# EM200

# Operational and Installation Guide

## Digital Readout System
## For
## Machine Tools

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# Contents Overview:

# Introduction

Congratulations on selecting and purchasing a **EM200** Series Digital Readout from EMS (International) Ltd. We take our products, their design and performance very seriously and make every effort to provide you with a quality product to help simplify many operations and improve productivity.

The **EM200** Series DRO is designed to quickly meet the needs of both users of lathes and milling machines and comes in versions specific to those types of machines. This allows for machine specific functions to be readily available without the complexity of added buttons you can never use as so often found on generic DRO that include both lathe and milling functions in a single unit.

If you would like to make any comments or share your experience of using our equipment we would very much like to hear from you. Please e-mail us at: info@ems-i.co.uk.

**Note:**

**Please familiarize yourself with the contents of thus operators manual before installing the DRO to ensure a easy installation.**

**Due to a process of continual development EMS (International) Ltd. reserve the right to change specifications without prior notice.**

# DRO Specifications

| | |
|---|---|
| **Mains Power** | 110-230 VDC @ 50/60Hz (15W) |
| **Storage Temperature** | -20°C to +70°C |
| **Operating Temperature** | 0°C to +40°C |
| **Dimensions** | 180 x 264 x 50mm |
| **Weight** | 1050g (approx. With swivel mount) |
| **Encoder Input** | EIA422 Full Differential |
| **Encoder Connection** | 9-Pin D-Type Female |
| **Display Resolutions** | 0.001, 0.005, 0.010mm |
| **Axis Display Type** | 7-Segment (Green) LED with +/- and decimal point |
| **Information Window** | 13-Segment (Green) LED |
| **Quantization Error** | +/- 1=Digit |
| **Standard Compliance** | EMC and Low Voltage Compliance BS EN 61326, CE RoHS |

# Please Read Before Proceeding

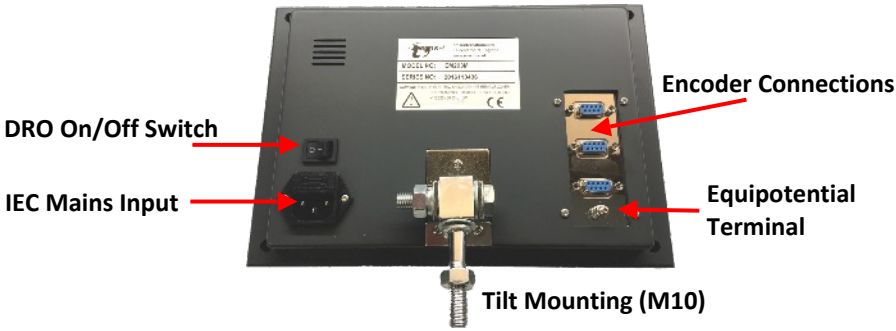
- The **EM200** DRO is sophisticated piece of electronic equipment and should be carefully handled and installed in order to avoid any potential damage.

- The rated supply to DRO should be within specified limits and should not be exceeded under any circumstances. Doing so may cause irreversible damage to DRO.

- DRO should be opened by authorized person only. Otherwise it will invalidate the warranty of the unit. If in any doubt or you believe the unit requires servicing please contact info@ems-i.co.uk for assistance.

- It is highly recommended that the Equipotential Point (Ground) should be connected to avoid the provided to avoid the potential for erratic operations through electrical noise in the working environment.

- Cable routing of DRO and encoders should not be routed through or nearby high capacity switching/inductive load or where it can cause danger. Avoid routing cables with those of the motor, lighting or other such sources of potential RF and electrical noise.




**Warranty will be considered void if and not limited to:**

Failing to meet manufacturers specified supply conditions.
Abusive handling.
Environmental conditions outside of Manufacturers specifications.
Manipulation, tampering of electronics.
Replacement of original parts with other parts than specified by manufacturer.
Used with encoders other than those supplied by the manufacturer.

## Disposal

At the end of its life the **EM200** DRO and systems should be disposed of in a safe an environmentally sympathetic manner as applicable to local legislation. The casework and other components may be suitable for recycling. DO NOT BURN.

# Quick Setup Guide

The **EM200** DRO **Setup** parameters allow you to configure your DRO for the encoders fitted to you machine. You only need to do this the once as the settings will be retained by the DRO. You can edit them at anytime should a need arise by re-entering Setup. All parameters must be entered in METRIC.

*1 Thou = 0.0254 microns*


**To Enter Setup and configure your DRO:**

- With the power OFF
- Press and hold the 6 key for Lathe
  or 9 key for Mill
- Turn power ON. DRO will start up.
- Wait until the display shows "**EXIT**"
- Release Number key

Navigate to the parameter you wish to set using the keys by the message window.

To exit setup from a menu item press the key until **"EXIT"** is displayed and then press ent

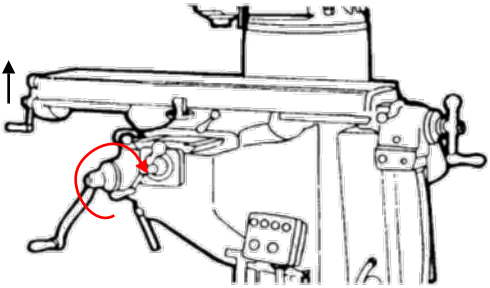
*The Setup options vary slightly between Lathe and Mill DRO*

**Display shows: "DIAL INC" Default: 0.200**

**Function:** This function is used on **2-axes Mill** DRO's by the Inclined machining and Arc contouring functions to simulate a Z-axis input by calibrating the DRO to the resolution and turns of the Knee axis dial.

*If your 2-axes Mill only has a Quill and not a Knee then set this as the smallest resolution you can accurately move the Quill.*

**Operation:** Press the key
The message display will show "ENTR PPM"
Enter the distance moved by the Z-axis for one Z-axis dial increment



Measure the movement of the table for one Z-axis dial increment.

*You can either take this straight off the dial or for a more accurate result use a dial gauge from the spindle to measure the true physical movement.*

**Display shows: "Z DIAL" Default: 2.500**

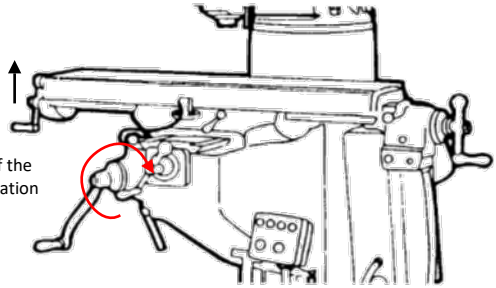
**Function:** This function is used on **2-axes Mill** DRO's by the Inclined machining and Arc contouring functions to simulate a Z-axis input by calibrating the DRO to the resolution and turns of the Knee axis dial.

*If your 2-axes Mill only has a Quill, and not a Knee, then set this as a large number greater than the Quill total travel.*

**Operation:** Press the key

The message display will show "ENTR PPM"

Enter the distance moved by the Z-axis for one complete turn of the Z-axis handle.



Measure the movement of the table for one complete rotation of the Z-axis handle.

**Display shows: "ALL CLR"**

**Function:** This function is used to reset the DRO to its factory default settings. