instruments

Innovations in Precision

DR403 DIGITAL READOUT

Operation and Installation Manual

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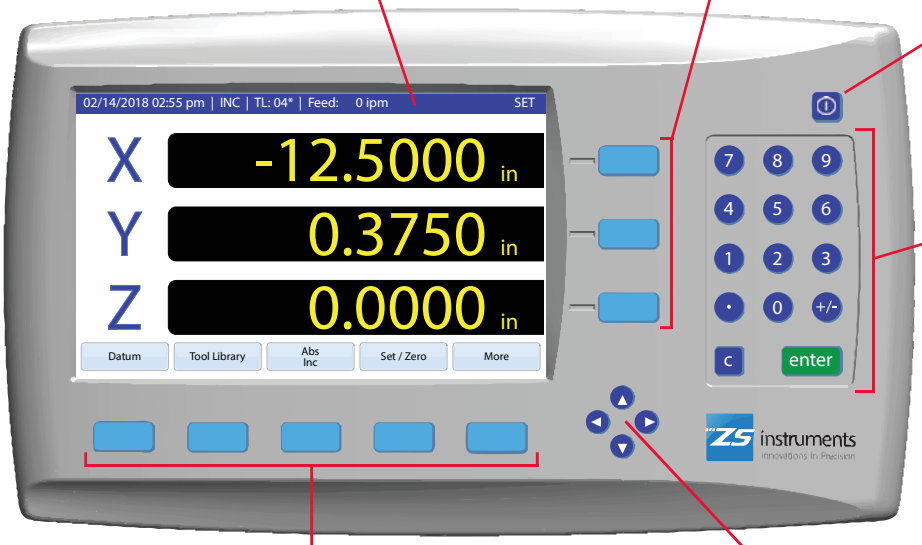
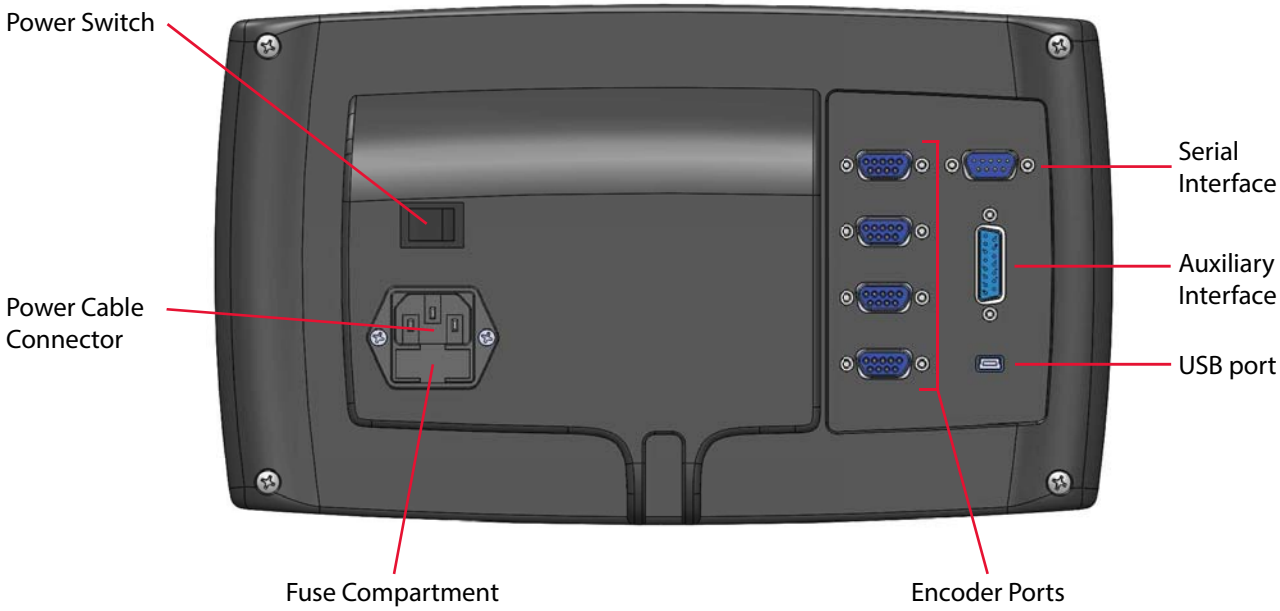
Introduction

Thank you for purchasing ZS Instruments DR400 series DRO. Your new digital readout is capable of many advanced features that make machining operations fast and easy. This guide will cover the installation and setup of the unit, as well as how to use all of the included functions. Please read through this manual in its entirety before beginning installation or using the unit to avoid damage to the DRO, encoders, or your machine. Save this manual for future reference.

Product Overview



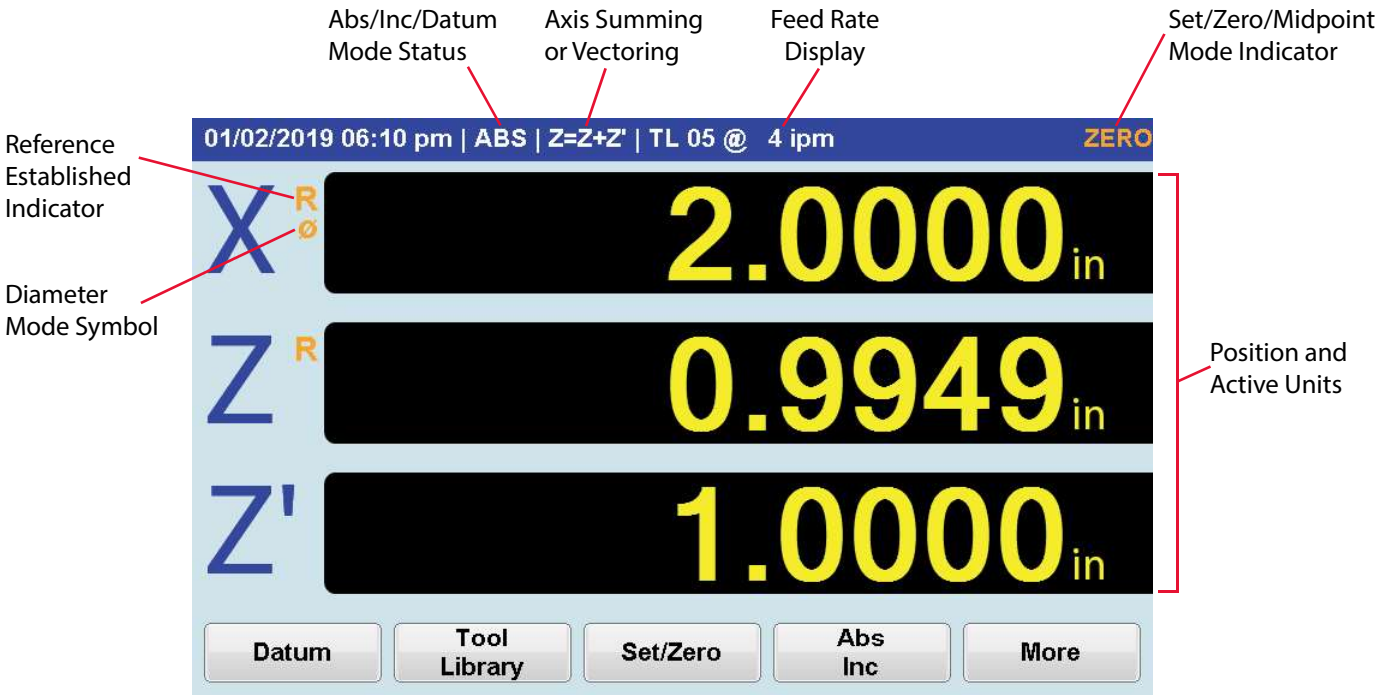


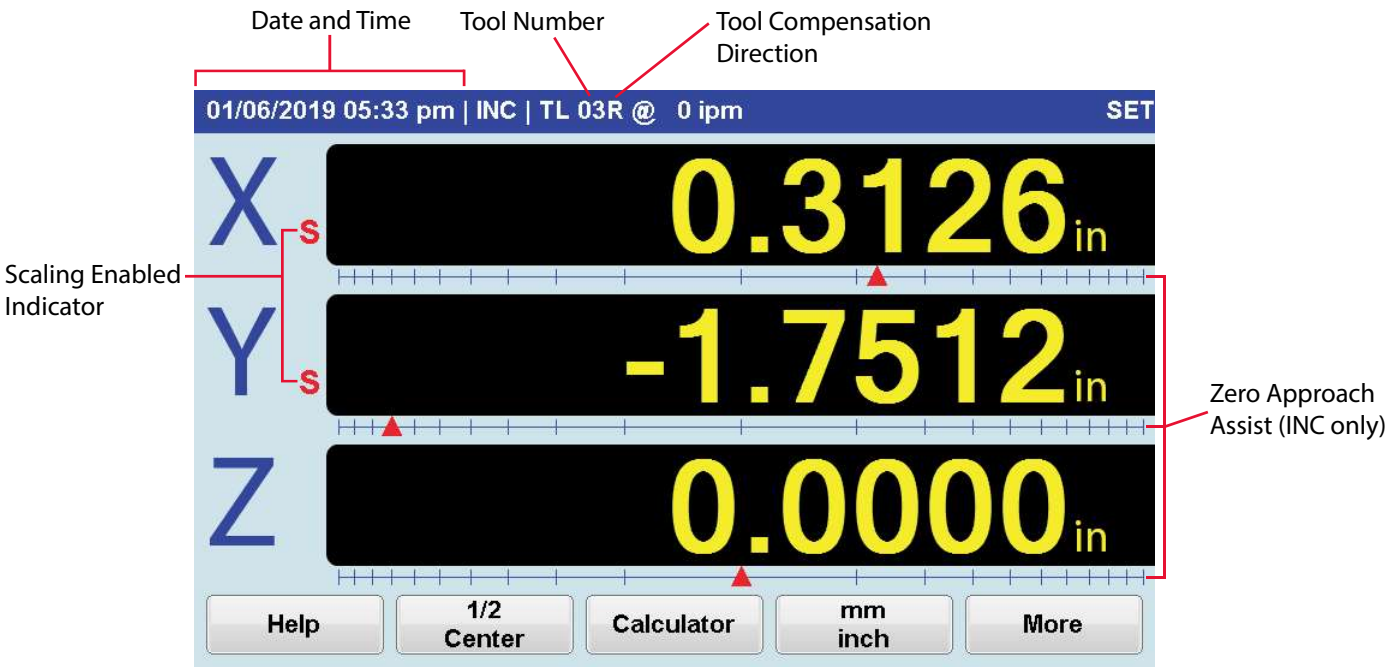
Introduction

Information Bar

At the top of the screen is a status bar that displays current modes and settings to the user. From left to right you will find the date and time, coordinate mode (ABS/INC/current sub-datum), Axes Summing/Vectoring mode status (if enabled), Tool Number with Tool Compensation Direction, and feed rate. At the right of the status bar is a currently active axis buttons mode - SET, ZERO, or 1/2.

Main Screen





Button Descriptions

"Sleep"
Located at the top right corner of the DRO, this button toggles sleep mode.

"Numeric Keypad"
Buttons labeled 0-9, "." and "+/-" used to enter numeric values.

"C"
Button used to clear the current field or to cancel an operation and return to the previous screen.

"Enter"
Button used to save the current field, and if applicable, move to the next entry field.

"Navigation Arrows"
Four buttons consisting of up, down, left, and right arrows, used to navigate around the display fields.

"Axis Buttons"
Three buttons along the right side of the LCD display aligned with and used to select the three axes.

"Soft Keys"
Five buttons along the bottom of the LCD display aligned with and used to select the soft key menu options.

Use the **"More"** soft key to go to the next page of soft keys. Alternatively, use the **"Left"** and **"Right"** arrow buttons to go back and forward between different soft key pages.

Soft Keys

The following soft keys are available on the Main screen:

"Datum"
To select and edit sub-datums, open the Sub-Datum screen by pressing the "Datum" soft key. Up to 99 sub-datum points can be added to define the position of features relative to the absolute origin zero point. When a sub-datum point is selected, the DRO will display the distance from that sub-datum.

"Tool Library"
To select and edit tools, open the Tool Library screen by pressing the "Tool Library" Soft Key. In mill mode, the DRO can store the diameter and length offsets for up to 99 unique tools and use these values to offset the axis position to allow parts to be machined directly from the drawing. In lathe mode, the DRO can store the offsets for up to 99 unique tools and use these values to automatically account for the difference in tool geometry when tools are indexed.

"Set/Zero"
To toggle between the Zero and Set modes, press the "SET/ZERO" soft key. In Zero mode, an axis' current Absolute or Incremental position can be instantly set to zero by pressing the corresponding axis button. In Set mode, pressing an axis button will open the Preset screen, which allows an axis to be set to any arbitrary value.

"Abs/Inc"
To switch between Absolute and Incremental Mode, press the "Abs/Inc" soft key.

When the DRO is in absolute mode, the coordinates are displayed relative to the absolute origin point (i.e. corner of the part or a vise stop location). If the absolute origin is moved, all sub-datum locations will change to maintain their relationships to the absolute origin.

In incremental mode, the coordinates are displayed relative to the last feature. This can be helpful when dimensions reference two features to each other.

The INC mode position is independent from the ABS position and resetting one will not affect another.

"½ Center" (Mill mode only)

To enter the ½ Center function screen, press the "½" button. This function enables finding the midpoint between 0 and the current position. (Only available in ABS and INC modes)

"Calculator"

To open the calculator app, press the "Calculator" soft key. This app can be used to perform simple mathematical and trigonometric operations.

"mm/inch"

To toggle between imperial and metric units, press the "mm/inch" soft key.

"Bolt Circle" (Mill mode only)

To automatically calculate the position of holes in a circular pattern, use the "Bolt Circle" soft key. Full or partial circles are possible.

"Bolt Array" (Mill mode only)

To automatically calculate the position of holes in a linear pattern, press the "Bolt Array" soft key. 1 to 10 lines with up to 99 holes per each line can be calculated at the same time.

"Radius" (Mill mode only)

To machine a radius or rounded feature in any plane, press the "Radius" soft key.

"Incline" (Mill mode only)

To machine a flat diagonal face in any plane, press the "Incline" soft key.

"Diameter Mode" (Lathe mode only)

To quickly toggle the X axis display between Radius and Diameter, press the "Diameter Mode" soft key. The "Ø" indicator is shown next to the axis Letter Label to indicate that the corresponding axis is in diameter mode.

"Summing & Vectoring" (Lathe mode only)

To add a compound axis motion to the longitudinal and/or cross axis, use the "Summing Vectoring" soft key. Summing combines 2 selected axes together, while vectoring splits the movement of the compound (Z') into its axial components and adds them to the X and Z axes.

"Taper Measure" (Lathe mode only)

To determine the angle of taper, use the "Taper Measure" soft key. This key automatically calculates the taper angle after touching a conical workpiece with a tool, edge finder or dial indicator in two positions along the Z axis.

"Setup"

To adjust the display settings, time & date, DRO mode & settings, and encoder parameters, press the Setup Soft Key.

"Zero Ref. Search"

To establish a link between the ABS axis zero and a physical reference mark on the scale, use the "Zero Ref. Search" soft key. Your position can be restored only if reference search was performed before ABS zero was set. We recommend executing reference search for all axes immediately after turning the DRO power on to avoid losing your position in case of a sudden loss of AC power to the DRO.

The "R" symbol, shown next to the axis Letter Label, indicates that Reference has been established.

Mounting

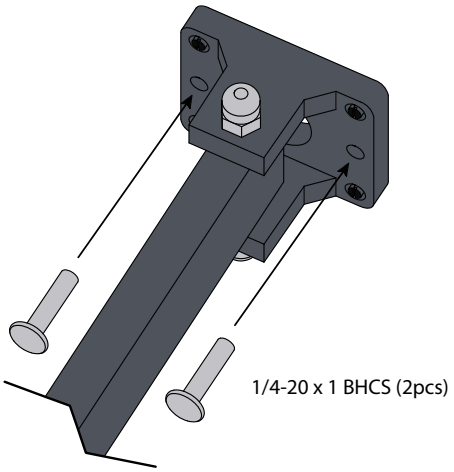
The DRO has different types of arms for mounting to a mill or a lathe. Check that you have the correct type of arm for your machine before attempting to install the DRO.

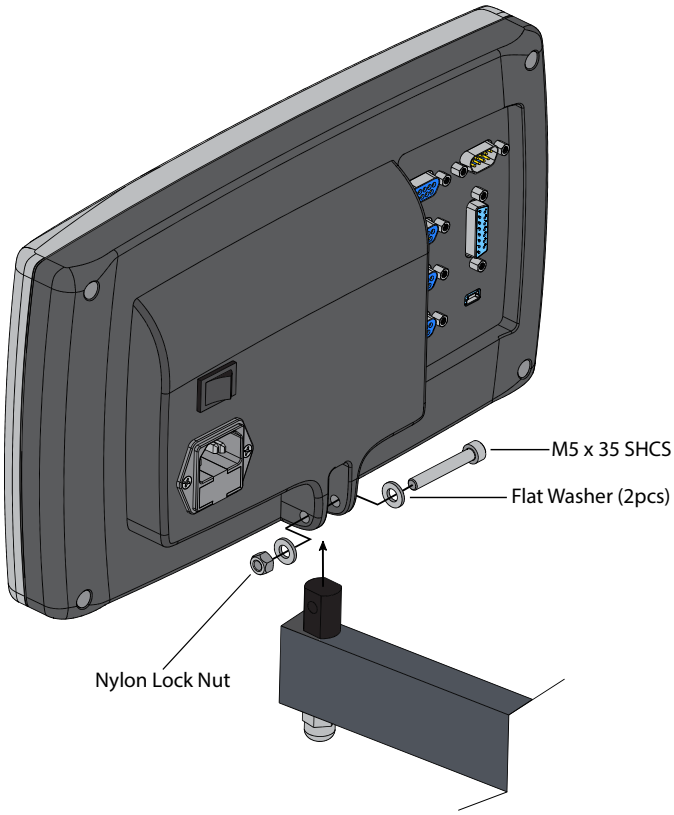
The following **tools** will be required to complete installation:

1. Battery or power operated electric drill.
2. 1/4" center punch, #7 drill bit, and 1/4-20 tap with tap holder.
3. 5/32" and 4mm allen wrenches.
4. 8 mm and 14mm combination or box wrenches. Lathe mounting arm will additionally require an 18 mm wrench.

Mill Mounting

1. Determine the ideal mounting location for your particular machine. Make sure that the DRO and cabling will clear all moving parts of the machine and will not be subjected to coolant spray, flying chips, or other hazards.
2. Using the mounting base as a guide, center punch, drill, and tap two 1/4-20 holes. Attach the arm assembly to the machine using 1/4-20 x 1 BHCS, do not tighten at this point.
3. Use the four set screws to level the mounting arm and securely tighten the 1/4-20 screws using 5/32" allen wrench.
4. Attach the DRO to the end of the mounting arm using M5 x 35 SHCS, two flat washers and a nylon lock nut. Adjust DRO position and securely tighten using 8 mm box wrench while holding the M5 screw with 4 mm allen wrench at the same time.
5. Adjust the final DRO position and tighten acorn nuts using 14 mm box wrench.

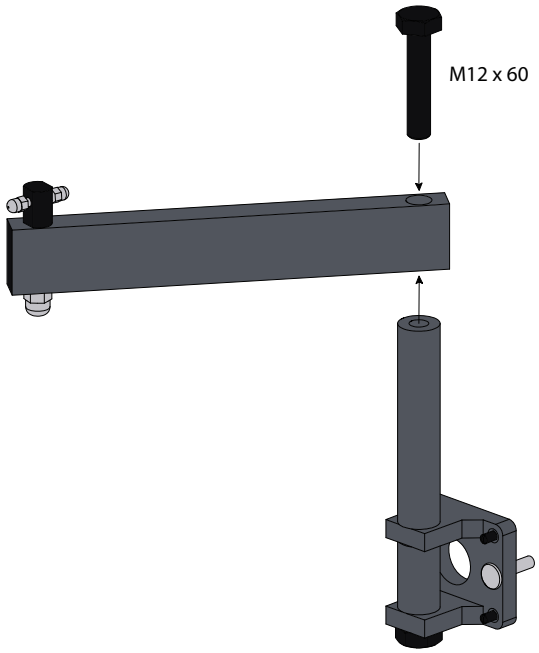




Installation

Lathe Mounting

1. Assemble mounting arm per drawing bellow. Do not fully tighten the M12 x 60 hex screw at this point.
2. Follow steps 1 through 5 of the Mill Mounting instructions.
3. Adjust the final position of the mounting arm, then fully tighten M12 Hex head screws using an 18 mm box wrench.



Connecting Encoders

Before attempting to connect the encoders to the DRO, ensure that they are properly installed on the machine. Check the encoder manual for the installation procedures. Encoder alignment can drastically affect the accuracy of the DRO system, and severely misaligned encoders will result in premature wear and/or permanent damage.

Once the linear encoders are properly installed, plug the encoder cables into their respective axis inputs on the back of the unit. Switch the DRO power off before connecting the encoders. Move each axis along its full range of motion to ensure that cables are not caught on any parts of the machine and do not rub against sharp edges that may cause damage to the cables. Secure the cables such that they can not fall into the lubricant tray when disconnected from the DRO.

Connecting AC Power and Ground

Use only **3-prong grounded outlet** and a supplied **3-wire power cable** to connect the DRO to AC voltage. Route power cable away from any potential pinching, cutting, and flooding hazards. Always follow national and local electric codes while installing electrical equipment!

⚠ Failure to provide a **properly grounded** outlet as well as failure to use a **correct power cord** may cause equipment damage and/or electric shock!

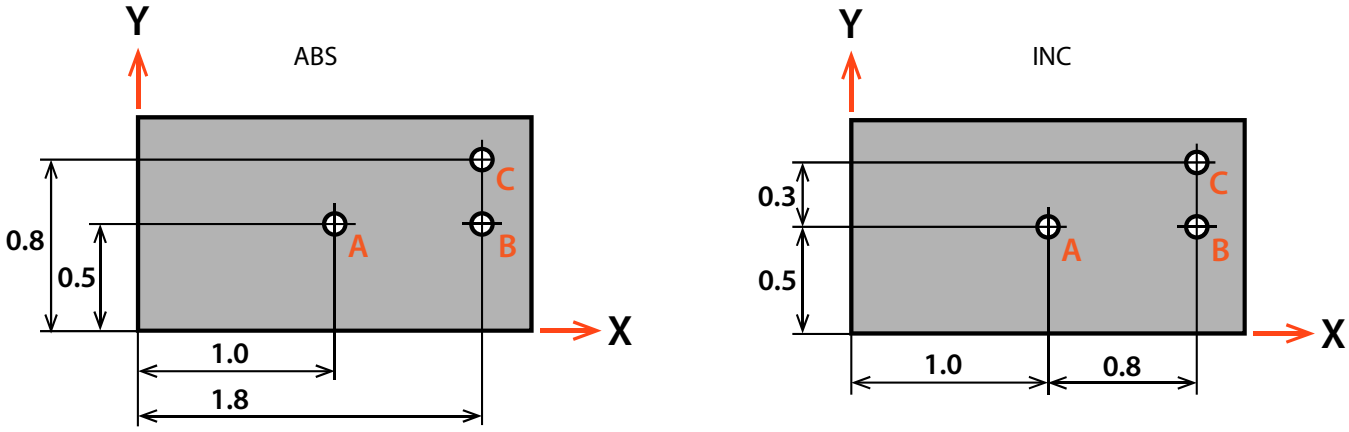
Coordinate Modes

The use of absolute, incremental and sub-datum modes allows for different methods of referencing measurements. Proper use of these modes helps the machinist to perform operations without the need for manual calculations. The currently active mode is displayed on the information bar ("ABS" for absolute, "INC" for incremental, and "DTxx" for sub-datum).

Absolute and Incremental

When the DRO is in **absolute mode**, the coordinate display is always showing the position from the origin. In the example part below, we set this origin point on the top surface at the front left corner of the part. If we were to move to drill feature "A", the DRO would display X=1.000" and Y=0.500". To drill feature "B", move the X axis until DRO displays X=1.800" .

In **incremental mode**, the coordinate display will show the position relative to the last feature. This can be helpful when the working dimensions reference two features from each other. In the example part below, we would zero X and Y after feature "A" is complete, and then move until DRO displays X=0.800" and Y= 0.300" to machine feature "C". The INC mode position is independent from the ABS position and resetting one will not affect another.



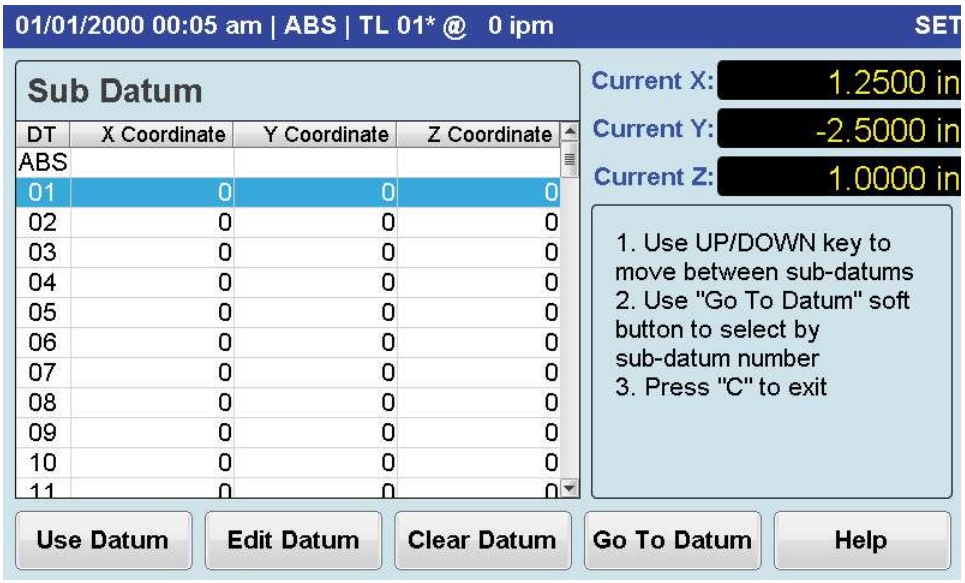
To switch between Absolute and Incremental Mode, press the "Abs/Inc" soft key.

Sub-datum

Up to 99 sub-datum points can be added to define the position of features relative to the ABS mode zero point. When a sub-datum is selected, the DRO will display the distance from the sub-datum position so that when the machine is in position, the DRO axes will display zero.

Note, all sub-datum points are referenced from ABS mode zero. If ABS mode zero changes, all sub-datum consequently move with it. This function is useful when machining multiple complex parts with several features or holding multiple parts in a vise at the same time. In this case, ABS zero can be set to the part corner and sub-datum can be established for each of the features. Moving to the next part will only require reestablishing the 1st corner point (ABS mode zero).

Use the "UP" and "DOWN" keys to move the cursor (highlighted line) through the datum list.



The following soft keys are available on the Sub-datum screen:

"Use Datum"
To set the highlighted sub-datum as the current one, press the "Use Datum" soft key. If the "ABS" datum is highlighted, the DRO will switch back to the ABS mode.

"Edit Datum"
To edit the highlighted datum, press the "Edit Datum" soft key to open the Edit Datum screen.

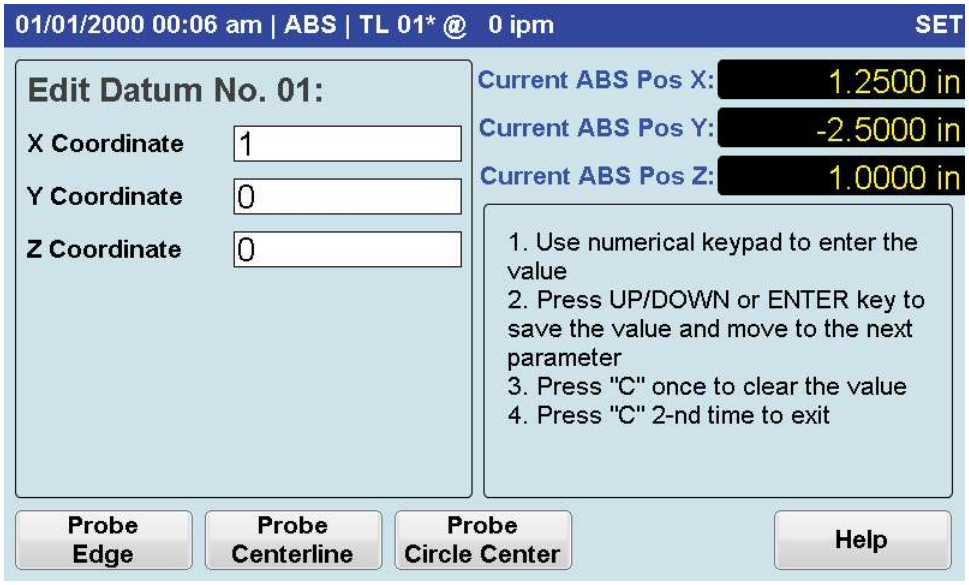
"Clear Datum"
To set the highlighted datum's position as (0, 0, 0), press the "Clear Datum" soft key.

"Go To Datum"
To jump to a sub-datum number without scrolling through the sub-datum list, press the "Go To Datum" soft key. Type a number from 1-99 in the pop-up dialog box and press the "Enter" button. Press the "C" button in the pop-up dialog to exit without changing which sub-datum is highlighted.

Editing Datum

Setting a sub-datum point assigns an offset to that datum from the ABS mode zero. Use the "UP" or "DOWN" keys to move the cursor to the axis you wish to edit. To edit the currently selected axis, either enter an ABS value on the numeric keypad, or use one of the probing functions to measure the position with a tool, edge finder, or electronic touch probe. Press the "Enter," "UP," or "DOWN" buttons to save the new value and move the cursor to the next axis. Press the "C" button to clear the entered value from the current axis. Press the "C" button a second time to exit the Edit Datum screen. If the "Enter," "UP," or "DOWN" buttons are not used to save the value before exiting, the offset for that axis will remain unchanged.

Sub-datums are stored in non-volatile memory, and will not be lost if DRO power is turned off.



The following soft keys are available on the Edit Datum screen:

"Probe Edge"
To probe the edge of a part and set the edge location as an origin of a sub-datum, press the "Probe Edge" soft key. This operation is axis-specific and will need to be repeated for each axis.

"Probe Centerline"
To probe two edges of a part and set the midpoint location as an origin of a sub-datum, press the "Probe Centerline" soft key. This operation is axis-specific and will need to be repeated for each axis.

"Probe Circle Center" (Mill mode only)
To probe three edge points of a circular feature and set the center-point location as X and Y origin of a sub-datum, press the "Probe Circle Center" soft key. The Z coordinate is not affected by this function.

Zeroing or Presetting Axis Position

In either absolute or incremental mode, the current position can be zeroed (setting the origin to the current position) or preset to any number (offsetting the origin from the current position by the specified distance). The value for each axis is set independently.

In **ZERO mode**, an axis' current Absolute or Incremental position can be instantly set to zero by pressing the corresponding axis button. In **SET mode**, pressing an axis button will open the Preset screen, which allows an axis to be set to any arbitrary value.

To toggle between the Zero and Set modes, press the "SET/ZERO" soft key. 

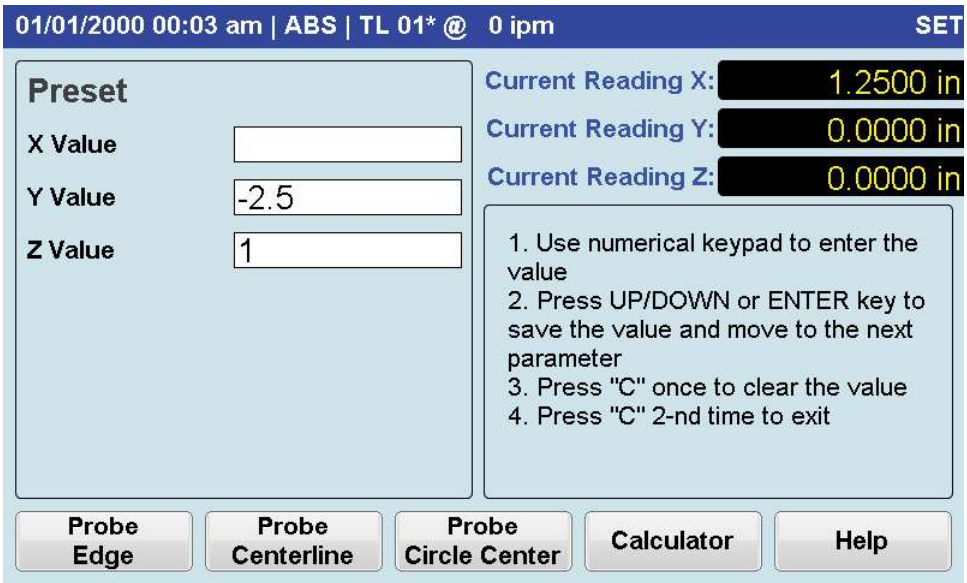
Preset

Use this function to set the current ABS or INC position value to either a user-specified dimension or to a value measured by one of the probing functions with the assistance of a tool, edge finder, or electronic touch probe.

To enter a preset coordinate for the selected axis, enter the value using the numeric keypad and press the "ENTER" button to apply and exit.

Multiple axes may be set from within the preset screen without exiting. Use the "UP" or "DOWN" buttons to move between the axes and to enter values. Press the "ENTER" button to save preset values for all axes and to exit. Axes for which the values were left blank will remain unchanged.

Press the "C" button once to clear the value for the selected axis. Press the "C" button a second time to exit without saving.



The following soft keys are available on the Preset screen:

"Probe Edge"
To probe the edge of a part and set the edge location as a new zero, press the "Probe Edge" soft key. This operation is axis-specific and will need to be repeated for each axis.

"Probe Centerline"
To probe two edges of a part and set the midpoint location as a new zero, press the "Probe Centerline" soft key. This operation is axis-specific and will need to be repeated for each axis.

"Probe Circle Center" (Mill Mode Only)
To probe three edge points of a circular feature and set the center-point location as a new X and Y zero, press the "Probe Circle Center" soft key. The Z coordinate is not affected by this function.

Probing

The probing function can be used for efficient and accurate locating of workpiece features and establishing datum points for future reference.

In order to achieve greater accuracy and to avoid marking the part, we recommend using an electronic touch probe. However, the manual edge finder can also perform probing with great success. Similar to tool diameter compensation, probe radius and direction of approach are automatically accounted for by the DRO.

