SHUMATECH

OpenDRO User's Guide

Release 0.3.1

Revision History

Revision	Description
1	OpenDRO release 0.3.0
2	OpenDRO release 0.3.1

Table of Contents

Introduction

OpenDRO is the open source software that runs on the ShumaTech DRO-550 and DPU-550 digital read-out (DRO) systems. The DRO-550 is a new design that replaces the DRO-350. It uses the exact same form-factor so it can fit in existing enclosures and can use the exact same front panel design. The DPU-550 is an upgrade daughterboard that gives the DRO-350 the same advanced functionality as the DRO-550. Both systems have nearly identical functionality. The main benefit to the DRO-550 is that it uses advanced technology components throughout the design and has much more expandability for future enhancements such as auxiliary LCDs, motor control, analog inputs, and generic digital I/O. This guide will highlight any differences in operation between the two systems with respect to OpenDRO.

The OpenDRO software is easily installed on either system over USB or RS-232 serial using either Microsoft Windows or Linux. More information on the exact software upgrade procedure for each system is found on their respective product pages .

OpenDRO Features

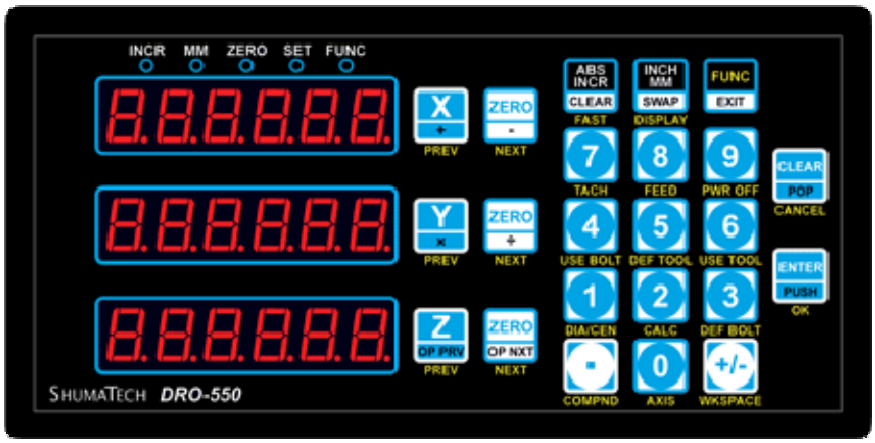
- Multi-protocol scale support for Chinese (24BIT, BCD7, BIN6) and quadrature scale.
- Chinese scale protocol auto-detection
- Fast scale reading for Chinese scales with a display update rate of up to 50 times a second per axis
- Metric/imperial units
- Absolute and incremental zeros
- Enter zero values for both coordinate systems entered via keypad
- Enter incremental presets via keypay
- Enter fractional numbers via the keypad
- Tool offsets
- Bolthole circles
- Sub-datum workspaces
- Hole grids
- Radius cutting (both concave and convex)
- Scale summing
- Compound vectoring
- Software upgradeable over USB & RS-232
- PC command/control interface over USB & RS-232
- Centerline
- Diameter mode
- Linear error correction
- Multi-machine support (simultaneous mill and lathe operation)
- Reverse polish notation (RPN) calculator with a 4 level stack
- RPN calculator operations: addition, subtraction, multiplication, division, cosine, sine, tangent, square root, power, memory, scale transfer, fractions, and more
- Zero warning with axis blink and piezo buzzer

- Audible key press
- Configurable scale precision up 4 decimal places in inch mode (3 for mm mode)
- Auto-precision to automatically reduce precision to fit the display
- Feed rate display
- Electronic edge finder zeroing
- Tachometer in RPM or surface feet per minute (SFM)
- Moving average scale filtering
- Display brightness configurable in 20% increments
- and More!

Front Panel

OpenDRO can easily switch back and forth between mill and lathe operations. Typically, there are two different naming conventions used for the axes on a mill vs. on a lathe. A mill names its three axes X, Y and Z where a lathe names them X, Z1, and Z2. The original DRO-350 has separate and dedicated software for each machine type as well as separate front panels that are labeled DRO-350M and DRO-350L. When using just one machine type, you can reuse the DRO-350 front panel that corresponds to the machine type that you will use with the DRO/DPU-550. If you plan on using both machine types, then you will have to pick one front panel to use and adapt the instructions presented here for when you switch to the other machine type. For example, if you pick the DRO-350M front panel and switch to lathe operation in OpenDRO, then you will have to adapt the instructions that reference Z1 and Z2 to Y and Z, respectively.

There is also a front panel available that is enhanced specifically for OpenDRO. This overlay shows the function speed keys in yellow text below each key as a reminder. The full range of functions remains available in OpenDRO's menu system. The enhanced front panel also shows the key operations for the RPN calculator. The enhanced overlay is shown below for reference.



DRO/DPU-550 Front Panel

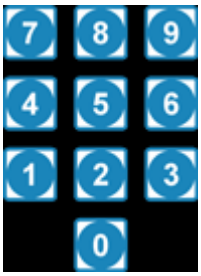
Above the three axis displays are five LED indicators that show current state and status. The right half of panel contains the keypad. The keypad is used to set presets, set zeros, change modes, begin functions, enter values, etc.

Indicators

INCR	**Incremental Mode** This indicator is on when the DRO is in incremental mode. All three axes will display their positions relative to their incremental zeros. When the indicator is off, the DRO is in absolute mode and each axis will display its position relative to its absolute zero. The ABS/INCR key toggles between incremental and absolute modes.
MM	**Metric Mode** This indicator shows when the DRO is in metric mode. When in metric mode, all positions either displayed by the DRO or entered via the keypad are in millimeters. When the indicator is off, the DRO is in imperial mode and all positions are in inches. The INCH/MM key toggles between metric and imperial modes.
ZERO	**Absolute Zero Set** The absolute zero set indicator is on when the DRO in the middle of setting an absolute zero. The ENTER key or the axis ZERO set key must be pressed to complete the absolute zero set. Alternatively, an electronic edge finder can be used to trigger the absolute zero set at the position where an edge is contacted.
SET	**Set Value** The set value indicator is a prompt that the DRO expects the user to enter a number on the numeric keypad.
FUNC	**Function** The function indicator turns on when the FUNC key is pressed to indicate that a function

	should be selected through the function menu or via a speed key. The indicator is also kept on if a function such as bolthole or grid is currently active. When it turns off, the DRO is back in its normal mode.

