula Field.
- 4 Press the appropriate channel using the Soft key at the right.



NOTE: Each channel MUST have a formula in order to perform master setup so even if no Mathematical formulas are required, Dimension A must equal at least C1. Other Symbols and Math functions are also available by pressing the 5 Soft-keys located at the bottom of the screen.

See [Chapter 4: Formulas](#) for help with additional formulas.

- 5 Press **FINISH** when complete, Formulas will again be highlighted

- 1 Scroll down to **TOLERANCES**
- 2 Scroll over and Highlight Dimension A



NOTE: At this screen you may enter Actual Master Values or +/- Part Tolerances If you desire to enter actual Master values (min. & max limits, cautions etc.) press Limits Softkey or if you desire to enter the +/- part tolerances press the +/- Softkey.

- 3 Press **FINISH** when complete, **TOLERANCES** will again be highlighted

- 1 Scroll down to **CHANNELS**
- 2 Scroll over to highlight **CHANNELS**
- 3 Scroll Down to Type, setting should be A2D
- 4 Scroll Up to Reversed and enter **YES** (MUST BE IN “YES” POSITION)
- 5 Scroll down to Gain
- 6 Press **TEACH** (lower left button). Follow prompts on screen.
- 7 With air tooling untouched, press **ENTER**.
- 8 With air tooling fully restricted (closed off by placing fingers over jets) press **ENTER**.

The Red Ball at the bottom of the screen will go to the extreme right and when the fingers are removed the Ball will return to the near middle of the screen.

- 1 Scroll up to **RESOLUTION**. (This procedure will be performed using the Min/Max Masters)
- 2 Press the **TEACH** (lower left button)
- 3 Press **MIN.** button and enter Min. Master Value.
- 4 Insert Tooling into Min. Master and Press **ENTER** and answer **YES** to Question “Do You Want to Calibrate”.
- 5 Press **MAX.** button and enter Max. Master Value.
- 6 Insert Tooling into Max. Master and Press **ENTER** and answer **YES** to Question “Do You Want to Calibrate”.
- 7 Press **FINISH & QUIT** to return to the main Current Value screen. The P-400 is now Setup and ready for master setup.

Master Setup

- 1 Press: **MASTER** soft key
- 2 Place all Air Tooling in the **MIN.** masters
- 3 Type in Min. master size in C1 and other used channels.
- 4 Press: **MIN** soft key
- 5 Press: **ENTER**
Screen will display "Perform a min calibration now?"
- 6 Press: **YES**
One green light will be displayed if Calibration was successful. If green is not displayed, repeat Min. master setup.
- 7 Remove Air Tooling from Min. master and place in Max. masters.
- 8 Type in Max. master size in C1 and other used channels.
- 9 Press: **MAX** soft key
- 10 Press: **ENTER**
Screen will display "Perform a max calibration now?"
- 11 Press: **YES**
Two green lights will be displayed if Calibration was successful. If green is not displayed, repeat Max. master setup.
- 12 Remove Air Tooling from Max. master.
- 13 Press **FINISH** to display main screen.

At this point if you want to lock the settings proceed with the following:

- 1 Press: **MENU** Softkey
- 2 Press: **SETUP** Softkey, the About Screen will appear.
- 3 Scroll up to the **SUPERVISOR** Screen
- 4 Scroll right to highlight the Password Entry Line.
- 5 Scroll down and lock **PART SETTINGS, CLEARING DATA** and **CONTROL KEYS** by using lower **SOFTKEY** labeled **LOCKED**.
- 6 Scroll to **MASTER NOW**. If you want your operators to have the capability of mastering, press the **SOFTKEY** labeled **RD. ONLY**; if you don't, press the **SOFTKEY** labeled **LOCKED**.
- 7 Scroll up to the Password Entry Line and press the cancel button until all of the X's have disappeared.
- 8 Press **ENTER, FINISH** and **QUIT** to return to the main Current Value screen.

The P-400 is now Setup and ready to be used.

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