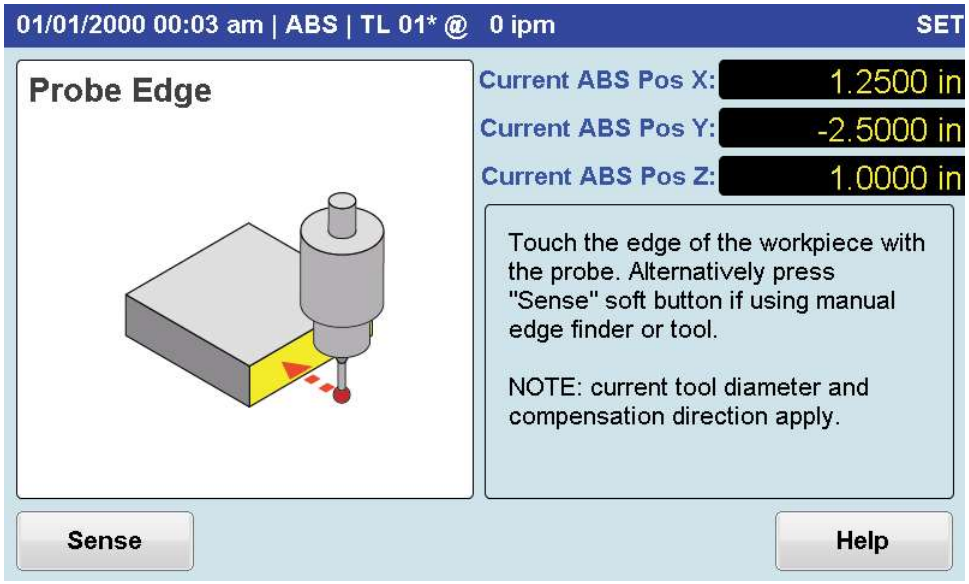
The DRO supports the following probing types:

- **Edge** - determine the location of an edge along one axis
- **Centerline** - by locating two edges, the position of a mid-line between the two can be determined
- **Circle Center** - determine the XY coordinates of a circle center point

Probe Edge

To probe the edge of a part and set the edge location as a new zero, perform the following procedure:

Use the tool or an edge finder to touch the side of the part. Press the "Sense" soft key once in position. Alternatively, the electronic touch probe can be used. When the touch probe has been triggered or the "Sense" key has been pressed, this dialog will close and the DRO will automatically populate the measured coordinate into the parent window. Current tool and compensation direction will be applied.



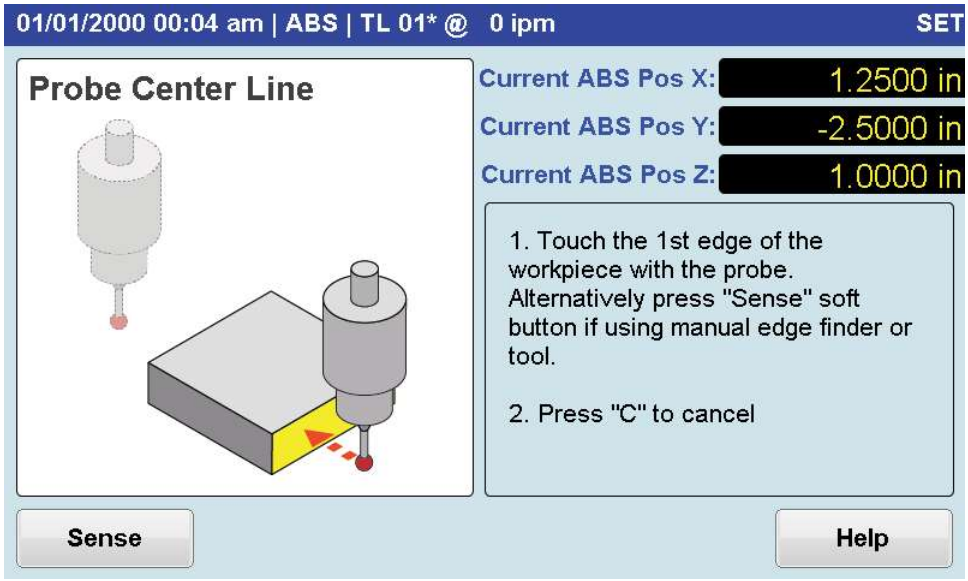
The following soft keys are available on the Probe Edge screen:

"Sense"
To instantly measure and populate the current position value into the coordinate entry field, press the "Sense" soft key.

Probe Centerline

To probe two edges of a part and enter the midpoint location as a new zero, perform the following procedure:

1. Use the tool or an edge finder to touch the first edge of the part and press the "Sense" soft key. Alternatively, the electronic touch probe can be used. When the touch probe has been triggered or the "Sense" key has been pressed, the DRO will automatically move to the next step.
2. Retract the tool, edge finder, or touch probe and move to the second edge of the part. At this point, the DRO position has not been modified, and you can return to the previous step by pressing the "C" key once, or the operation may be canceled by pressing the "C" key during step 1. Touch the edge and press the "Sense" soft key (or move the electronic touch probe towards the edge until it triggers).
3. When the touch probe has been triggered or the "Sense" key has been pressed, the DRO will exit Center Find mode, calculate the midpoint between the 2 measured points, and transfer the calculated coordinate to the parent window.



The following soft keys are available on the Probe Centerline screen:

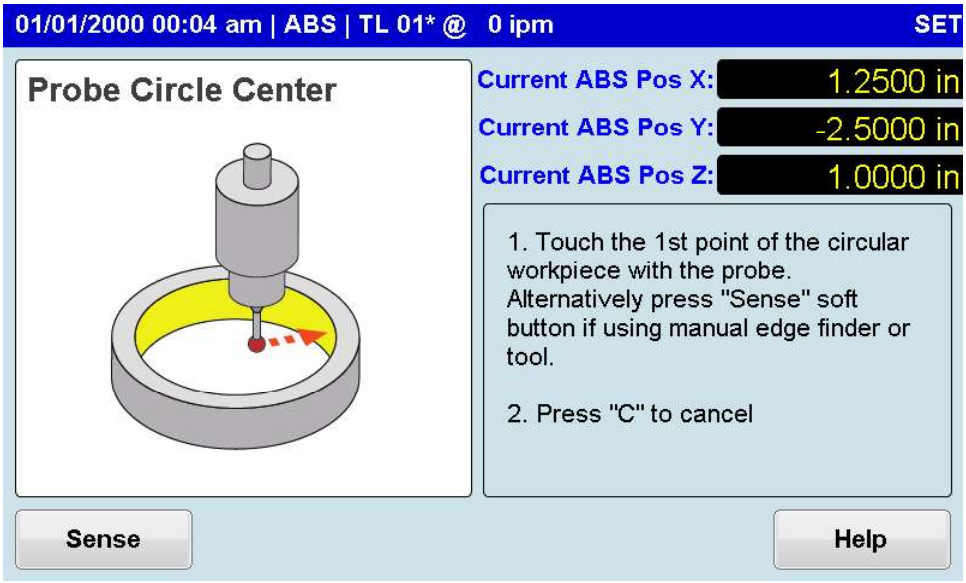
"Sense"

To instantly measure and populate the current position value into the coordinate entry field, press the "Sense" soft key.

Probe Circle Center

To probe three edge points of a circular feature and enter the center-point location as a new X and Y zero, perform the following procedure:

1. Use the tool or an edge finder to touch the ID or OD surface of a circular feature and press the "Sense" soft key. Alternatively, the electronic touch probe can be used. When the touch probe has been triggered or the "Sense" key has been pressed, the DRO will automatically move to the next step.
2. Retract the tool, edge finder, or touch probe and move to the next point on the circular feature. To achieve the best accuracy, these should be spaced as close to 120 degrees apart as possible. At this point, the DRO position has not been modified, and you can return to the previous step by pressing the "C" key once, or the operation may be canceled by pressing the "C" key during step 1. Touch the edge and press the "Sense" soft key (or move the electronic touch probe towards the edge until it triggers).
3. Repeat step 2 for the third point.
4. After the third trigger, the DRO will automatically calculate the center point of the circular feature and transfer X and Y coordinates of the center to the parent window. If the center cannot be found, a pop-up window displaying "Probed points do not form a circle!" will appear and either the "Enter" or "C" buttons need to be pressed to go back to step 1.



The following soft keys are available on the Probe Circle Center screen:

"Sense"
To instantly measure and populate the current position value into the coordinate entry field, press the "Sense" soft key.

Position Data Output

You can easily integrate our DR400 series consoles with your automated equipment by transmitting position readings via the RS232 interface. Output of the current position data can be initiated remotely by the foot pedal/hand pendant, external pulse signal, or automatically upon completing of each probing operation with an electronic touch probe.

Position Data Output initiated by engaging the foot pedal/hand pendant or external pulse signal will be in the following format:

ABS: X=1.3750in; Y=-2.5000in; Z=1.0000in; TS: 01/02/2019 12:29pm						
ABS	X=	1.3750	in	Y=-2.5000in	Z=1.0000in	01/02/2019 12:29pm
Coordinate Mode • ABS - absolute • INC - incremental • DTxx - sub-datum	1st axis label • X • Y • Z • Z' • W	1st axis position value	1st axis position units • in • mm	2nd axis label, position value & units	3rd axis label, position value & units	Time-stamp

The Digital Readout must be in the main screen mode to respond to foot pedal/hand pendant or external pulse

If "Probe Data Out" parameter is set to "RS-232" in the DRO setup, the probed position will be sent to the asynchronous serial interface upon completion of each probing operation.

CCNTR: X=1.7550in; Y=-1.2500in; RAD=1.0000in; TS: 01/02/2019 12:32pm					
ABS	X=1.7550	in	Y=-1.2500in	RAD=1.0000in	01/02/2019 12:29pm
Probing function • E - edge • CL - center line • CCNTR - circle center	X coordinate of the circular feature's center	Position units • in • mm	Y coordinate of the circular feature's center & units	Radius of the circular feature & units	Time-stamp

Zero Reference Search

This function establishes a relation between the ABS axis zero and a physical reference mark on the scale. The position can be restored only if Reference Search was performed before ABS zero was set. We recommend executing Reference search for all axes immediately after turning the DRO power on in order to avoid losing position in case of a sudden loss of AC power to the DRO.

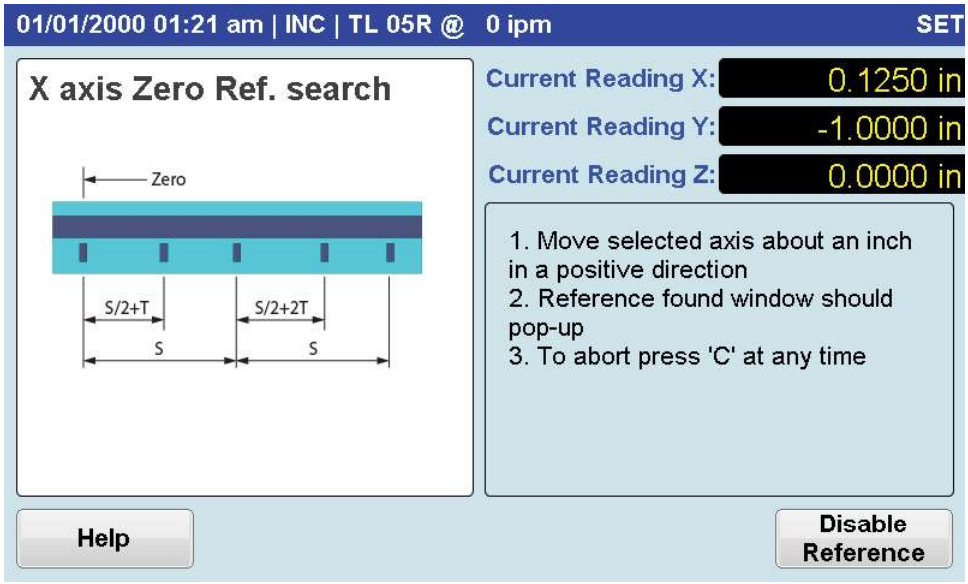
Three types of reference marks are typically used with incremental linear encoders to determine zero after the encoder is powered up: single, periodic, and distance-coded.

In case of single marks, the entire encoder has just one mark, and exact zero can be established by crossing the mark. However, they can be disadvantageous, since a long distance must be traveled before zero is established.

Periodic reference marks are repeated after a certain distance (typically 50mm). While this approach provides some flexibility in choosing which mark to use, establishing zero may require long travel, and moreover, a mechanism to ensure that the same mark is always used as a reference must be implemented.

Distance-coded reference marks are uniquely spaced along the encoder, using a certain mathematical algorithm, typically with distance between each set of marks progressively decreasing by 1 grating period. This allows reestablishment of the absolute position with only minimal movement.

The type of a reference mark is determined by the installed encoder and a correct set of parameters must be entered on the "Encoder Setup" screen for Zero Reference Search function to work.



The following soft keys are available on the Zero Reference Search screen:

"Disable Reference" (Only if Enabled)
To ignore reference marks, press the "Disable Reference" soft button. This feature is useful for locating periodic reference marks when the machine axis must be first moved to the end of travel or another fixed point. All crossed reference marks will be skipped and not taken into account.

"Enable Reference" (Only if Disabled)
To evaluate reference marks again, press the "Enable Reference" soft button. Each crossed mark will now be evaluated.

Distance Coded Reference Search

To find a smart (distance coded) reference mark, perform the following procedure:

1. Move the selected axis about an inch in the positive direction. To abort the procedure, press the "C" button.
2. The "Reference found" pop-up message should appear. It will display the calculated absolute position as well as the locations of three found reference marks. Press the "C" button to discard the found reference and to return to step 1. Press the "Enter" button to use the found reference and return to the reference search axis selection screen.
3. Proceed with the next axis until all references have been established. The reference search procedure must be executed for each axis independently, one at a time. Once this is completed, press the "C" button to return to the Main Screen.

The "R" symbol will appear next to each axis Letter Label for which Reference has been successfully established.

If the smart reference cannot be found after evaluating three reference marks, an error message will pop up. The following recommendations will help to avoid errors during smart reference search:

- Move the axis smoothly and continuously for at least an inch.
- Maintain the same direction of movement (do not jog back and forth).
- Verify that the encoder settings, reference mark type, and parameters match those of the installed encoder.
- Avoid excessive speed during the reference search procedure.

If an error still exists, move the axis a few inches from the current location and try searching reference again.

Single/Periodic Reference Search

If scales with single/periodic reference marks are used, it is important to always start from the end of travel or consistently use another fixed point on the machine and to move the axis in the same direction during the reference search, so that the same mark is crossed every time.

To find single/periodic reference marks, perform the following procedure:

1. Press the "Disable Reference" soft key to temporarily skip reference mark detection.
2. Move the selected axis to the most negative end of travel or to a fixed stop.
3. Press the "Enable Reference" soft key.
4. Move in the positive direction until the "Reference found" pop-up message appears. Press the "C" button to discard the found reference and to return to step 1. Press the "Enter" button to use the found reference and return to the reference search axis selection screen.
5. Proceed with the next axis until all references have been established. The reference search procedure must be executed for each axis independently, one at a time. Once this is completed, press the "C" button to return to the Main Screen.

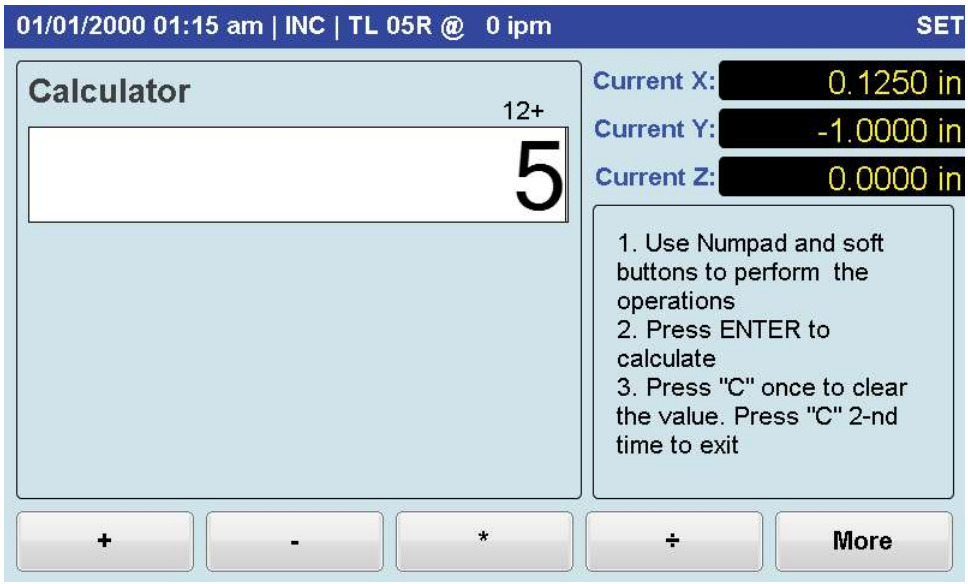
The "R" symbol will appear next to each axis Letter Label for which Reference has been successfully established.

The reference can be verified by repeating the search procedure. If the reference was previously established, the "Reference found" message will always display "axis ref. at: 0.0000."

Calculator

To open the calculator app, press the "Calculator" soft key. This app can be used to perform simple mathematical and trigonometric operations.

Press the "Enter" button in the calculator to perform a calculation. Press the "C" button to clear the value and pending operation. Press the "C" button a second time to discard the result and exit the calculator.



The following soft keys are available on the Calculator screen:

"+", "-", "*", "/", "Sqrt", x2*", "1/x"
Used to perform simple arithmetics.

"Pi"
Used to invoke Pi number.

"Sin", "cos", "tan", "Arc Sin", "Arc Cos", "Arc Tan"
Used to perform trigonometric operations.

"Transfer" (available only if calculator is invoked while a cursor is on one of the numeric data entry fields)
Press the "Transfer" soft key to close the calculator and populate the result into the current numeric field.

Sleep Mode

Sleep mode can be toggled by pressing the power button on the front panel of the DRO. Sleep mode saves power and prolongs the LCD life by putting DRO into low consumption mode and turning off LCD back-light but continues to track tool position.

It is safe to move machine axis while the DRO is in sleep mode, and position loss will not occur.

Scaling and Shrinkage

Each axis can have a linear scaling factor applied as a percentage. This can be used to compensate for shrinkage or to scale a part. Factor of >100% scales the part up, while <100% scales the part down.

To enter the scaling and shrinkage menu, press the following soft keys.

Use the navigation arrows to select the desired axis for modification. Press the "ENTER" button to save the new value. Press the "C" button to discard the change. Press the "C" button twice to exit the Scaling & Shrinkage screen.

Scaling factors are stored in non-volatile memory and will not be lost if DRO power is turned off.

Units

Your Digital Readout can be set to display position in either imperial or metric units of measure. Imperial units are displayed in inches while metric units are in millimeters. Note that changing units will not affect current position and you may switch the active units at any time.

The current units are indicated on the position screen.

To toggle between imperial and metric units, press the "mm/inch" soft key.

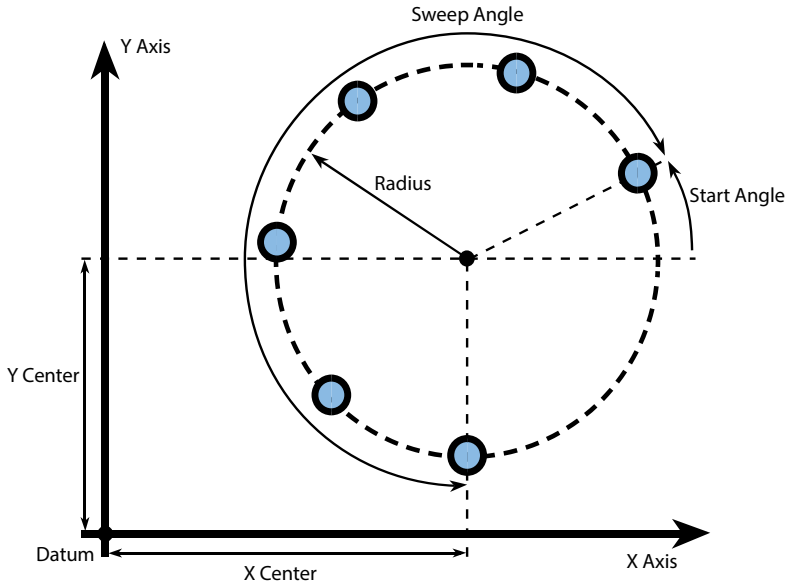
Feed-rate Display

The feed rate is automatically displayed on the information bar either in inches per minute (ipm) or millimeters per second (mm/s) based on the active units.

The feed rate is highlighted in yellow below.

Bolt Circle

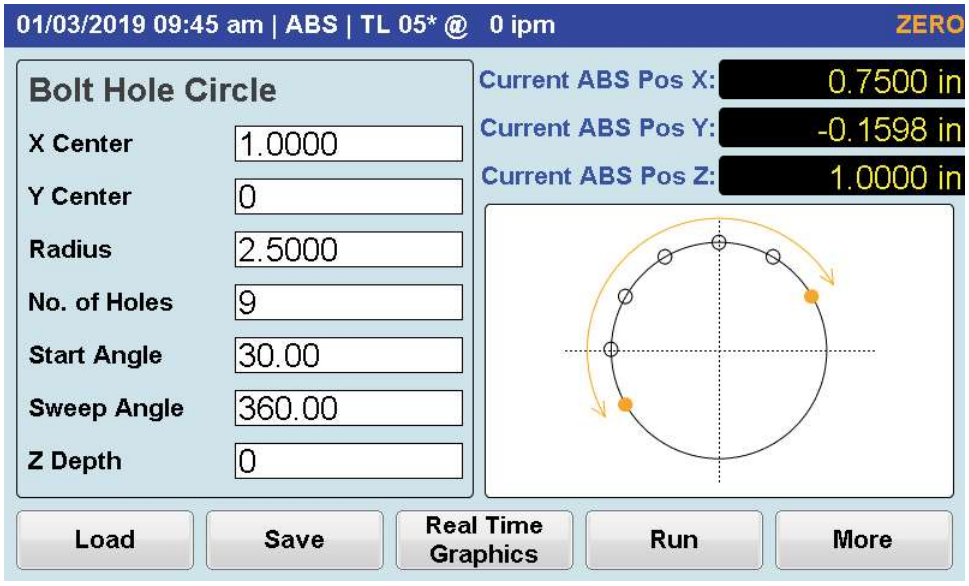
The Bolt Circle function automatically calculates the position of holes in a circular pattern.



To define a new Bolt Circle feature, enter or edit the following parameters:

- **X Center, Y Center** – The position of the center of the circle. Enter the ABS coordinates or press the "Sense" soft key to use the current position as the center point.
- **Radius** – The radius of the circle.
- **No. of Holes** – The number of holes to be drilled. Enter a number between 1 and 999.
- **Start Angle** – The starting angle in degrees (counterclockwise from the three o' clock position).
- **Sweep Angle** – The sweep of the bolt circle in degrees. Use 360 degrees for a full bolt circle.
- **Z Depth** – Final drill depth of the holes (optional).

Up to 99 unique Bolt Circle features can be stored in the non–volatile memory. The current feature can also be executed without saving.



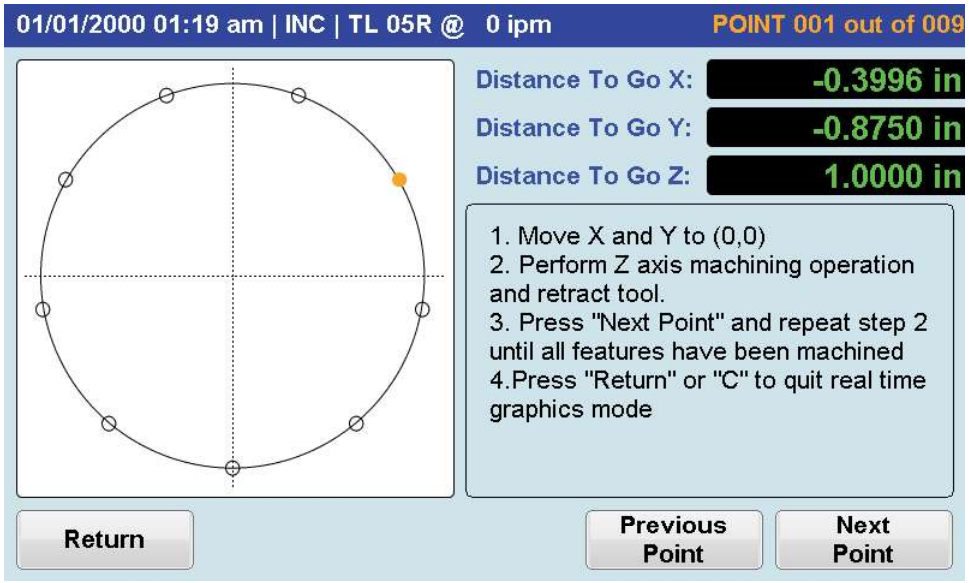
Mill Functions

The following soft keys are available on the Bolt Circle screen:

"Save"
To save the currently entered Bolt Circle feature parameters to the memory, press the "Save" soft key. A pop-up dialog will open and prompt for a feature number. Refer to the "Saving and Loading Features" section of this manual for more details.

"Load"
To load a previously saved Bolt Circle feature, press the "Load" soft key. A pop-up dialog will open and prompt for a feature number. Refer to the "Saving and Loading Features" section of this manual for more details.

"Real Time Graphics"
To open a graphic view that illustrates the calculated tool path to scale, press the "Real Time Graphics" soft key. This enables verifying the feature and stepping through the calculated tool positions. Refer to the "Using Real Time Graphics" section of this manual for more details.



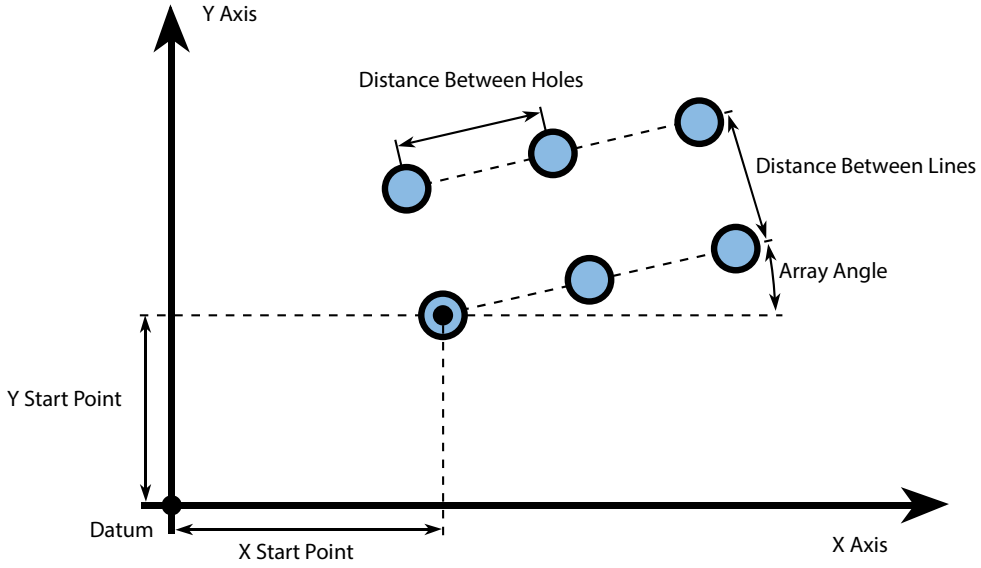
"Run"
To begin machining the current Bolt Circle feature, press the "Run" soft key. This key opens a modified version of the main screen that displays the current point on the farthest right side of the status bar. Refer to the "Machining Programmed Features" section of this manual for more details.

"Calculator" (Available only if the cursor is currently set to one of the numeric entry fields.)
To perform simple mathematical and trigonometric operations, press the "Calculator" soft key.

"Sense" (Available only if the cursor is currently set to the Start Point or the End Point.)
To instantly measure and populate the current ABS position value into the coordinate entry field, press the "Sense" soft key.

Bolt Array

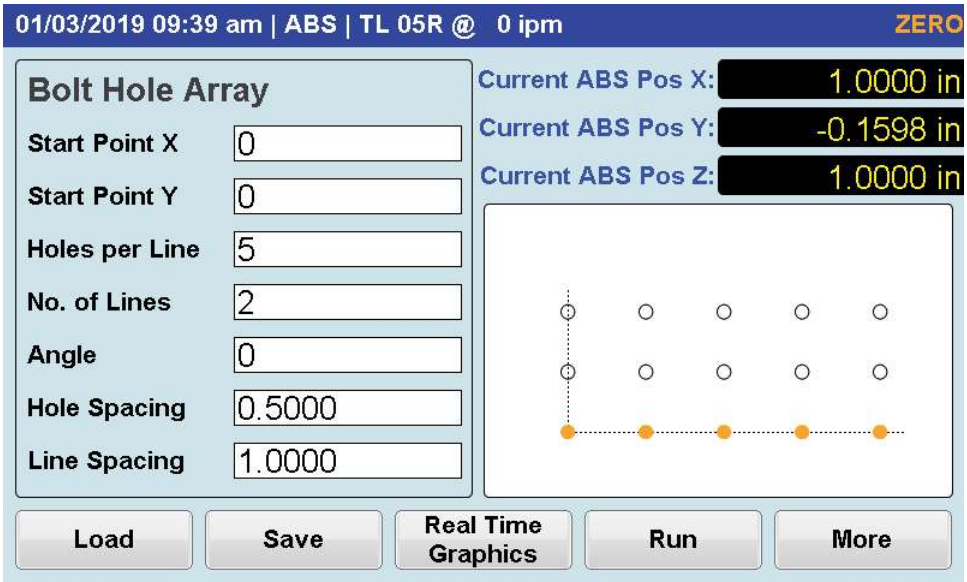
The Bolt Array function automatically calculates the position of holes in a linear pattern and at any angle to the X axis.



To define a new Bolt Array feature, enter or edit the following parameters:

- **Start Point** – The position of the first hole in the array on the XY plane. Enter the ABS coordinates or press the "Sense" soft key to use the current position as the starting point.
- **Holes per Line** – The number of holes to be drilled per line. Enter any number up to 99.
- **No. of Lines** – The number of lines. Enter a number between 1 (single bolt line) and 10.
- **Angle** – The angle of the array (counterclockwise from the three o' clock position). Enter a value between 0 and 360 degrees.
- **Hole Spacing** – The distance between the holes on the lines.
- **Line Spacing** – The distance between the lines.

Up to 99 unique Bolt Array features can be stored in the non–volatile memory. The current feature can also be executed without saving.



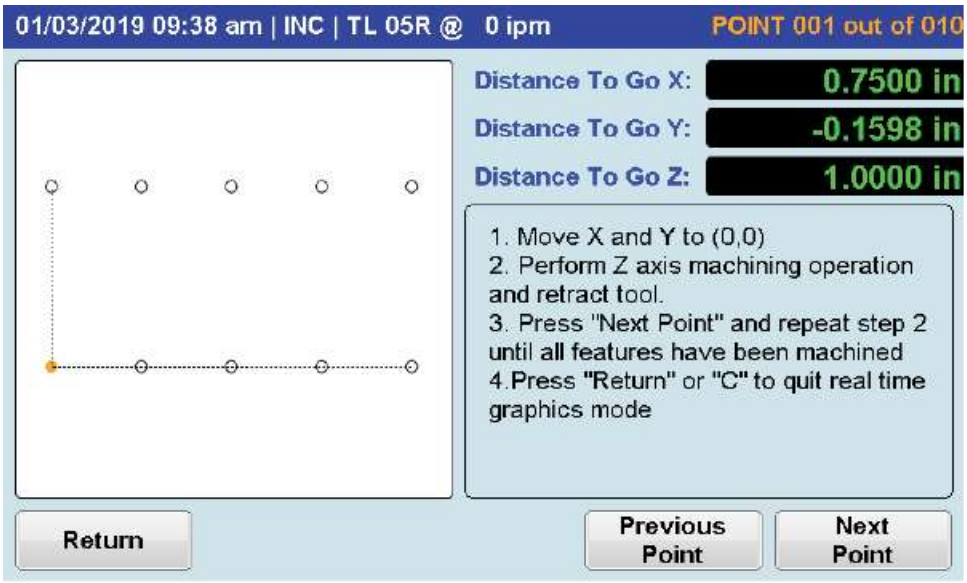
Mill Functions

The following soft keys are available on the Bolt Array screen:

"Save"
To save the currently entered Bolt Array feature parameters to the memory, press the "Save" soft key. A pop-up dialog will open and prompt for a feature number. Refer to the "Saving and Loading Features" section of this manual for more details.

"Load"
To load a previously saved Bolt Array feature, press the "Load" soft key. A pop-up dialog will open and prompt for a feature number. Refer to the "Saving and Loading Features" section of this manual for more details.

"Real Time Graphics"
To open a graphic view that illustrates the calculated tool path to scale, press the "Real Time Graphics" soft key. This enables verifying the feature and stepping through the calculated tool positions. Refer to the "Using Real Time Graphics" section of this manual for more details.



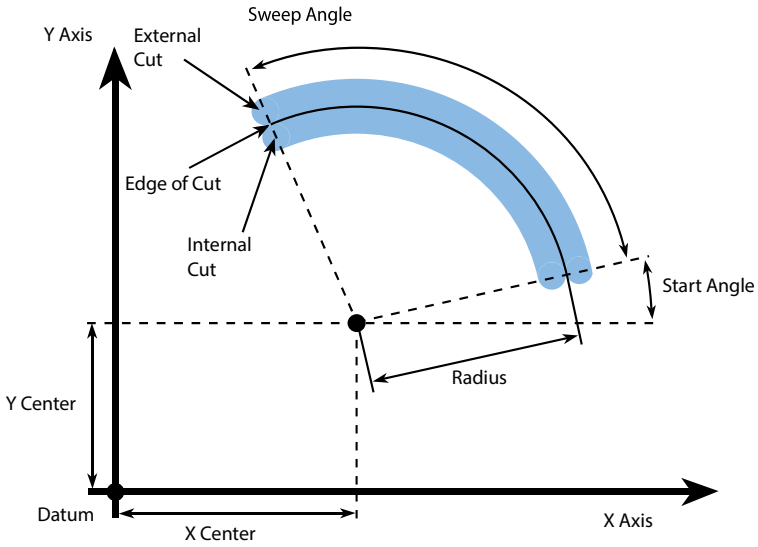
"Run"
To begin machining the current Bolt Array feature, press the "Run" soft key. This key opens a modified version of the main screen that displays the current point on the farthest right side of the status bar. Refer to the "Machining Programmed Features" section of this manual for more details.