Keypad

	**X Preset** This key begins a preset operation on the X axis. See the operation section for more detail on how to set a preset.
	**Y/Z1 Preset** This key begins a preset operation on the Y axis for a mill or the Z1 axis for a lathe. See the operation section for more detail on how to set a preset.
	**Z/Z2 Preset** This key begins a preset operation on the Z axis for a mill or the Z2 axis for a lathe. See the operation section for more detail on how to set a preset.
	**Zero Axis** This key is used to set either an incremental or absolute zero on an axis. For detailed information on setting axis zeros, see the operation section.
	**Numeric Keypad** Numbers are entered into the DRO via the numeric keypad. It is used during preset and zero operations to enter offsets and is also used to enter information for function operations. The set indicator is lit when the DRO expects the user to enter a number on the numeric keypad. The  key is used to finish number entry. The  key is used to delete the right-most digit or decimal point or to exit numeric entry when all digits are cleared.

Decimal Point

This key enters a decimal point at the current position when entering a number on the numeric keypad.

The 

key can be used to delete the decimal point if it is at the right-most position. A second decimal point is used to indicate that the number entered is a factional number instead of a floating point number as described below.

Sign

The sign key toggles between a positive or negative value while entering a number on the numeric keypad. It can be pressed at any time during number entry.

Clear

The clear key serves a variety of uses:

- During number entry, it deletes the right-most digit or decimal point. If the number is a single zero, it will end number entry without entering a number.
- During setup, it serves as an abort key to not save the changed configuration.
- During functions, it serves as a backward key while moving through function steps.

Enter

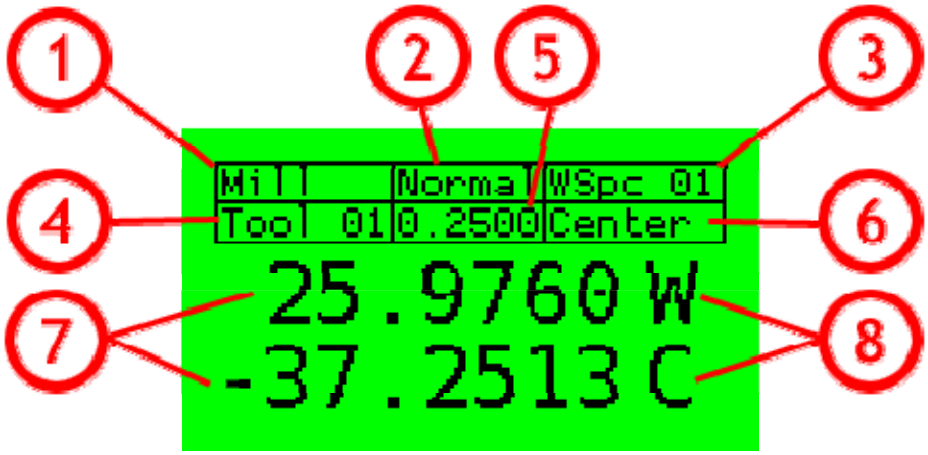
The enter key serves a variety of uses:

- During number entry, it is used to finish entering the number.
- During setup, it serves as an accept key to save the changed configuration.
- During functions, it serves as the forward key while moving through function steps.

ABS / INCR	**Absolute/Incremental Toggle** This key toggles between absolute and incremental positions for all axes.
INCH / MM	**Imperial/Metric Toggle** This key toggles between imperial (inches) and metric (millimeters) modes for all axes.
FUNC	**Function Key** The function key is pressed to display the function menu. A numeric key can also be pressed as a speed key to quickly access a function in a similar way as the original DRO-350.

LCD Display

OpenDRO supports a secondary LCD display that shows two additional axes as well as current status information. Like all OpenDRO axes, you can configure which axes are displayed on the LCD. You can also display other information such as the tachometer, SFM, or axis feed rate. The figure below shows the LCD screen with callouts listing each of its visual components.



Secondary LCD Display

1. Machine Type - Displays the selected machine type either "Mill" or "Lathe".

2. Function State - Displays the active function - "Bolt" for a bolthole operation, "Grd" for a grid operation, "Calc" for RPN calculator, or "Normal" if no function is active. The selected bolthose or grid number is also shown after the text.
3. Workspace/Step - During normal operation, this displays the active workspace. During a function operation, this displays the function step number.
4. Tool Number - Displays the active tool number or "No Tool" if none is selected.
5. Tool Offset - Displays the diameter of the active tool.
6. Edge/Comound - In mill mode, this displays the edge compensation side, either "Left", "Right", "Back", "Front", or "Center". In lathe mode, this displays the angle of the compound if compound vectoring is selected.
7. W/C Axis - This is the fourth and fifth display lines. These show the W and C axes by default though you can configure it to display any axis. You can also display tachometer, SFM, or feed rate data on either or both lines.
8. Axis Labels - Displays the labels for what the fourth and fifth display lines are showing. For a tachometer, a "T" is shown. For feed rate, an "F" is shown with a subscript with the axis letter.

The LCD display also has additional keys that control its operation. These additional keys are summarized below.

	**W Preset** This key begins a preset operation on the W axis. By convention, the W axis is a secondary Z axis. See the operation section for more detail on how to set a preset.
	**C Preset** This key begins a preset operation on the C axis. By convention, the C axis is a rotational axis in the Z plane. See the operation section for more detail on how to set a preset.
	**Zero Axis** This key is used to set either an incremental or absolute zero on an axis. For detailed information on setting axis zeros, see the operation section.

Operation

Absolute Zero

Start an absolute zero set on an axis by pressing the 

key for that axis when the DRO is in absolute mode. The zero set indicator will turn on indicating that an absolute zero set is in progress. After an absolute zero set is started, there are three ways to set the absolute zero, at the current position, by an offset from the previous absolute zero, or at the position of an electronic edge finder.

- Set an absolute zero at the current position by pressing either the 

key or the 

key at the desired position.
- Set an absolute zero with an electronic edge finder by contacting the work piece with the electronic edge finder. An absolute zero is set at the current position on the instant of contact. Before using the electronic edge finder, make sure it is properly connected to the DRO and that the machine setting in the setup is set to use it".

Incremental Zero

Set an incremental zero at the current position by pressing the 

key when the DRO is in incremental mode. The incremental zero is set immediately without any additional key presses.

Absolute Preset

An absolute preset is an incremental zero set at an absolute position. With the DRO in absolute mode, press the preset key for the desired axis. The DRO will switch to set mode and you can enter an absolute position via the numeric keypad. Use the 

key to complete the position and the 

key to make corrections or cancel the absolute preset.

Incremental Preset

An incremental preset is an incremental zero set at an offset from the current position. With the DRO in incremental mode, press the preset key for the desired axis. The DRO will switch to set

mode and you can enter an offset via the numeric keypad. Use the 

key to complete the offset and the 

key to make corrections or cancel the incremental preset.

Fractional Numbers

You can enter fractional numbers any time the DRO is expecting you to enter a floating point number, as evidenced by the SET indicator LED at the top of the display being on. For example, to enter the fractional number 2 3/16, press the following keys:

The display will also show "2.3.16" and when you press 

, the display will change to the fractional number's decimal equivalent of 2.1875. You can use the 

key just like when entering floating point numbers and it will back up past numbers and decimal points.

Functions

Function Menu

The function menu is displayed by pressing the 

key. The FUNC indicator will turn on and the function menu is shown on the the display. The top line will display FUNC as a reminder. The second line will display the menu and the third line will display the menu item. You can move through the menus by pressing the 

key to move forward and the 

key to move backward. The menu item is correspondingly changed by pressing the 

key to move forward and the 

key to move backward. When you have the desired menu item

representing the function you want to perform, then press the 

key to activate it. Press the 

key to exit the function menu without activating a function.

The following tables summarizes the function menu. Differences between mill and lathe operation are noted.

Function Menu

PREVIOUS

NEXT

Position	Status	Define	Setup	System
Tool Offset	Tachometer	Tool Offset	Machine	Power Off
Diameter (Mill)	Feed Rate	Bolthole (Mill)	Axis	Machine
Centerline (Lathe)	Calculator	Grid Pattern (Mill)	Scale	Send Fast
Bolthole (Mill)		Radius (Mill)	Display	Version
Grid Pattern (Mill)			Keypad	Update (DRO-550)
Radius (Mill)				Erase
Workspace				

Speed Keys

Speed keys are numeric shortcuts that jump straight to a menu item without having to navigate through the menus. To execute a speed key, first press the 

key and then press a number

key 

through 

. The FUNC menu is displayed until the speed key is pressed. The speed keys are shown in the table below with mill and lathe differences noted.

Speed Keys

Speed Key	Menu	Item
FUNC .	Position	Compound (Lathe)
FUNC 0	Setup	Axis
FUNC +/-	Position	Workspace
FUNC 1	Position	Centerline (Mill) Diameter (Lathe)
FUNC 2	Status	Calculator
FUNC 3	Define	Bolthole (Mill)
FUNC 4	Position	Bolthole (Mill)
FUNC 5	Define	Tool
FUNC 6	Position	Tool
FUNC 7	Status	Tachometer
FUNC 8	Status	Feed Rate
FUNC 9	System	Power Off

Special Function Speed Keys

Item	Description
	**Fast Mode Toggle** This function will program the fast mode sequence on any 24BIT or BCD7 protocol scales connected to the DRO that are not already in fast mode. This function can be used to put a newly connected scale into fast mode without powering the DRO off and back on.
	**Display Toggle** This function is used to toggle between displaying the axis reading, the raw scale counts, and the scale jitter. This function is mainly used for troubleshooting and helping to determine how much a scale reading isjittering. Each subsequent activation of this function will toggle between the three possible displays.

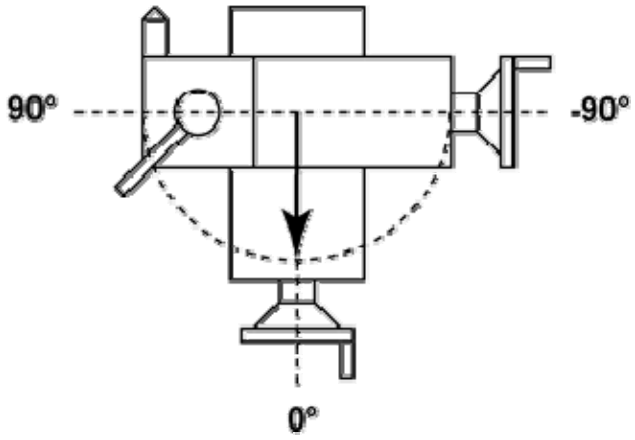
Function Operation

The following tables describe each menu item in detail.

Position Menu

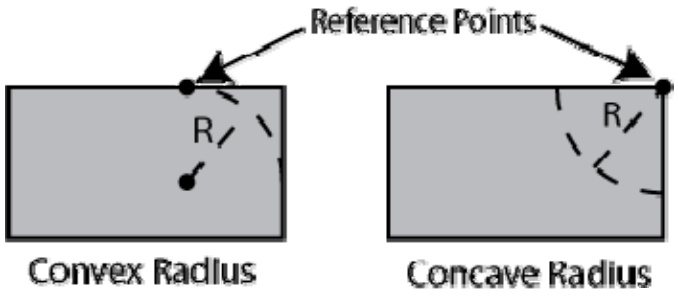
Item	Machine	Description
Tool Offset	Mill	This function selects one of the defined tool offsets. The DRO prompts you to select a tool offset number with the numeric keypad. Tool offset 0 is a special number that applies a tool with no offsets and is effectively used to turn off tool offsets. After selecting the tool offset, use the numeric keypad to select the cutting edge to compensate for. The edge positions are selected according to the following keypad pattern.

		 When an axis position is compensated due to an edge position selection, the left-most decimal point in the display for that axis is turned on.
Tool Offset	Lathe	This function selects one of the defined tool offsets. The DRO prompts you to select a tool offset number with the numeric keypad. Tool offset 0 is a special number that applies a tool with no offsets and is effectively used to turn off tool offsets.
Centerline	Mill	Centerlines are meant to quickly find center points in lines and circles. The centerline function sets a zero at the half way point between the current zero and current position for an axis. If the scale is in incremental mode, the zero will be an incremental zero. Vice versa, if in absolute mode, the zero will be an absolute zero. Set a centerline zero by first moving to the desired position. Switch to incremental or absolute mode with the  key for the desired zero type. Select the centerline menu item and the DRO will display a prompt to press the preset key for the axis the zero is desired on.
Diameter	Lathe	Diameter mode allows work in diameter dimensions instead of radius dimensions. When an axis is in diameter mode, the axis reading is doubled and any zero or preset positions entered via the keypad are taken as diameter dimensions. After selecting the centerline menu item, the DRO displays a prompt to select the axis that diameter mode is desired on. The left-most decimal point in the display is turned on for that axis to indicate that the axis is currently in diameter mode. Selecting an axis already in diameter mode will turn it off.
Compound Angle	Lathe	This function sets the angle of the compound for use when vectoring the compound (Z2 axis) movement into the cross-slide (X axis) and carriage (Z1 axis). The compound angle is stored in

		non-volatile memory on the DRO and is retained even if power is removed. Positive angles indicate that the compound is positioned clockwise from the center position and negative angles indicate that the compound is positioned counter-clockwise.  Enter the angle from positive to negative 99.9 degrees with the numeric keypad and press the ENTER key to accept the angle. Press the CLEAR to make corrections or exit without setting the angle.
Bolthole	Mill	This function uses the defined bolt-hole pattern to set X and Y axis incremental zeros at each bolt-hole position in the pattern. The center of the bolt-hole pattern is always taken as the incremental zero of the X and Y axes when the function is started so before starting this function, set X and Y incremental zeros at the center of the bolt-hole pattern. A "hole 1" prompt is displayed when this function is initiated. This indicates that an incremental zero is about to be set for the first bolt-hole. Press the ENTER key and the DRO switches to displaying the axis positions so that you can move the X and Y axes to zero for the first bolt-hole. Press the ENTER key again and continue through the bolt-hole pattern. After the incremental zero is set for the last bolt-hole, press ENTER to exit out of the bolt-hole pattern use function. The incremental zeros for the X and Y axis are

		restored to the values that were defined for the center of the bolt-hole pattern. If you make a mistake, you can go backward through the screens at any time with the  key.
Grid	Mill	This function uses the defined grid pattern to set X and Y axis incremental zeros at each grid hole in the pattern. The center of the first hole in the grid pattern is always taken as the incremental zero of the X and Y axes when the function is started. Before starting this function, set X and Y incremental zeros at the center of the first grid hole. A "hole 1" prompt is displayed when this function is initiated. This indicates that an incremental zero is about to be set for the first grid hole. Press the  key and the DRO switches to displaying the axis positions so that you can move the X and Y axes to zero for the first hole. Press the  key again and continue through the grid hole pattern. After the incremental zero is set for the last grid hole, press  to exit out of the grid use function. The incremental zeros for the X and Y axis are restored to the values that were defined for the first hole in the grid pattern. If you make a mistake, you can go backward through the screens at any time with the  key.
Radius	Mill	The radius function is used to cut a convex or concave radius into a workpiece by progressing through the cut in a series of small steps. See the description of the radius function in the define menu section below for more detail on the parameters that define the radius. The reference point for the radius is taken from the incremental zeros for the two axes in the plane of the radius, either X and Z or Y and Z. The reference point is defined as the center point of the radius for a concave radius or the point on the radius directly above the center point for a convex radius. You must define the incremental zeros that define the reference point before starting the function. The figure below shows the location of the

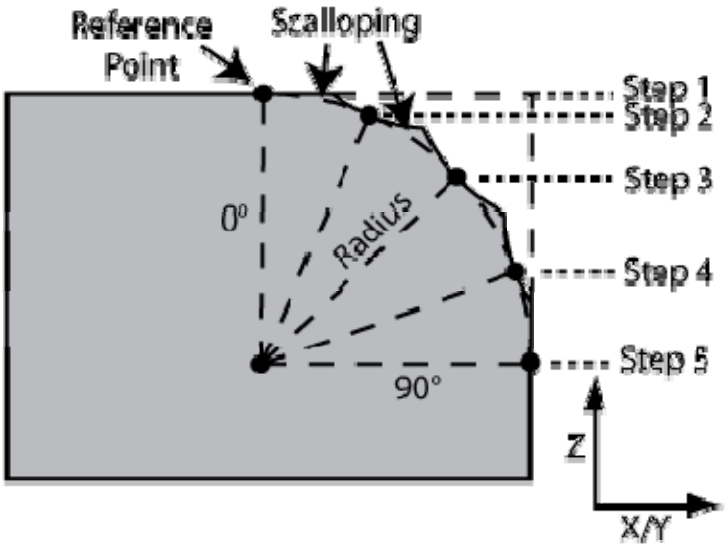
reference points for both convex and concave radii.



Before starting the function, select the tool that you want to use for the cut. The tool must be a ball nose cutter and the diameter and Z offset must be correctly defined for the tool. If you initiaite the radius function without a tool selected, it will display a message and cancel the function.

A "step 1" prompt is displayed when this function is initiated. This indicates that incremental zeros are about to be set for the first step cut. Press the ENTER key and the DRO switches to displaying the axis positions so that you can move the Z and X/Y axes to their zeros for the first step. After reaching the zero points, you can lock those axes and begin the cut. The cut is made by moving the third axis, either X or Y, that is perpendicular to the plane of the radius.

When finished with the current cut, press the ENTER key again and proceed through the rest of the cuts. After incremental zeros are set for the last step, press ENTER to exit out of the radius function. The previous incremental zeros for the X, Y, and Z axes are restored to the values that were defined before starting the radius function. Also, the cutting edge compensation is reset to the previous setting. If you make a mistake, you can go backward through the screens at any time with the CLEAR key. An example of a finished radius cut is shown below. In this example, the radius is convex, has a start angle of 0 degrees, has an end angle of 90 degrees, and is defined for 5 steps. Notice the circular cuts from the ball nose cutter are tangent to the radius at each step point but arc out from that point leaving excess

		material. This is called scalloping and can give the radius a non-smooth finish. To reduce scalloping, define the radius with more steps and/or use a larger diameter ball nose cutter. 
Workspace	Both	Workspaces, sometimes known as sub-datums, are incremental and absolute zero points defined in addition to the primary zero points. When you switch to a new workspace, the current zeros are saved and the zeros for the new workspace are used instead. You can switch around between all of the workspaces and the zero points for each workspace are permanently saved, even across a power cycle. Zeros for the other workspaces are established just like they are with the primary zeros using the  and axis preset keys. Workspaces are useful when switching between multiple parts or when working on a drawing that establishes a new datum and using an incremental zero is not convenient or possible.

Status Menu

Item	Machine	Description
Tachometer	Both	Selecting this function will toggle the tachometer display off and on. You are first asked to enter the desired units for the tachometer display either in RPM or in surface rate. You then select the axis line to replace with the tachometer reading.

<table>
<tr><td></td><td></td><td>The surface rate is calculated with the RPM reading from the tachometer and the currently selected tool diameter and calculates the surface rate with the equation Surface Rate = (RPM * 2 * PI * radius).</td></tr>
<tr><td>Feed Rate</td><td>Both</td><td>Display the instantaneous rate of movement per second for an axis. After initiating this function, the DRO will prompt you to select an axis to display the rate of. It will then ask for the line to display the feed rate on. The axis position display for the selected line is replaced by the feed rate display for the previously selected axis. This allows for simultaneously displaying both the position reading and rate for an axis.