"Calculator" (Available only if the cursor is currently set to one of the numeric entry fields.)
To perform simple mathematical and trigonometric operations, press the "Calculator" soft key.

"Sense" (Available only if the cursor is currently set to the Start Point or the End Point.)
To instantly measure and populate the current ABS position value into the coordinate entry field, press the "Sense" soft key.

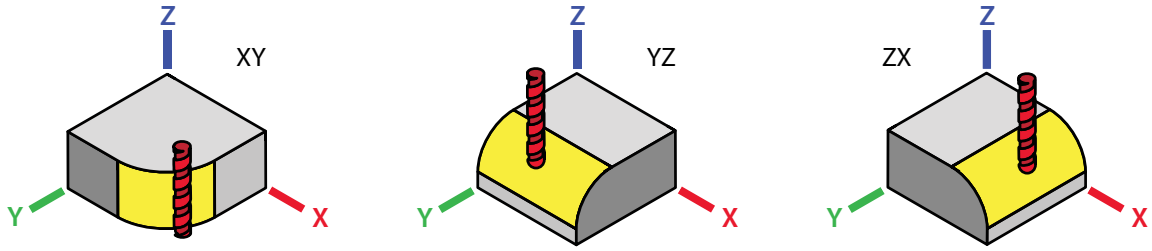
Radius

The radius function enables machining of a radius or rounded feature in any plane. The digital readout will sequentially display the location where the tool needs to be positioned to create the cylindrical surface.



To define a new Radius feature, enter or edit the following parameters:

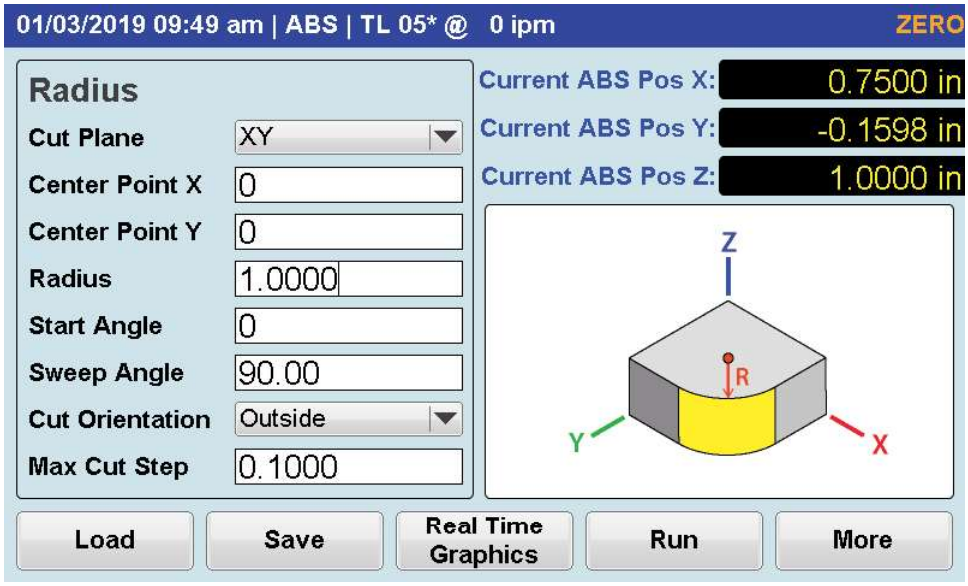
- **Cut Plane** – The plane perpendicular to the desired cylindrical face. Select XY, YZ, or ZX.



- **Center Point** – The center point of the circle on the cut plane. Enter the ABS coordinates or press the "Sense" soft key to use the current position as the center point.
- **Radius** – The radius of the cylindrical surface.
- **Start Angle** – The starting angle in degrees (counterclockwise from the three o' clock position). If machining a concave feature in the YZ or XZ planes, the start angle cannot be less than 180 degrees.
- **Sweep Angle** – The sweep of the radius in degrees. This can vary from 1 to 360 degrees for the XY plane, and from 1 to 180 degree for the YZ and XZ planes. Note, if the start angle is not zero, maximum sweep will be limited, so the end angle does not exceed 180 degrees for convex features and 360 degrees for concave ones.
- **Cut Orientation** – In the XY plane, orientation will determine if tool compensation is applied on the inside (milling a hole) or outside (milling a solid cylinder). A currently selected tool must have a non-zero diameter for the tool compensation to apply. In YZ and XZ modes, "inside" compensation will calculate a concave feature while the "outside" option will result in a convex feature. (A ball end mill with non-zero diameter MUST be used when milling inclines on the XZ or YZ planes.)
- **Max Cut Step** – The length of a linear path between 2 consecutive tool stops. A smaller number produces a smoother surface but requires more machining steps.

Up to 99 unique Radius features can be stored in the non–volatile memory. The current feature can also be executed without saving.

Mill Functions



The following soft keys are available on the Radius screen:

"Save"
To save the currently entered Radius feature parameters to the memory, press the "Save" soft key. A pop-up dialog will open and prompt for a feature number. Refer to the "Saving and Loading Features" section of this manual for more details.

"Load"
To load a previously saved Radius feature, press the "Load" soft key. A pop-up dialog will open and prompt for a feature number. Refer to the "Saving and Loading Features" section of this manual for more details.

"Real Time Graphics"
To open a graphic view that illustrates the calculated tool path to scale, press the "Real Time Graphics" soft key. This enables verifying the feature and stepping through the calculated tool positions. Refer to the "Using Real Time Graphics" section of this manual for more details.

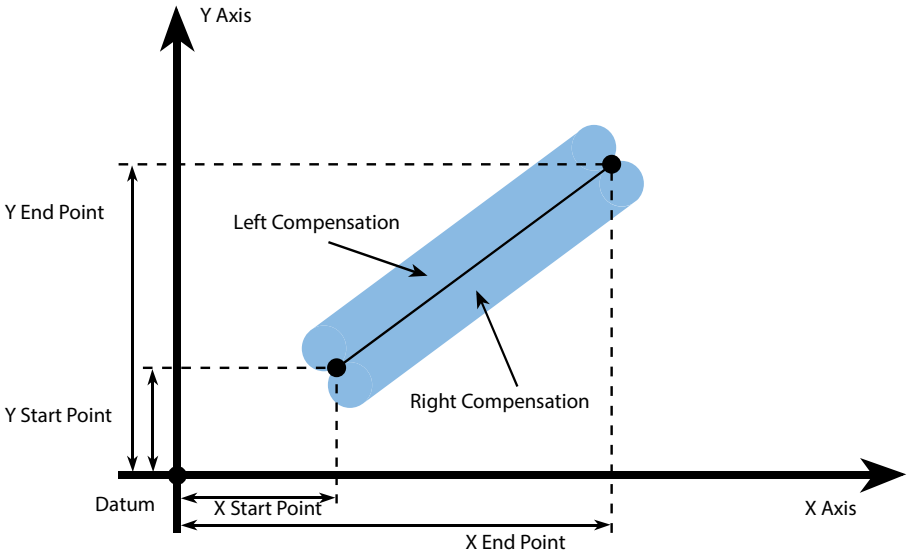
"Run"
To begin machining the current Radius feature, press the "Run" soft key. This key opens a modified version of the main screen that displays the current point on the farthest right side of the status bar. Refer to the "Machining Programmed Features" section of this manual for more details.

"Calculator" (Available only if the cursor is currently set to one of the numeric entry fields.)
To perform simple mathematical and trigonometric operations, press the "Calculator" soft key.

"Sense" (Available only if the cursor is currently set to the Start Point or the End Point.)
To instantly measure and populate the current ABS position value into the coordinate entry field, press the "Sense" soft key.

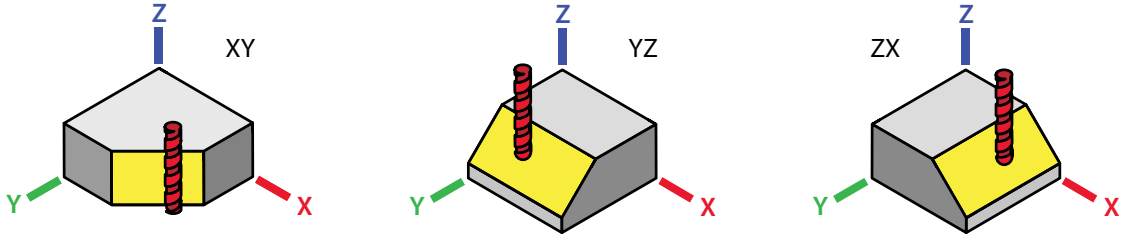
Incline

The Incline function enables machining of a flat diagonal face. The digital readout will sequentially display the location where the tool needs to be positioned to create a diagonal face perpendicular to the cut plane and passing through the line connecting 2 points.



To define a new Incline feature, enter or edit the following parameters:

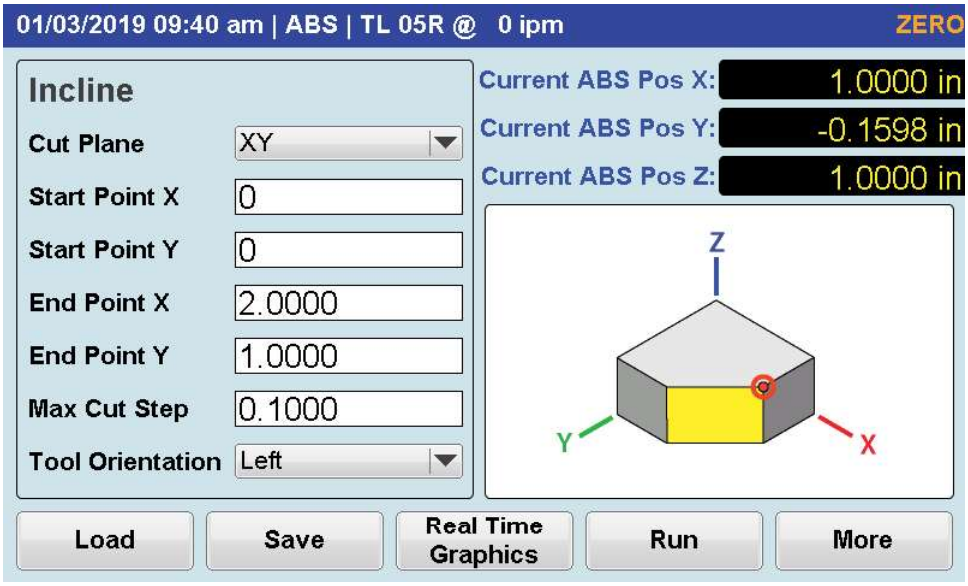
- **Cut Plane** – The plane perpendicular to the desired diagonal face. Select XY, YZ, or ZX.



- **Start Point** – The starting point of the incline on the cut plane. Enter the ABS coordinates or press the "Sense" soft key to use the current position as the starting point.
- **End Point** – The ending point of the incline on the cut plane. Enter the ABS coordinates or press the "Sense" soft key to use the current position as the ending point.
- **Max Cut Step** – The length of a linear path between 2 consecutive tool stops. A smaller number produces a smoother surface but requires more machining steps.
- **Tool Orientation** – Whether tool compensation will be applied to the right or left. Applicable to the XY cut plane only. A currently selected tool must have a non-zero diameter for the tool compensation to apply. (A ball end mill with non-zero diameter MUST be used when milling inclines perpendicular to the XZ or YZ plane.)

Up to 99 unique Incline features can be stored in the non–volatile memory. The current feature can also be executed without saving.

Mill Functions



The following soft keys are available on the Incline screen:

"Save"
To save the currently entered Incline feature parameters to the memory, press the "Save" soft key. A pop-up dialog will open and prompt for a feature number. Refer to the "Saving and Loading Features" section of this manual for more details.

"Load"
To load a previously saved Incline feature, press the "Load" soft key. A pop-up dialog will open and prompt for a feature number. Refer to the "Saving and Loading Features" section of this manual for more details.

"Real Time Graphics"
To open a graphic view that illustrates the calculated tool path to scale, press the "Real Time Graphics" soft key. This enables verifying the feature and stepping through the calculated tool positions. Refer to the "Using Real Time Graphics" section of this manual for more details.

"Run"
To begin machining the current Incline feature, press the "Run" soft key. This key opens a modified version of the main screen that displays the current point on the farthest right side of the status bar. Refer to the "Machining Programmed Features" section of this manual for more details.

"Calculator" (Available only if the cursor is currently set to one of the numeric entry fields.)
To perform simple mathematical and trigonometric operations, press the "Calculator" soft key.

"Sense" (Available only if the cursor is currently set to the Start Point or the End Point.)
To instantly measure and populate the current ABS position value into the coordinate entry field, press the "Sense" soft key.

Machining Programmed Features

To begin machining Bolt Circle, Bolt Array, Radius, or Incline features press the "Run" soft key from the corresponding feature definition screen. This will put the DRO in run mode with the current machining point displayed on the right most side of the information bar. Use the soft keys or arrow buttons to move between the tool position points to machine the programmed feature.

The following soft keys are available on the Run screen:

"Real Time Graphics"
To open a graphic view that illustrates the calculated tool path to scale, press the "Real Time Graphics" soft key. This enables verifying the feature and stepping through the calculated tool positions.

"Finish"
Press the "Finish" soft key to exit and return to the main screen.

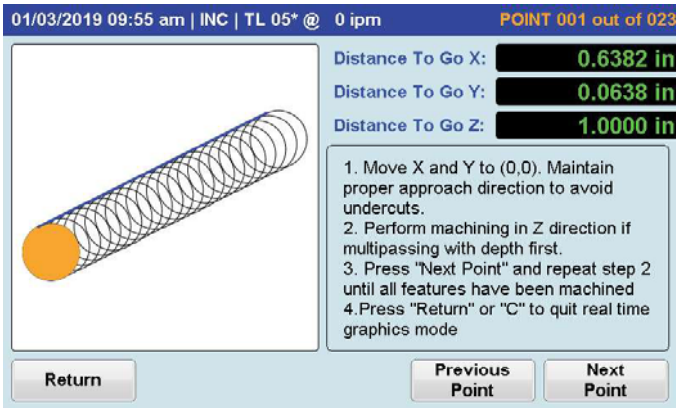
"Previous Point"
To return to the previous tool position point of the programmed feature press the "Prev. Point" soft key. Alternatively press the left or down arrow button.

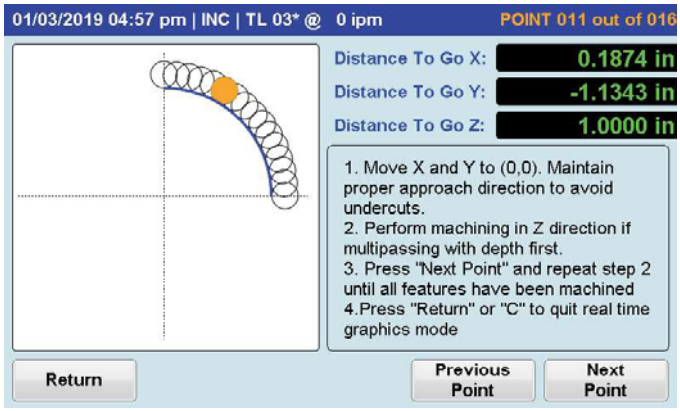
"Next Point"
To move to the next tool position point of the programmed feature press the "Next Point" soft key. Alternatively press the right or up arrow button.

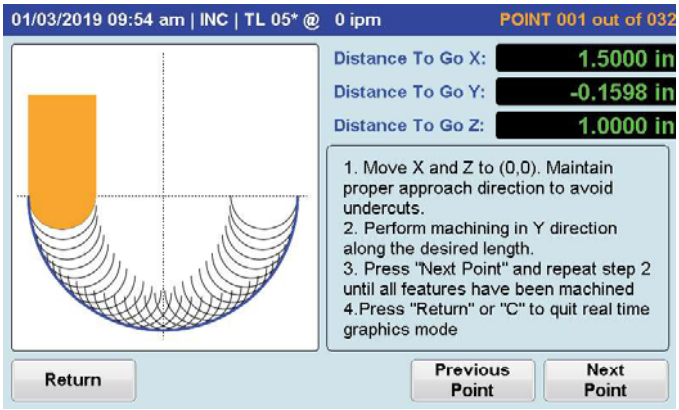
Using Real Time Graphics

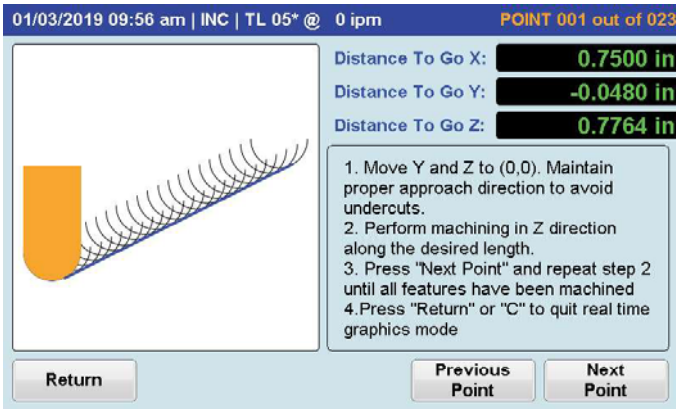
Real time graphics screen displays an entire tool path of the programmed feature. All calculated tool positions are shown along the path. Diameter of the currently active tool is used to generate the drawing.