When you move the axis, the rate is displayed for the axis relative to the current units. For example, if the DRO is in metric mode and you move the axis at the rate of 5mm per second, then the display will show 5.0. When you stop moving the axis, it will display 0.0.

To turn off the feed rate display, initiate this function again and the line displaying the feed rate will return to displaying the position reading for its axis.</td></tr>
<tr><td>Calculator</td><td>Both</td><td>Enter the reverse polish notation (RPN) calculator function. The RPN calculator has a 4-level stack and supports basic mathematical functions and a number of special operations.

<table>
<tr><th>Key</th><th>Function</th></tr>
<tr><td> 
</td><td>Exit Exit the calculator and return to normal DRO function. When the operation menu is displayed, this exits operation selection and returns to normal calculator function.</td></tr>
<tr><td> 
</td><td>Addition (+) Add the current and penultimate stack values together and push the result back on the stack.</td></tr>
<tr><td> 
</td><td>Subtraction (-) Subtract the current stack value from the penultimate stack value and push the result back on the stack.</td></tr>
<tr><td> 
</td><td>Divide (/) Divide the penultimate stack value (dividend) from the current stack value (divisor) and push the result back on the stack.</td></tr>
</table>
</td></tr>
</table>

	**Multiply (*)** Multiply the current and penultimate stack values together and push the result back on the stack.
	**Operation Previous** Move to the previous operation in the list (see below).
	**Operation Next** Move to the next operation in the list (see below).
	**Sign (+/-)** Toggle the sign for the current stack value making a positive number negative and vice versa.
	**Exit** Leave calculator mode and return to DRO processing.
	**Swap** Exchange the values for the current and penultimate positions in the stack.
	**Clear** Erase all stack values and set them to zero.
	**Pop** Remove the current stack value and shift the stack down.
	**Push** Push the current value onto the stack. The next number entered will shift the stack up and start a new current value. When the operation menu is active, this serves as a confirmation to execute the displayed operation

Example:

To divide 2.4 by 3, enter the following keys:

The result of 0.8 is now the current value on the stack.

Operations

The calculator supports a number of mathematical operations in addition to the basics of addition, subtraction, multiplication, and

division. The operations are accessed with the operation pervious (OP PRV) and operation next (OP NXT) keys. The first press of either key will recall the last used operation. The next press will either move backwards or forwards through the operations list summarized below:

Operation	Display	Description
Memory In	M IN	Store into a memory location 0-9. The operation prompts you to enter a location 0-9 and will store the value on the bottom of the stack to that memory location replacing any previous value.
Memory Out	M OUT	Read out from a memory location 0-9. The operation prompts you to enter a location 0-9 and will read the value at that location and insert it into the bottom of the stack.
Sine	SIN	This operation calculates the geometric sine of the angle on the bottom of the stack expressed in degrees and replaces it with the result.
Cosine	COS	This operation calculates the geometric cosine of the angle on the bottom of the stack expressed in degrees and replaces it with the result.
Tangent	TAN	This operation calculates the geometric tangent of the angle on the bottom of the stack expressed in degrees and replaces it with the result.
Square Root	SQRT	Calculates the square root of the value on the bottom of the stack and replaces it with the result.
Power Of	POW	Takes the penultimate value on the stack and raises it to the power of the value on the bottom of the stack. Both values are replaced with the

		result.
Pi	PI	Inserts the constant Pi (3.14159...) onto the bottom of the stack.
Axis Preset	PRESET	Perform an incremental preset on an axis with the value on the bottom of the stack. The operation will ask for an axis which you must select by pressing the preset key corresponding to the axis you want to set. The value on the bottom of the stack is NOT removed.
Length	LENGTH	Calculate the hypotenuse of a right-angled triangle with the Pythagorean theorem { c = sqrt(a^2 + b^2) } given the two other sides. The two sides are taken from the two values on the bottom of the stack and they are replaced by the result.
Fraction	FRAC	Display the fractional power-of-2 equivalent of a decimal value along with the amount of error. The top line shows the whole value on the left and the numerator on the right. The middle line shows the denominator. The bottom line shows the decimal amount of error in the fraction. Press  to clear the display.
Axis Reading	AXIS	Get the current incremental position for an axis and insert it onto the bottom of the stack. The operation will ask for an axis which you must select by pressing the preset key corresponding to the axis you want to get the position for.

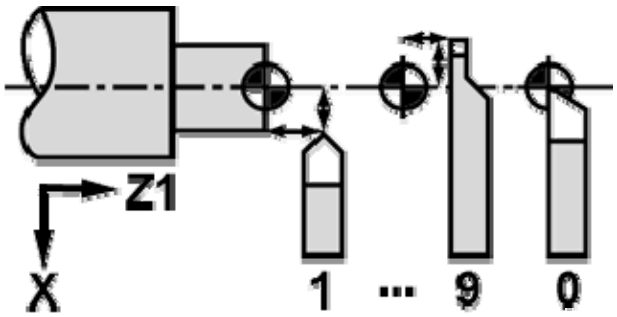
Speed Keys

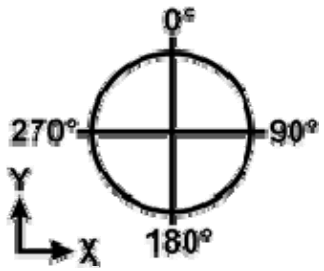
The operations also have speed keys to allow you to access them

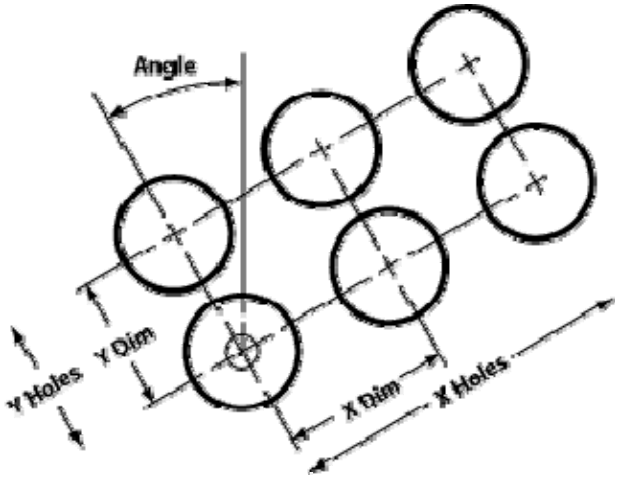
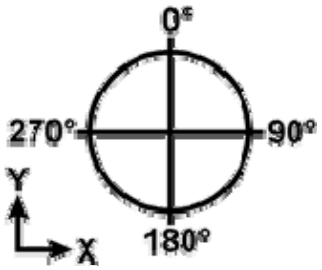
more quickly rather than scrolling through the list. After the operation menu is displayed, press one of the following keys to immediately jump to and execute the function.