The selected machining point is displayed on the right-hand side of the status bar, and the corresponding tool position is highlighted on the drawing.









The following soft keys are available on the real time graphics screen:

"Return"
To return to the previous screen, press the "Return" soft key or the "C" button.

"Previous Point"
To return to the previous tool position point of the programmed feature press the "Prev. Point" soft key. Alternatively press the left or down arrow button.

"Next Point"
To move to the next tool position point of the programmed feature press the "Next Point" soft key. Alternatively press the right or up arrow button.

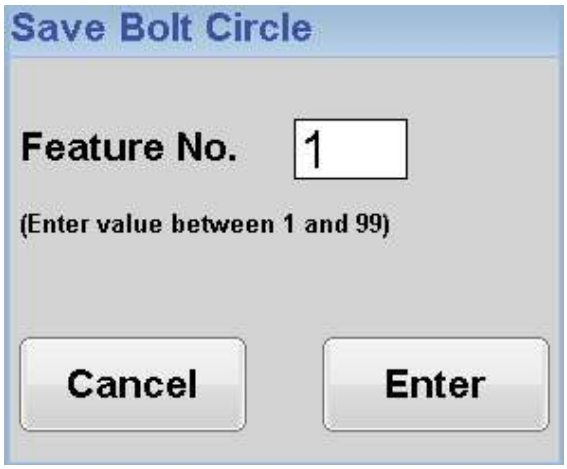
Saving and Loading Features

The Bolt Circle, Bolt Array, Radius, and Incline features all can store up to 99 configurations each in the non-volatile memory. To save or load feature, use the following soft key from the corresponding feature screen:

Save

To save the currently entered feature parameters to the memory, press the "Save" soft key. A pop-up dialog will open and prompt for a feature number. Use the numeric buttons to enter a number from 1 to 99 and press the "Enter" button. To cancel saving, press the "C" button in the pop-up dialog.

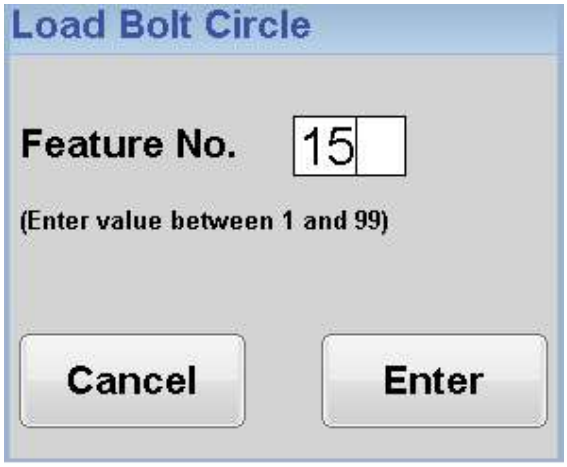
If there was a feature previously saved under the same number, it will get overwritten.



Load

To load a previously saved feature, press the "Load" soft key. A pop-up dialog will open and prompt for a feature number. Use the numeric buttons to enter a value from 1 to 99 and press the "Enter" button. Press the "C" button in the pop-up dialog to cancel loading and keep the current feature parameters unmodified.

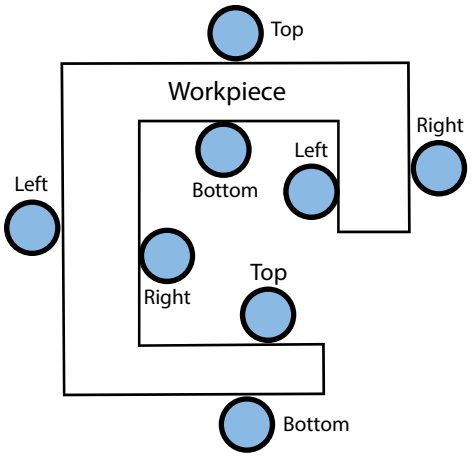
The current feature parameters will be overwritten by the values from the memory.



Mill Tool Library

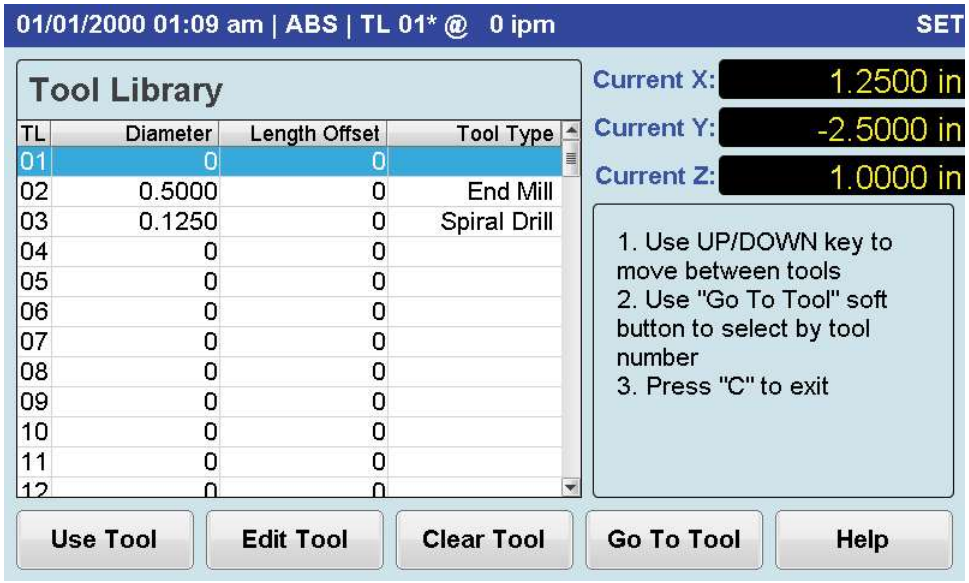
The DRO can store the diameter and length offsets for up to 99 unique tools and use these values to offset the axis position to allow parts to be machined directly from the drawing. The current tool is displayed on the information bar (e.g. "TL02").

In mill mode, once a tool is selected, compensation in the Z direction is automatically applied. The compensation required in the X and Y directions is based on the position of the tool in relation to the part. The current cut direction is displayed next to the tool number on the status bar as L, R, T, B, or * (Left, Right, Top, Bottom, or Center). A left cut direction means that the tool is on the left side of the workpiece. A center cut means that no radial compensation is applied. Press +/- until the desired cut direction appears.



Taking advantage of length offsets in mill mode requires a specialized tool holder or use of stopping collars, so tools are installed at the same depth every time.

Use the "UP" and "DOWN" keys to move the cursor (highlighted line) through the list of tools.



The following soft keys are available on the Tool Library screen:

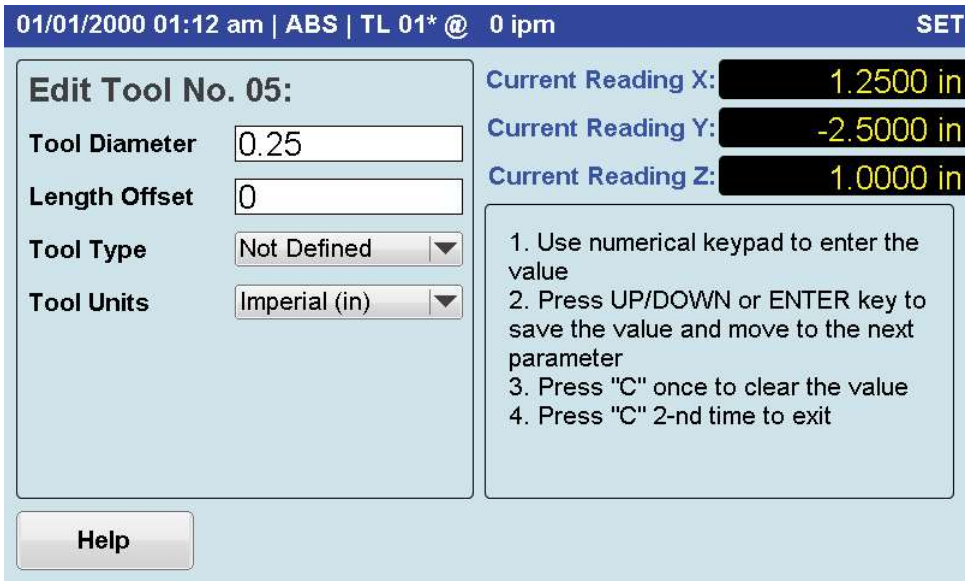
"Use Tool"
To set the highlighted tool as the current one, press the "Use Tool" soft key. The highlighted tool will now be set as active.

"Edit Tool"
To edit the highlighted tool, press the "Edit Tool" soft key, which will open the Edit Tool screen.

"Clear Tool"
To set the highlighted tool's diameter and length offset to zero and clear the tool type, press the "Clear Tool" soft key.

"Go To Tool"
To jump to a tool number without scrolling through the tool list, press the "Go to Tool" soft key. Type a number from 1-99 in the pop-up dialog box and press the "Enter" button. Press the "C" button in the pop-up dialog to exit without changing which tool is highlighted.

Editing Mill Tools



To change the tool diameter and length offset values, use the numeric keypad to enter the desired value and press the "Enter" button to save it and move to the next parameter, or press the "C" button to clear the value. Press the "C" button a second time to exit the Tool Edit screen. If the "Enter," "UP," or "DOWN" buttons are not used to save the value before exiting, the parameter will remain unchanged.

To change the units in which the tool diameter and length offset are specified, use the "UP" and "DOWN" buttons to select the corresponding drop-down list and press "Enter" to expand it. Select the desired unit and press the "Enter" button to save it, or press the "C" button to discard your selection.

Tools are stored in non-volatile memory, so tool parameters will not be lost if DRO power is turned off.

Optionally select the tool type of a milling cutter to reduce the risk of installing and selecting the incorrect tool. The following milling tool types are available to choose from:

- Ball End Mill
- Face Mill
- Fly Cutter
- Center Drill
- Spiral Drill
- Edge Finder
- Reamer
- Tap
- Boring Head
- Countersink
- Counter-bore
- Chamfer Mill

1/2 Centerline

To set the midpoint between zero and the current position as the new zero for the selected axis, use the ½ Center function. This function can be used in ABS or INC mode and is axis-specific, meaning that you must select an axis on which to perform the function. To set the midpoint for more than one axis, perform the function on each axis individually.

To Find a Midpoint:

1. Use Tool or Edge Finder to touch the first side of the part.
2. Set the selected axis to Zero.
3. Press the "1/2 Center" soft key. ½ will replace (ZERO/SET) at the far right of the Status bar to indicate that you have entered a midpoint mode.
4. Use Tool or Edge Finder to touch the second side of the part.
5. Press the axis button of the desired axis, and the DRO will calculate the midpoint between the current position and zero and set the new zero at the calculated location.

To set the sub-datum to the midpoint between 2 edges, use the "Edit Datum"->"Probe Centerline" feature instead.

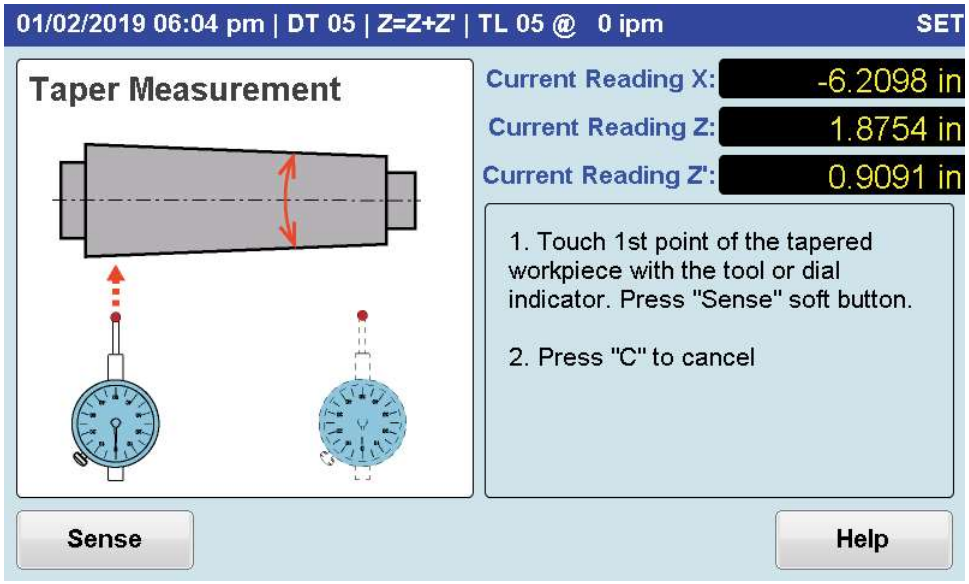
To find a midpoint with the assistance of an electronic touch probe, use the "Preset" function by clicking on the axis key in SET mode.

Radius/Diameter Mode

To quickly toggle the X axis display between Radius and Diameter, press the "Diameter Mode" soft key. The "Ø" indicator is shown next to the axis Letter Label to indicate that the corresponding axis is in diameter mode.

Taper Measurement

This function measures the angle of taper by touching a conical workpiece with a tool, edge finder or dial indicator in two positions along the Z axis.

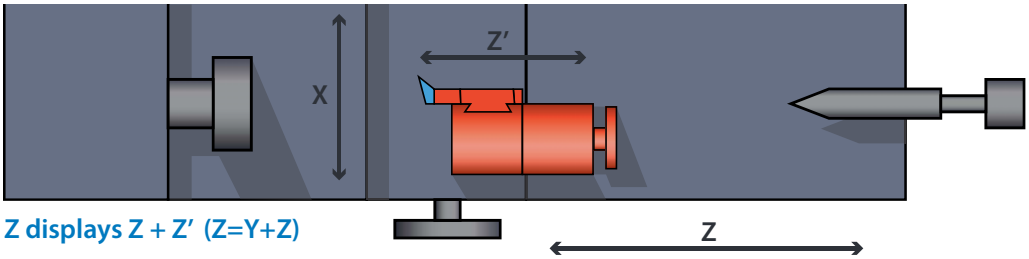


To perform taper measurement, execute the following procedure:

1. Move the compound to the first side of the tapered workpiece.
2. Use the tool or dial indicator to touch the first point and press the "Sense" soft key. When the "Sense" key has been pressed, the DRO will automatically move to the next step. At this point, pressing the "C" key once will allow the first point to be re-measured, or the operation may be canceled by pressing the "C" key a second time.
3. Move the compound to the second point of the tapered workpiece. To achieve the best accuracy, points must be as far apart as possible.
4. Use the tool or dial indicator to touch the second point of the tapered workpiece and press the "Sense" soft key again.
5. A pop-up dialog box will display the measurements and the calculated taper angle. Press the "C" button in the pop-up dialog to return to the step 1 and start over. Press the "Enter" button in the pop-up dialog to return to the Main screen. If there is no change in distance between the points, the pop-up dialog will display an error message stating: "!!! POINTS MUST BE APART !!!"

Axes Summing

The lathe compound axis (Z') is often aligned with either the longitudinal (Z) or radial (X) axis. To simplify tracking the exact tool position, the DRO provides an axis summing function which automatically adds the compound movement to either X or Z axis and displays the result in either axis position display window.



To enable Axis Summing, select the vector mode from the drop-down list. The following axes summing options are available:

Z=Z+Z'; Z'=Z+Z'; X=X+Z'; Z'=X+Z'

If summing mode is enabled, the current setting will be displayed on the status bar (e.g. Z=Z+Z').

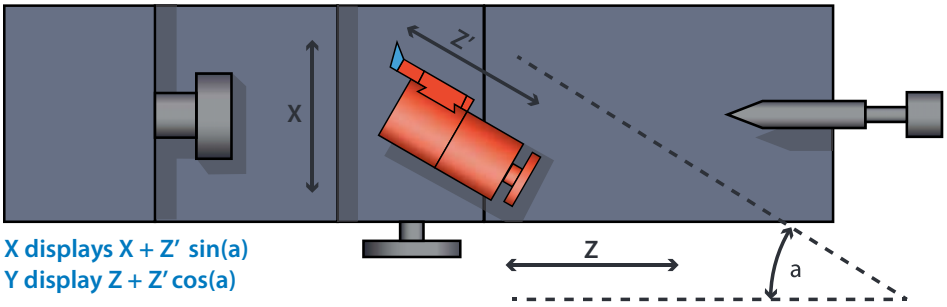
To disable Axis Summing, select the "OFF" option from the drop down list.

Summing settings are stored in non-volatile memory and will not be lost if DRO power is turned off.

Axes Vectoring

If the compound is not aligned with one of the other two axes and is set at a known angle, vectoring function will split the movement of the compound into its axial components and add them to the X and Z axes.

This function allows to track a true position of the tool in relation to the workpiece while performing operations such as thread cutting and taper machining.



To enable vectoring, select the "On" option from the corresponding drop down box and enter compound angle into the numeric entry field below. Angle is specified in degrees.

If vectoring is enabled, the status bar will display user specified compound angle (e.g A=30 deg).

To disable vectoring, select the "OFF" option from the drop down list.

Vectoring is unavailable if DRO is in axes summing mode

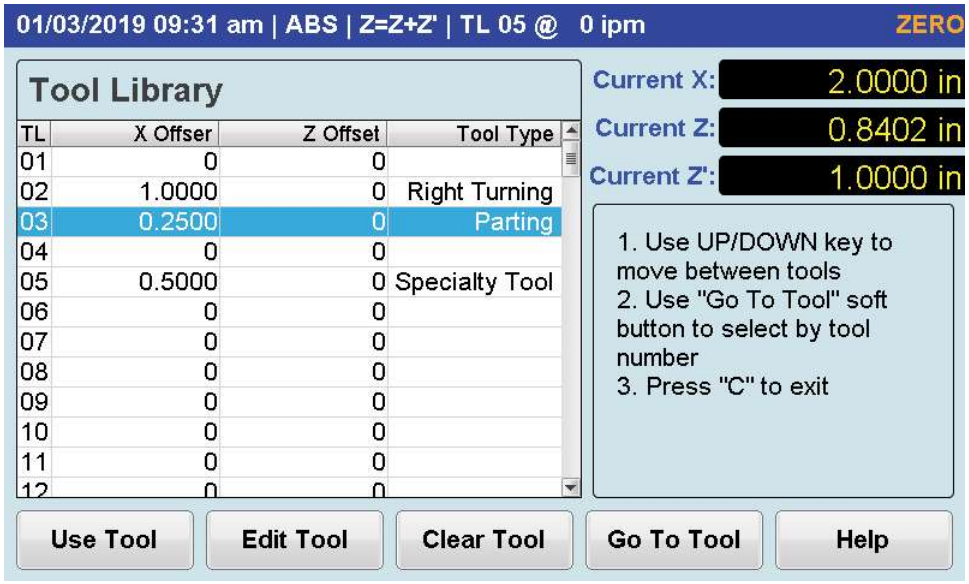
Vectoring settings are stored in non-volatile memory and will not be lost if DRO power is turned off.

Lathe Tool Library

Lathe Tool Offsets function improves productivity and eliminates the need to rezero tools after every tool change if used together with a quick-change or indexable tool post. Simply index the cutter and choose a corresponding tool number from the tool table, and a previously defined offset will automatically apply. The DRO can store up to 99 lathe tool configurations, each with its own unique X and Z offset. The current tool is displayed on the status bar (e.g. "TL02").

In lathe mode, the digital readout will offset the displayed position from the actual position by the difference in tool geometry. This feature enables performing operations with multiple tools without re-zeroing every time the quick-change tool is swapped or turret is indexed.

Use the "UP" and "DOWN" keys to move the cursor (highlighted line) through the list of tools.



The following soft keys are available on the Tool Library screen:

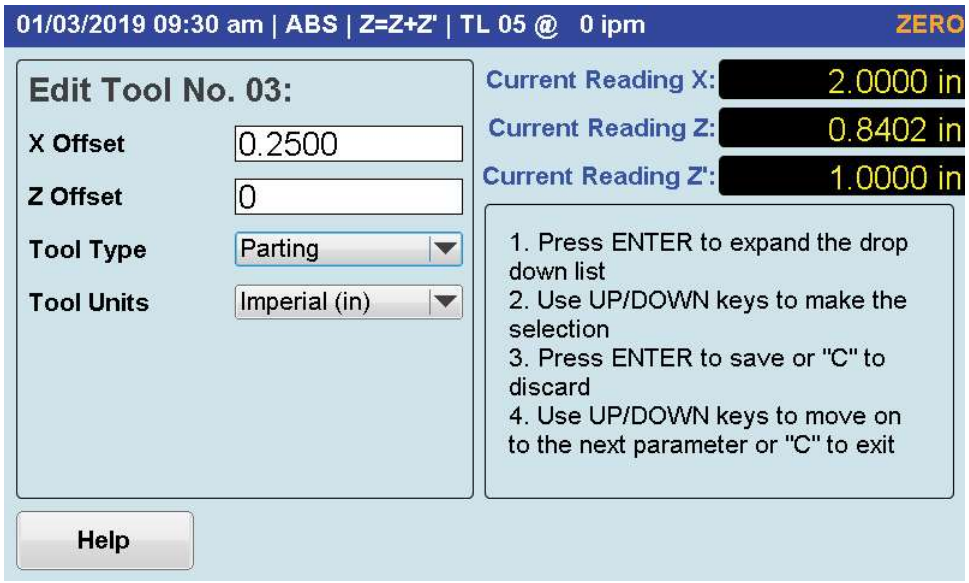
"Use Tool"
To set the highlighted tool as the current one, press the "Use Tool" soft key. The highlighted tool will now be set as active.

"Edit Tool"
To edit the highlighted tool, press the "Edit Tool" soft key, which will open the Edit Tool screen.

"Clear Tool"
To set the highlighted tool's X and Y offset to zero and clear the tool type, press the "Clear Tool" soft key.

"Go To Tool"
To jump to a tool number without scrolling through the tool list, press the "Go to Tool" soft key. Type a number from 1-99 in the pop-up dialog box and press the "Enter" button. Press the "C" button in the pop-up dialog to exit without changing which tool is highlighted.

Editing Lathe Tools



To manually change the tool offset values, use the numeric keypad to enter the desired value and press the "Enter" button to save it and move to the next parameter, or press the "C" button to clear the value. Press the "C" button a second time to exit the Tool Edit screen. If the "Enter," "UP," or "DOWN" buttons are not used to save the value before exiting, the parameter will remain unchanged.

To measure and enter the tool offsets into the DRO, perform the following steps:

1. Make sure the offsets for TL01 are set to 0 and select TL01. Go back to the main screen.
2. Use tool #1 to touch a cylindrical bar of a known diameter and set X to 0.
3. Open Tool Library/Tool Edit. If the X axis is in diameter mode, enter the bar diameter as a "Tool Offset X" for TL01; otherwise, use the bar radius.
4. Select TL02, make sure its offset is set to 0, and go back to the main screen.
5. Use tool #2 to touch a cylindrical bar of a known diameter.
6. Subtract the current X axis reading (with sign) from the bar diameter. Open Tool Library/Tool Edit and enter the resulting value as "Tool Offset X" for TL02.
7. Repeat steps 4 -6 for TL03, TL04, etc.

To change the units in which the tool offsets are specified, use the "UP" and "DOWN" buttons to select the corresponding drop-down list and press "Enter" to expand it. Select the desired unit and press the "Enter" button to save it, or press the "C" button to discard your selection.

Tools are stored in non-volatile memory, so tool parameters will not be lost if DRO power is turned off.

Optionally select the tool type of a milling cutter to reduce the risk of installing and selecting the incorrect tool. The following lathe cutters are available to choose from:

- Right Turning
- Left Turning
- Right Facing
- Left Facing
- Parting
- Chamfering
- Ext. Grooving
- Int. Grooving
- Boring Bar
- Ext. Threading
- Int. Threading
- Knurling
- Specialty Tool

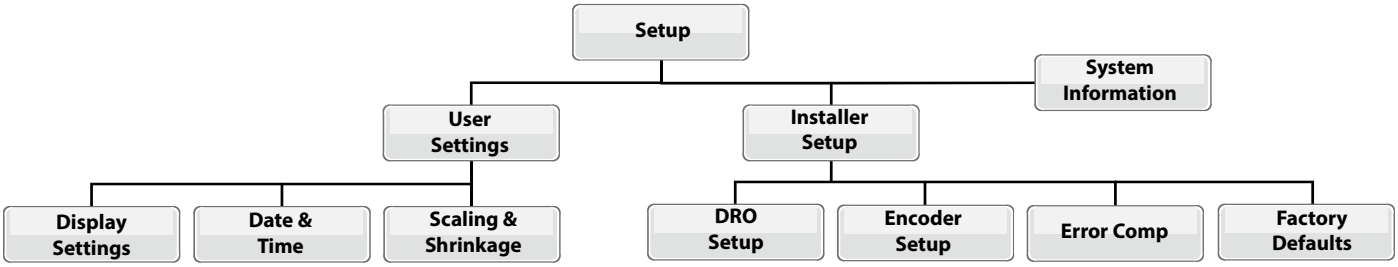
Settings

The "Setup" menu consists of two sections, "User Settings" and "Installer Setup".

The "Installer Setup" is password protected and contains parameters which are typically set once during the initial installation of the Digital Readout (e.g. encoder resolution, number of axes, etc). Installer password is set at the factory to: 1807

The "User Settings" section allows to customize some of the functions and contains user preferences (e.g. screen brightness, number of digits after decimal point, etc)

All settings and parameters are stored in non-volatile memory and will not be lost if DRO power is turned off.

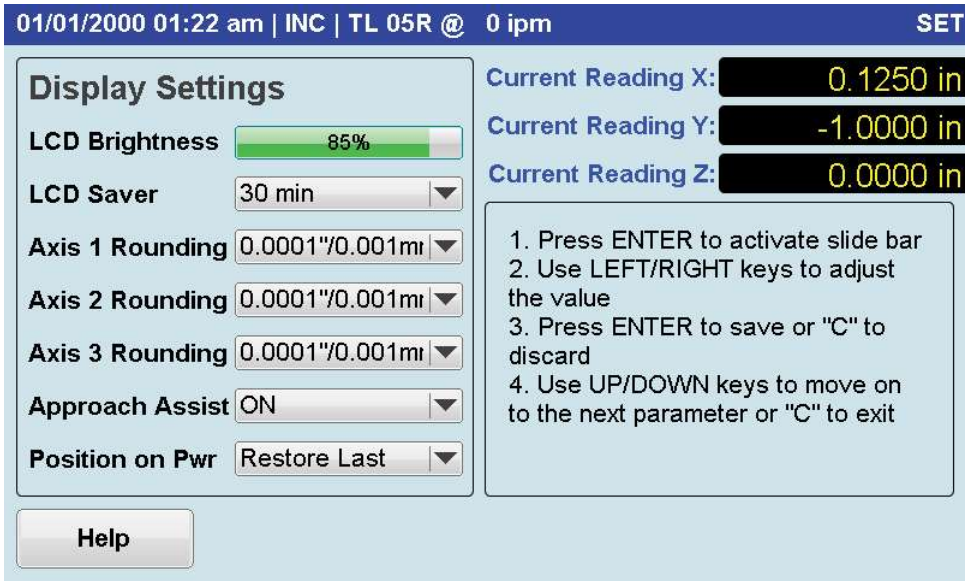


Display Settings

To enter the display settings menu, press the following soft keys:

Setup → User Settings → Display Settings

Use the navigation arrows to select the desired parameter for modification. Press the "ENTER" button to expand the drop-down list and then use the up and down navigation arrows to select from the available options. Press the "ENTER" button to save a modification. Press the "C" button to discard a modification. Press the "C" button twice to exit the Display Settings screen.



Settings

The following parameters may be changed by the user:

"LCD Brightness"
To adjust the LCD brightness, press the "ENTER" button and use the left and right navigation arrows to adjust.

"LCD Saver"
To change the length of time with no activity before the DRO enters Sleep Mode, press the "ENTER" button to open the drop-down list and use the up and down navigation arrows to select a new value. The DRO will exit sleep mode upon the pressing of any button or once movement has been detected on any axis.

"Axis Rounding"
To change the number of decimal places for each axis, press the "ENTER" button to open the drop-down list and use the up and down navigation arrows to select a new value.

"Approach Assist"
Displays the distance to zero in INC mode in the form of a logarithmic scale with a pointer.

To toggle the Approach Assist on or off, press the "ENTER" button to open the drop-down list and use the up and down navigation arrows to select the new value.

"Position on Power"
To select whether or not the last known position and coordinate mode will be preserved when DRO power is turned off, choose one of the following options:

- **"Recover Last"** will restore the previous position, ABS/INC or current Sub-datum, tool compensation direction, and all other settings just as they were immediately before the AC power was switched off.
- **"Zero"** will power the DRO up in ABS mode with all axis position displays at 0.0000 and the tool compensation direction set to center (if machine type is set to Mill). The rest of the settings are preserved.

Axis movements while DRO is without power will be lost, even if "Recover Last" is selected. We recommend executing Zero Reference Search for all axes every time the DRO power is turned on.

Date and Time

The DRO shows the current date and time in the farthest left corner of the Information Bar. The real-time clock is powered by a backup battery and time will not be lost during AC power outages.

To enter the date and time menu, press the following soft keys:

Setup → **User Settings** → **Date & Time**

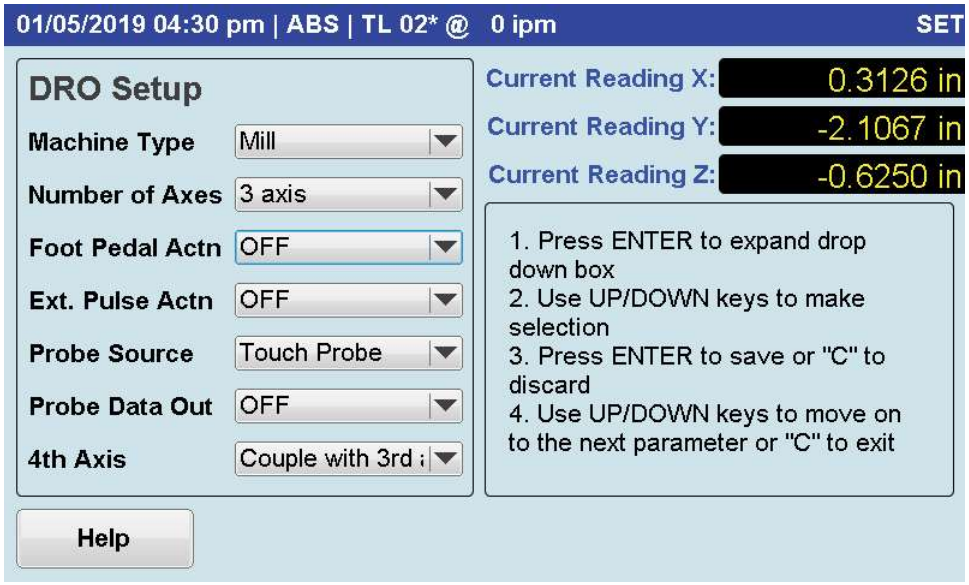
Use the navigation arrows to select the desired setting for modification. Use the numeric keypad to enter new values. To modify the AM/PM drop-down list, highlight the drop-down selection, press the "ENTER" button, and use the up and down navigation arrows to select the new value. Press the "ENTER" button to save a modification. Press the "C" button to discard a modification. Press the "C" button twice to exit the Date Settings screen.

DRO Setup

To enter the DRO Setup menu, press the following soft keys:

Setup → **Installer Setup** → **DRO Setup**

Use the navigation arrows to select the desired parameter for modification. Press the "ENTER" button to expand the drop-down list and then use the up and down navigation arrows to select from the available options. Press the "ENTER" button to save a modification. Press the "C" button to discard a modification. Press the "C" button twice to exit the DRO Settings and return to the parent screen.



The following parameters may be changed by the user:

"Machine Type"
Select the correct machine type from the drop-down list. The available options are "Mill" and "Lathe." Mill mode includes functions such as Incline, Radius, Bolt Circle, Bolt Array, and Tool Diameter/Height Compensation. Lathe mode specific functions are Tool Offsets, Radius/Diameter, Axis Summing & Vectoring, and Taper Measurement.

The resulting pop-up dialog box indicates that rebooting the DRO is required for completion of the change. Press the "Enter" button to continue or the "C" button to cancel.

"Number of Axes"
Enter the number of axes used by the DRO.

The pop-up dialog box indicates that rebooting the DRO is required for completion of the change. Press the "Enter" button to continue or the "C" button to cancel.

"Foot Pedal Action & Ext. Pulse Action"

Select the action to perform upon activation of the foot pedal or the hand pendant switch. Similarly, "Ext. Pulse Actn" selects the action to perform on the external pulse. Available actions:

- **Send to RS-232** – Transmits the current position via asynchronous serial interface.
- **Zero X** – Sets the current X axis to zero in Absolute or Incremental mode.
- **Zero Y** – Sets the current Y axis to zero in Absolute or Incremental mode.
- **Zero Z** – Sets the current Z axis to zero in Absolute or Incremental mode.
- **Zero XYZ** – Sets the current Absolute or Incremental position to Zero for the X, Y, and Z axes simultaneously.

The Digital Readout must be in the main screen mode to respond to foot pedal/hand pendant or external pulse

See the warning under the "Probe Source" section.

"Probe Source"

Select the signal source to be used for the probing functions from the drop-down list. Using a dedicated touch probe input and setting this parameter to "Touch Probe" is recommended. However, if other devices are being used (e.g. simple grounding probe), either the foot pedal input (debounced) or the external pulse can be used as a trigger during the probing operations.

Foot pedal input is intended for static measurements (the axis is stationary when the switch is pressed). Foot pedal input incorporates an internal "debounce" circuit which filters out transition noise generated by the mechanical switch. This circuit will delay arrival of the pulse by the order of 10ms, so the measured position will be inaccurate if the axis has moved during this period. For the dynamic measurements (moving axes), external pulse or touch probe inputs must be used.

"Probe Data Out"

To transmit the probed position data over the asynchronous serial interface after each probing function has been successfully performed, set to "RS-232." To disable this function, set to "OFF."

"4th Axis"

To enable fourth axis input and to couple it to the third axis encoder, set to "couple with 3rd axis." This function can be used on milling machines with the Z axis encoders installed on both Quill and Knee, or for other specialty applications.

Factory Defaults

This function erases all custom memory in the digital readout and restores every setting and parameter to its original value set at the factory. This is useful if the digital readout changes owners, is transferred from one machine to another, or behaves abnormally due-to improper settings performed by the end user.