Speed Key	Operation
	Memory In
	Memory Out
	Axis Preset
	Axis Reading
	Fraction
	Length
	Pi
	Square Root
	Power Of
	Sin
	Cosine
	Tangent

Define Menu

Item	Machine	Description
Tool Offset	Mill	This function defines a tool offset for cutting edge compensation. The tool offsets are stored in non-volatile memory inside the DRO and are retained even if power is removed. The tool offsets are defined in terms of the tool diameter and the Z axis offset. The first screen will prompt you to enter the tool offset number with the numeric keypad. After pressing the number, you are prompted to enter the tool diameter. When entering the offsets, press the ENTER key to complete the offset or the CLEAR to make corrections or exit. Next, you will be prompted to enter the Z offset. After entering the Z offset, the tool offset is stored in the DRO.
Tool Offset	Lathe	This function defines a tool offsets for lathe operations. The tool offsets are stored in non-volatile memory inside the DRO and are retained even if power is removed. The tool offsets are defined as offsets of the X and Z1 axes. The following figure shows a visual representation.  The first screen will prompt you to enter the tool offset number with the numeric keypad. After pressing the number, you will be prompted to enter the X offset. When entering the offsets, press the ENTER key to complete the offset or the CLEAR key to make corrections or exit. Next, you will be prompted to enter the Z1 offset. After entering the Z1 offset, the tool offset is stored in the DRO.

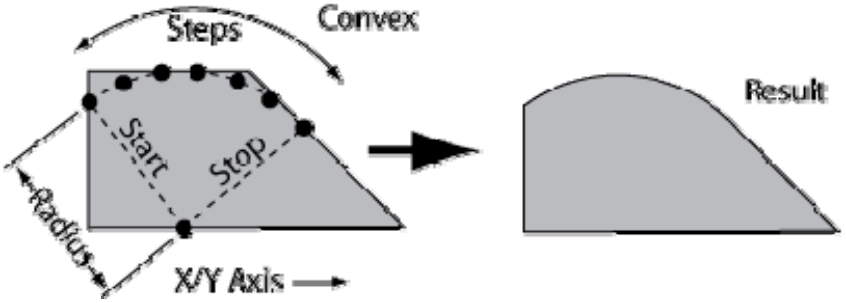
Bolthole	Mill	This function defines a new bolthole pattern for use with a mill. When this function is selected, the first screen will prompt you for the number of the bolthole memory position. Memory positions allow the specification of multiple sets of bolthole patterns and are recalled when the bolthole function is used. Enter the memory position number and press the ENTER key. Next, you are prompted to enter the total number of holes in the bolthole pattern. Enter the number and press the ENTER key. After entering the number of holes, the next prompt will be for the radius of the bolthole circle. Enter the radius and press the ENTER key. Next, the starting and ending angles of the bolthole circle are entered. The angles are entered in degrees and with respect to the following diagram when looking at the bolt-hole circle from the top:  The valid angle ranges are from 0.0 to 359.9 degrees. If the same angle is entered for both the starting and ending angles, a full circle bolt-hole pattern is created. Press the ENTER key to enter each angle. After entering the end angle, the bolt-hole pattern is stored in the DRO at the given memory position.
Grid	Mill	The grid function is used to define a series of equally spaced points along the X and Y axes that are oriented on an angle. When this function is selected, the first screen will prompt you for the number of the grid memory position. Memory positions

		allow the specification of multiple sets of grid points and are recalled when the grid function is used. Enter the memory position number and press the ENTER key. The diagram below shows the parameters that define a grid. Upon executing this function, you are prompted for each parameter. Enter the desired value via the numeric keypad and press the ENTER key to proceed on to the next parameter until all of them are defined.  The angle of the grid is centered on the lower left hole and is expressed in terms of the angular directions in the diagram below. 
Radius	Mill	The radius function is used to define a convex or concave radius that is cut step by step. When this function is selected, the first screen will prompt you for the number of the radius memory position. Memory positions allow the specification of multiple

sets of radii and are recalled when the radius function is used.

Enter the memory position number and press the ENTER key.

There are a number of parameters that define how the radius is cut. Each of the parameters are summarized in the figure below and described in more detail in the text that follows.

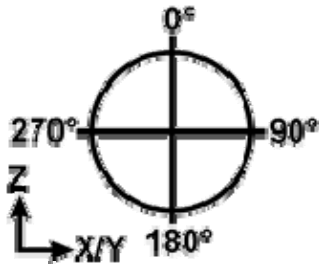


The first parameter to enter is the radius length. This defines the size of the arc for the cut. Enter the radius via the numeric keypad and press the ENTER key. For all parameters, press the ENTER key to confirm and move on to the next parameter.

The second parameter is the radius shape, either concave or convex. A convex radius bulges out from its center point while a concave radius bulges in. Press the Z key to toggle between the two shapes.

The next parameter is the second axis of the radius and defines the plane of the radius. The first axis is implicitly always the Z axis. If the X axis is selected, then stepping for the radius will proceed on the X and Z axes with the direction of the cuts occuring on the Y axis direction (front and back). If the Y axis is selected, then stepping for the radius will proceed on the Y and Z axes with the direction of the cuts occuring on the X axis direction (left and right). Press the Z key to toggle between the two axes.

The steps parameter is next and defines the number of steps to cut along the radius. The more steps the smoother the radius but

		also the more cutting operations that you must perform. Enter the desired number between 2 and 99. The start parameter defines the starting angle for the radius. Look at the figure below for a definition of the angles. For a convex radius, the angle must be on the top angular hemisphere between 270 and 90 degrees. For a concave radius, the angle must be on the bottom angular hemisphere between 90 and 270 degrees.  The ending angle is the next parameter and it defines the stopping point on the radius. The radius cut always proceeds in a clockwise direction beginning at the starting angle so the ending angle must be in a clockwise direction from the starting angle and also be in the correct angular hemisphere. For example, for a convex radius with a starting angle of 0 degrees, 270 degrees is an invalid ending angle since it is counter-clockwise from the starting angle in the top angular hemisphere.

Setup Menu

The setup menu allows you to change the configurable parameters for each DRO object. When you select an object type from the menu, OpenDRO switches the display to show the object instance in the top line, the parameter name for that object on the middle line, and the parameter's current setting on the bottom line. For objects with multiple instances, like scales and axes, press the X key to cycle forward the available instance numbers and press he ZERO key cycle back. Press the Y Z1 keys moves to the next parameter and press the ZERO key moves to the previous parameter. To change a parameter, press the Z Z2 key which will, depending on the parameter, either rotate through the allowable settings or will prompt you to enter a numeric value. After changing a parameter, you can cycle through

additional parameters to change for that object instance. You can also cycle through additional object instances.

To permanently store your parameter changes in the DRO's non-volatile memory, press the 

key. To continue without permanently storing your changes, press the 

key. If you want to return to the setting stored in non-volatile memory, then reboot the DRO.

<table>
<tr><th>Object</th><th>Parameters</th></tr>
<tr><td>Machine</td><td>The following setup parameters apply to the current machine. You can change the current machine in the system menu.
<table>
<tr><th>Parameter</th><th>Description</th></tr>
<tr><td>Type</td><td>Set the machine type - lathe or mill</td></tr>
<tr><td>Tach</td><td>Set the machine's tachometer - tach 1 or tach 2</td></tr>
<tr><td>Edge</td><td>Set the machine's edge finder - none, edge 1, or edge 2

DPU-550: You can also select tach 1 or tach 2 to mimic the DRO-350 auxiliary port where the edge and tachometer functions are shared on the same port.</td></tr>
<tr><td>Display</td><td>Set what is shown on the axis displays:

• Reading - The normal scale reading in either inches or mm.
• Counts - The raw counts from the scale before conversion. This is useful for troubleshooting the scales.
• Jitter - For a BIN24 scale, this displays the standard deviation of the samples in the filter window. You can use this to display a quantitative measurement of the scale jitter for troubleshooting noise problems.</td></tr>
<tr><td>Warning</td><td>Set the near-zero warning threshold. When an axis approaches a zero within a positive or negative distance from this value, then the display will flash and the beeper, if configured, will sound. Once a near-zero warning is triggered, then you must travel 10% farther away than this value to rearm the near-zero warning. This prevents repeated triggering when working around the near-zero threshold.</td></tr>
</table></td></tr>
</table>

	Beeper: Turn the beeper on or off. DPU-550: Sets the tachometer port the beeper is connected to since it must e shared. **Line**: For each display line on the DRO, set the axis that is displayed on it or turn off the line entirely.
Axis	For each axis on the DRO, you can set the following parameters: **Parameter** / **Description** **Scale**: Set the scale that is the primary input for this axis. **Summing**: Sum a second scale into this axis. **Reverse**: Reverse the polarity of the axis. When enabled, this makes all positive values negative and all negative values positive. **Precision**: Set the precision value to high, medium, or low. The number of displayed digit after the decimal point depends on the current units. For a a half digit, the DRO lights the right-most decimal point to represent the half value. Also, if a configured precision cannot fit on the display, then the DRO automatically changes the precision to the next lower value until it does fit. **Imperial** / **Metric** High: 4 / 3 Medium: 3 1/2 / 2 1/2 Low: 3 / 2 **LEC**: Linear error correction. Enter the LEC factor in parts per million (PPM) and the reading for the axis is automatically adjusted by that amount. 1 PPM = 0.0000001.
Scale	For each scale input on the DRO, you can set the following parameters: **Parameter** / **Description** **Type**: Set the protocol type for the scale input to one of: • Auto - Automatically detect the Chinese scale type and set the CPI accordingly

		• BIN24 - The original Chinese scales that are a knock-off of the Sylvac scales. • BCD7 - A less common format sometimes seen in calipers. • BIN6 - Format typically seen on newer Harbor Freight calipers. • Quadrature - Glass scales, linear and rotary encoders, or any other measuring device that sends two signals that are 90 degrees out of phase from each other.
	CPI	Set the counts per inch for the scale input: • BIN24 - Use 20480 CPI • BCD7 - Use 2540 CPI • BIN6 - Use 2540 CPI • Quadrature - depends on the scale so check with your manufacturer If the scale type is Auto, then this setting is automatically changed for the detected scale type.
	Invert	Invert the scale counts which effectively reverses the direction of travel for the scale.
	Filter	Configure a moving average filter for a BIN24 scale. Since BIN24 scales have a high CPI and also update their readings at a fast rate, they can suffer from jitter where the least significant digit can rapidly change its value on the display. To work around this problem, you can configure a moving average filter that will average several readings together. The setting here configures the number of readings to average together. Higher values smooth the reading more but make the display slower to respond to movement. Configure a filter of 1 to remove all filtering. The filter ONLY applies to BIN24 scales and is ignored for other scale types.

Display

Parameter	Description
Intensity	Set the intensity of the LED display in steps of 20%.

Keyboard

Parameter	Description

	Key Beep	Turn key beep on or off. When key beep is on and a beeper is configured for the machine, then a brief "chirp" is heard after every key press.

System Menu

Item	Description
Off	Power off the DRO. When powered off, the processor still monitors the scale positions and will wake up if a key is pressed. To completely power down the DRO, then unplug the power supply.
Machine	Select the current machine as defined in the setup.
Send Fast	Send the fast mode sequence to all attached BIN24 and BCD7 scales.
Version	Display the OpenDRO software version and the hardware identifier.
Update	Erase the OpenDRO program and prepare the DRO to download a new software update. (DRO-550 Only)
Erase	Erase the contents of the non-volatile memory. This will erase all definitions, positions, setup, and other saved information and return the DRO to a factory default state. It does not erase the OpenDRO program.

Scales

OpenDRO supports both Chinese and quadrature scales. Chinese scales refer to any of a large number of linear scales and calipers that are sourced from China. These scales come in a huge variety of lengths and styles. Chinese scales usually have a four-pin output port in the side of the scale that sends the scale position data to the DRO. There are three different protocols used for sending the data:

- **24BIT** - Two 24-bit, binary numbers are sent with the first representing the absolute position and the second representing the relative position. The two numbers are counts with a resolution of 20480 counts per inch.
- **BIN6** - A single 20-bit, binary number followed by a 4-bit flag field. The 20-bit number is the count with a resolution of 2540 counts per inch when the scale is in metric mode.
- **BCD7** - A single 24-bit, BCD number followed by a 4-bit flag field. The BCD number represents the seven digits shown on the scale display.

In addition, the 24BIT and BCD7 scales support a "fast" mode where they send the data to the DRO at a much higher rate than normal. The BIN6 scales do not support that feature.