To perform reset to factory default values, press the following soft keys:

Setup → **Installer Setup** → **Factory Defaults**

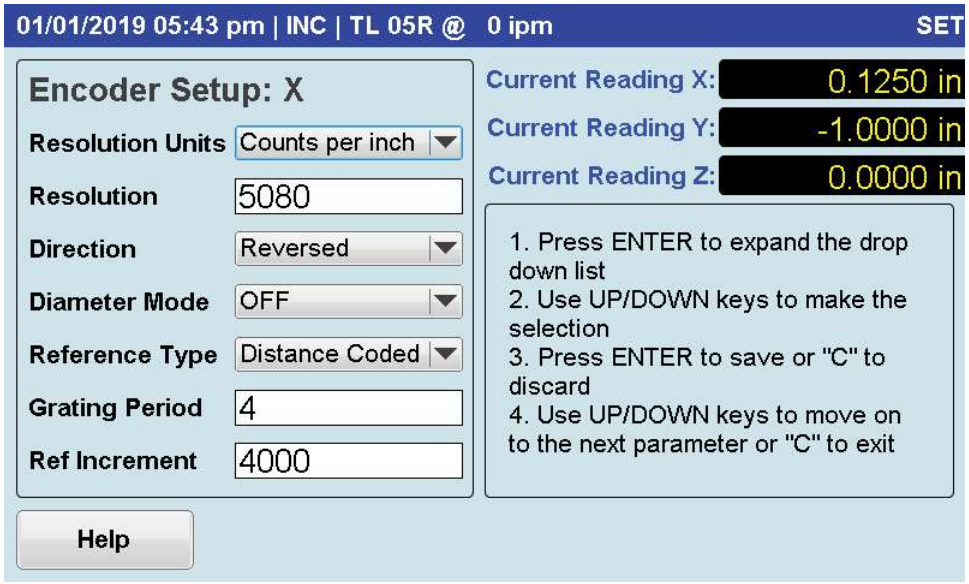
This process is **irreversible** and will **permanently erase** all feature programs, tool configurations, installer parameters and user settings.

Encoder Setup

To enter the Encoder Setup menu, press the following soft keys:

Setup → **Installer Setup** → **Encoder Setup**

Use the navigation arrows to select the desired parameter for modification. In the case of a numeric field, use the numeric keypad to enter a new value, otherwise press the "ENTER" button to expand the drop-down list and then use the up and down navigation arrows to select from the available options. Press the "ENTER" button to save a modification. Press the "C" button to discard a modification. Press the "C" button twice to exit the Encoder Settings screen.



The following parameters may be changed by the user:

"Resolution Units"

Select the units for the encoder resolution. The three options are Counts/inch, Counts/mm, or micron. To minimize rounding errors, this setting should match the native encoder units.

"Resolution"

Enter the number of counts per inch, counts per millimeter, or number in microns, depending on the previous setting. This value is determined by the linear encoder and must be an exact match to avoid incorrect readings.

Sample Linear Encoder Settings:

Encoder Resolution	Counts/in	Counts/mm
5.0 um (0.005mm)	5,080	200
1.0 um (0.001mm)	25,400	1000
0.5 um (0.0005mm)	50,800	2000
0.0002"	5,000	N/A

"Direction"

Select the direction of travel so that the DRO axes form a Right-handed Coordinate System. The two options are straight or reversed.

"Diameter Mode"
Select "On" to enable diameter mode. It assumes the cutting is being done on a circular workpiece in a radial direction and will effectively double the coordinate reading. Typically, diameter mode is set to OFF for all axes, except for X in turning mode, but it may be useful for some specialty machines and/or applications. Note, if the DRO is set to Lathe, X axis diameter mode can be toggled on and off by a soft key from the main screen.

"Reference Type"
Select the reference mark type. If the installed scales have distance coded reference marks, select distance coded; otherwise, choose single/periodic.

"Grating Period & Ref Increment" (Available only if Reference Mark Type is set to "distance coded.")
These parameters specify the scale grating period in counts of resolution and the nominal distance between reference marks, also in counts of resolution.

Distance Coded Reference Settings:

Grating Period/Resolution/Increment	Period, Counts	Increment, Counts
20 um/5.0 um/20 mm	4	4,000
20 um/1.0 um/20 mm	20	20,000
4 um/0.1 um/20 mm	40	200,000

Linear Error Compensation

This function provides a way to compensate for errors caused by temperature expansion/contraction, bow and deflection in a machine way guides, minor encoder installation errors, etc.

To enter the Error Compensation Setup menu, press the following soft keys:

If a linear error is found when an axis is compared against a known reference standard, a linear error compensation factor (ppm) can be applied to each axis. To calculate this value, move the axis a fixed distance and use the following formula: ((reference standard display - axis display) / axis display) x 10^6

Example:

Reference standard 12 inches long

Axis displays 11.990 inches of travel

((12.000"-11.990")/11.990"x10^6 ppm = 834 ppm

Use the navigation arrows to select the desired axis for modification and enter the number in part per million. Press the "ENTER" button to save the new value. Press the "C" button to discard the change. Press the "C" button twice to exit the Error Compensation screen.

Specifications

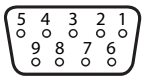
	DR403
Number of Displayed Axes	User Selectable -1, 2 or 3
Number of Encoder Inputs	4 (4th axis is available in coupling mode only)
Display Type	7" Wide Screen Color LCD
Supported Machines	Universal with User Selectable Mill or Lathe Set of Functions
Standard Functions	ABS/INC Coordinates; Imperial/Metric units; Sub Datum; Tool Library; Feed Rate Display; Sleep Mode; Zero Reference Restore; USB upgrade; Clock and Calendar with battery back up; calculator with trigonometric functions and value transfer
Number of Supported Sub Datums	99
Number of supported Tools	99
Mill Functions	Directional Tool Compensation; Centerline; Bolt Circle; Bolt Array; Radius Milling; Incline Milling
Lathe Functions	Tool Offsets; Radius/Diameter Mode with quick toggle button; Summing; Vectoring; Taper Measurement
Supported Reference Marks	Single; Periodic; Smart (Distance Coded)
Supported Encoder Resolutions	User Defined: 10nm..1.0mm; 0.0000004..1.0 in
Probing Support	Edge, Centerline, & Circle Center with the use of a Manual Edge Finder or Electronic Touch Probe
Remote Zero	Selected axis or all axes on foot pedal or external pulse
RS232 Data Output	On foot pedal, external pulse or completion of probing operation
AC Power Supply	100-240 VAC 50-60Hz 15W max
Encoder Inputs	Meet or exceed TIA/EIA-422-B and ITU Recommendation V.11
Internal Encoder Supply	5 VDC ±5%, max 300 mA per axis
Max. Encoder input Frequency	6.0 MHz
RS-232 Serial interface	EIA/TIA-232 & V.28/V.24 compliant 9,600 bps; 7 bits data + 1 stop bit; ODD parity
External Pulse input	TTL compatible

Environmental protection	IP54 Front & Sides, IP40 Rear
Operating temperature range	32°F. . .+113°F (0°C. . .+45°C)
Storage temperature range	-40°F. . .+185°F (-40°C. . .+85°C)
Humidity	Max 90% (non-condensing)
Housing Material	Aluminum
Housing Dimensions	11.7 x 6.8 x 2.8 in (298 x 173 x 70 mm)
Weight (without arm)	5.3 lbs (2.4 kg)

Specifications

Encoder Interface Connectors

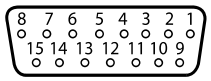
Four (4) female DB-9 connectors used to connect incremental encoders to the DRO.



1	2	3	4	5	6	7	8	9
NC	A+	A-	B+	B-	0 V	+5 V	R+	R-

Auxiliary Interface Connector

Female DB-15 connector used to connect touch probe, foot pedal/hand pendant, and/or external signal source to the DRO.



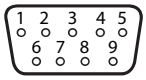
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
NC	Probe Ready	Reserved (CAN Low)	NC	NC	+5 V	0V	0 V	Reserved (CAN Hi)	NC	NC	Foot Pedal	Probe	External Pulse	0V

Position value is evaluated on a positive edge of the probe signal (e.g., input is connected to +5V) and negative edges of the external pulse and foot pedal (e.g., when the corresponding input is shorted to the ground).

Maximum continuous current drawn from the internal +5 V power supply (pin 6) should not exceed 300 mA

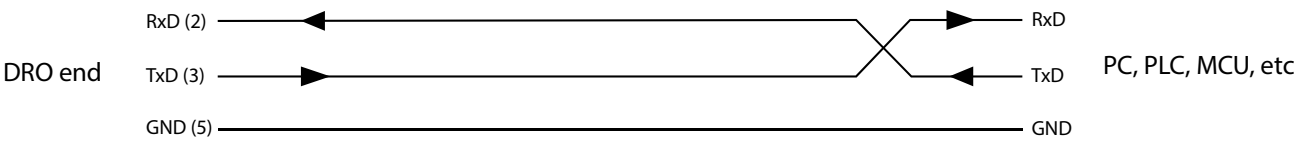
Serial Interface Connector

Male DB-9 connector used to transmit position data to the external devices over asynchronous serial interface (RS-232).



1	2	3	4	5	6	7	8	9
NC	RXD	TXD	NC	GND	NC	RTS	CTS	NC

Typical wiring diagram:



Common Problems

Unit does not turn on

1. Ensure that the power cable is installed properly and the switch on the back of the unit is in the "on" position.
2. Ensure that the power outlet has power and is supplying the proper voltage and current.
3. Ensure the fuse is intact. The fuse compartment is located directly below the power plug and can only be accessed with the power cable removed. Replace only with a 1.0 amp 250 volt fuse.

Axis display does not change when axis is moved

1. Ensure the encoder cables are plugged into their appropriate inputs.
2. Check the connectors for bent or missing pins.
3. If the problem persists, swap the unresponsive axis input with another axis. Move both axes and check the displays. If the same display does not change, the DRO may be faulty. If the axis display that you swapped the original encoder to does not change, the problem is most likely with the encoder. See the encoder manual for further troubleshooting.

Axis display "skips," change intermittently, or display inaccurate position

If an axis display always changes by a constant scale factor of the distance moved (e.g. the display always shows double the distance traveled), check that the "Scaling" parameter is set to 100% in the Scaling & Shrinkage menu. Verify that correct Linear Compensation factor is set for the axis in the "Error Compensation" menu, most applications do not require compensation and corresponding values should be set to 0 ppm.

It is also possible that the DRO has incorrect resolution (counts per unit) set for that axis. Determine the proper value for your encoder and adjust accordingly. See "Encoder Setup" section of this manual for instructions on changing resolution.

If the problem still persists, issue is likely caused by encoder misalignment or encoder hardware failure. Be sure to follow your encoder's installation instructions carefully to avoid misalignment. See your encoder manual for further troubleshooting and repair or replacement information.

Functions, such as Bolt Circle and Taper Measurement, are unavailable

Some functions are specific to the mill or lathe machine type. If the DRO is set to the incorrect machine type, the function you would like to use may be disabled. We strongly recommend leaving your DRO set to the machine type that it is installed on. See the "Machine Type" parameter in the "DRO Setup" section of this manual for more details.

Bolt Circles and other features turn out backwards or mirrored

Ensure the linear encoders are set to the proper directions of travel. See "Encoder Setup" for instructions on reversing the direction of travel. The directions should be set such that they obey the right hand rule (form a right-handed coordinate system). Typical this is done so that the positive X axis points right, the positive Y axis points forward, and the positive Z axis points up, all in relation to the operator

Attempting to repair the equipment will void any and all product warranties. Only qualified factory technicians may perform necessary repairs.

Three-Year Warranty

Limited Warranty and Disclaimer

The DR400 series Digital Readout comes with a three (3) years limited warranty and is guaranteed to be free of manufacturing defects in materials and/or workmanship. If the product is found to be defective within a 3 year period from the date of original purchase, ZS Instruments will replace or repair the product free of charge. See below for limitations.

All defective products must be first returned to ZS Instruments and pass an inspection process for a warranty claim to be approved. ZS Instruments, under its sole discretion, will repair, replace or refund the cost of the defective products. Defects caused by normal wear and tear, improper installation, use for not intended purpose and/or abuse are not covered. Warranty is void if any part of the product was physically damaged, submersed in liquids, subjected to electrostatic discharge or electromagnetic pulse, altered in any way, disassembled, or repaired by unauthorized personnel.

This warranty does not apply to installation and shipping costs. Any expenses occurred as a result of ZS Instruments product failure including but not limited to product installation and defective output are the sole responsibility of the purchaser.

ZS Instruments makes no warranty, express or implied, as to merchantability or fitness for a particular purpose. ZS Instruments shall not be liable for any direct, indirect, punitive, incidental or consequential injury, loss, or damage, including but not limited to lost data, lost savings, production downtime, cancellation of contracts, lost profits, or lost business opportunity arising from the use of ZS Instruments products.

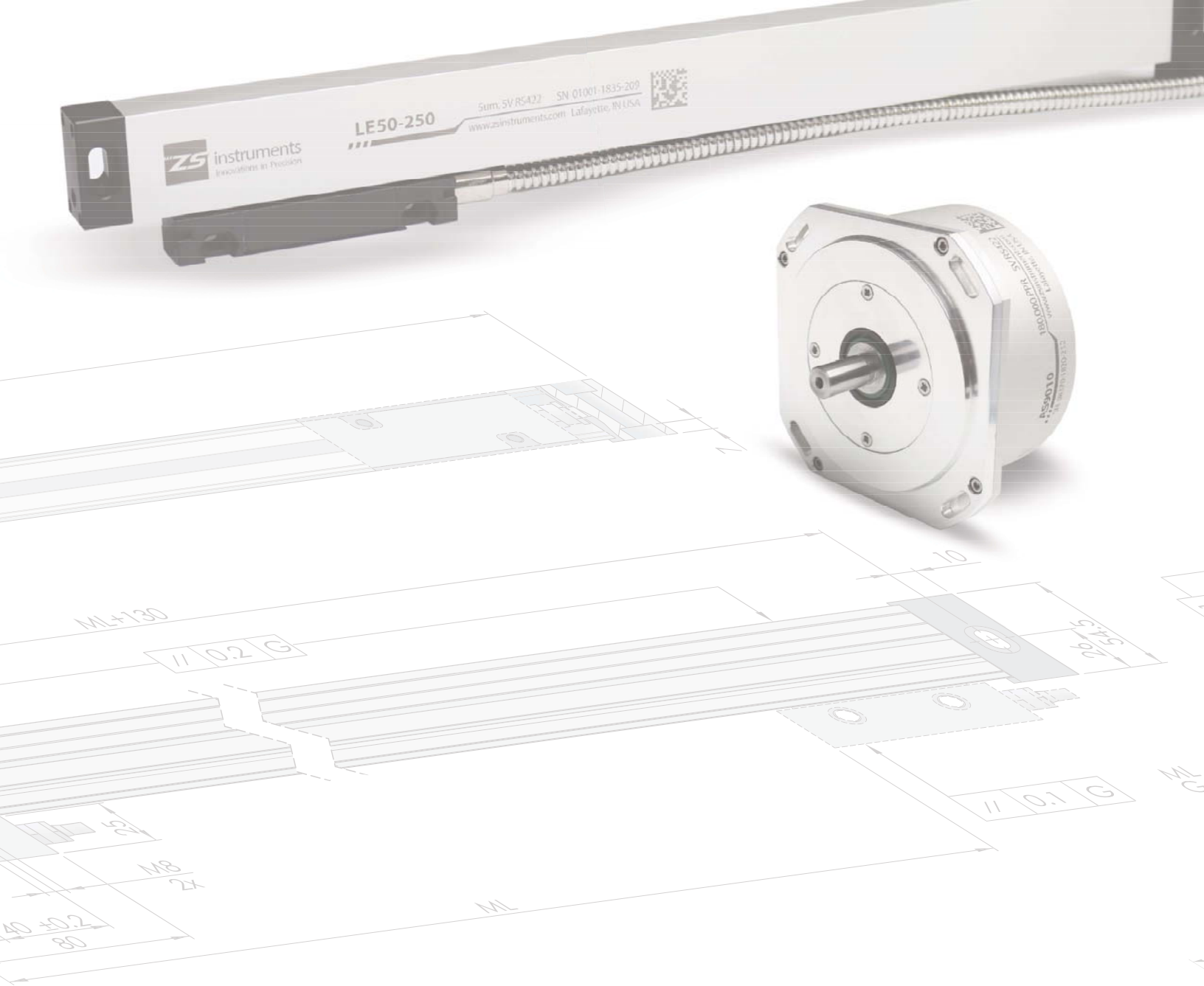
This warranty applies only to the DR400 series of digital readouts. Warranty terms for other categories of products and other models of digital readouts may vary.

The liability of ZS Instruments under this warranty may not exceed the original purchase price of the product, regardless of legal theory applied, including but not limited to, contract, warranty, negligence, or strict liability.

ZS Instruments products are not authorized for use in critical applications. Critical applications defined herein as systems in which the failure of a single component could cause a life loss or substantial property damage (life support systems, nuclear, military etc). If you intend to use our products in such applications, you must first obtain a written authorization and have a written agreement with ZS Instruments regarding such a use.

If you have any questions related to ZS Instruments Products, Installation, Warranties, or Returns, please contact us by using one of the methods listed in this manual or on our website:

www.zsinstruments.com



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