The metal backs of Chinese scales are connected to one of the battery terminals. For 24BIT and BCD7, they are connected to the positive terminal and for the BIN6 scales, they are connected to the negative terminal. If you use both types on one DRO, then you must insulate them to avoid shorting the DRO power supply through the machine.

WARNING!!! Do not use BIN6 scales with 24BIT or BCD7 scales without electrically insulating the scales.

It is difficult to determine which protocol a Chinese scale uses just by looking at it. You can differentiate between BIN6 and a 24BIT/BCD7 by using a multimeter to determine which side of the battery the scale back is connected to. Differentiating a BCD7 from a 24BIT is more difficult and is best done with an oscilloscope. Note, however, that 24BIT scales are much more common than BCD7 scales. Most of the time, you can set the scale type to "Auto" and OpenDRO will automatically detect and configure the scale type.

Quadrature scales are linear or rotary encoders that output two signals that are 90 degrees out of phase with each other and includes most glass scales encountered on machining equipment. OpenDRO supports any quadrature encoder that outputs a signal that is electrically compatible with the hardware it is running on. The DPU/DRO-550 supports quadrature encoders that output a digital, 5V output. A partial list of scale manufactures and their compatibility with the DPU/DRO-550 is shown in the following table.

Manufacturer	**Support**
Acu-rite	Some models
Anilam	Yes
DRO Pros	Yes
Easson	Yes
Futaba	No
Heidenhain	Some models
Jenix	Yes
Meister	Yes
Mitutoyo	Some models
mTech	Yes
Newall	Some models
QMS	Yes
RSF	Some models
Sargon	Yes
Sino	Yes
Sinpo	Yes

Sokki	No
Sony	No
TDS	Yes
Teledyne Gurley	No
Uniq	Yes
US Digital	Yes

Auxiliary Devices

Tachometer

The tachometer function is used to display the spindle speed of a mill or lathe. A small probe that optically measures the rotational speed is mounted to the machine. The probe sends a 5V pulse to the DRO through the tachometer connector for every rotation of the spindle. The DRO measures the period between these pulses and converts it to either RPM or SFM for display on the Z/Z2 axis. The tachometer display is updated once per second.

Electronic Edge Finder

Absolute zeros can be set on the DRO with an electronic edge finder by contacting the work piece with the edge finder while it is mounted in the spindle. Many commercially available edge finders can be adapted for use with the DRO. A circuit inside the edge finder sends a 5V pulse to the DRO through the edge finder connector. To set the absolute zero for an axis with the electronic edge finder, set the DRO to absolute mode and press the 

button once for that axis. When the edge finder contacts the work piece, the axis is zeroed at the current position. To compensate for the diameter of the edge finder, use a tool offset with the cutting edge compensation feature.

PC Interface

OpenDRO can interface with a PC for controlling its operation and reporting information. Anything that you can do on the front panel can be done over the PC interface. The PC interface works over both the USB port and the RS-232 port. When connected over the USB port, the

DRO appears to the PC as a virtual COM port. A Windows INF file is available at OpenDRO sourceforge site to install the proper driver for the virtual COM port.

Both the USB and RS-232 interface use a baud rate of 57600 and communication parameters at 8-N-1. You can use Windows HyperTerminal or any other serial communication software to enter commands. The list below describes the available commands. Command parameters are shown between < and > symbols. For example <on|off> means that you can enter either "on" or "off" for that parameter.

Help Commands

- **help** - Display a list of all commands and the number of parameters each takes.

System Commands

- **system echo <off|on>** - Control whether received commands are transmitted back. Turn this on for interactive use or off for automated scripting.
- **system trace <debug|info|warning|error|fatal>** - Set the trace message level at or below which messages are displayed. For example, setting to warning displays warning, error, and fatal messages
- **system reset** - Cause a hardware reset of the processor.
- **system version** - Display the OpenDRO hardware and version number.
- **system show** - Display detailed debug information for the entire system. This is useful to attach when submitting a bug report.

Display Commands

- **display readget <0|1|2|3|4>** - Return the contents of the axis reading at the given line where 0 is the X line, 1 is the Y/Z1 line, 2 is the Z/Z2 line, 3 is the W line, and 4 is the C line.
- **display readset <0|1|2|3|4> <number> <precision> <mark>** - Set the axis reading at the given line. The <number> is the floating point number to display. <Precision> is the number of half digits to display from 0 to 8. For example, 7 half digits is 3.5 digits. <Mark> controls the display of the leading axis mark used to show that an axis is offset from its true position. It can be set to 0 for no mark or 1 for a mark.
- **display readblk <0|1|2|3|4>** - Blink the axis reading at the given line. This is typically used for zero warning but also can be used to get the operator's attention for other uses.
- **display ind** - Return the state of each of the indicator LEDs. A "1" indicates the LED is on and a "0" indicates the LED is off. The order of return is <INCR> <MM> <ZERO> <SET> <FUNC> and each value is separated by a space.
- **display off** - Turn the DRO display completely off without losing the current contents.

- **display on** - Turn the DRO display on and redisplay the last contents.
- **display menuset <0|1|2> <text>** - Display <text> on the display at the given menu line where 0 is the top line, 1 is the middle line, and 2 is the bottom line. For example, "display line 2 hello" will display "hello" on the bottom line of the DRO.
- **display menuget <0|1|2>** - Return the text currently displayed by the menu on the given line.
- **display menuclr** - Clear all lines on the menu display.

Machine Commands

- **machine units <mm|inch>** - Set the units for the active machine.
- **machine zero <abs|incr>** - Set either absolute or incremental mode for the active machine.
- **machine start** - Start processing the scale inputs to the machine.
- **machine stop** - Stop processing the scale inputs to the machine effectively freezing them in place.
- **machine show** - Display detailed debug information for all of the current machine settings.

Function Commands

- **function show** - Display detailed debug information for all function settings.

Axis Commands

- **axis read <0|1|2>** - Return the current reading for the given axis.
- **axis abs <0|1|2>** - Set an absolute zero at the current position for the given axis.
- **axis incr <0|1|2>** - Set an absolute zero at the current position for the given axis.
- **axis show <0|1|2>** - Display detailed debug information for the given axis.

Scale Commands

- **scale count <0|1|2|3|4>** - Return the scale counts for the given scale number.
- **scale show <0|1|2|3|4>** - Display detailed debug information for the given scale number.

Keypad Commands

- **keypad press <key>** - Cause the DRO to think that <key> was pressed by the operator where <key> is one of: 0 1 2 3 4 5 6 7 8 9 +- func mminch clear enter zero0 preset0 zero1 preset1 zero2 preset2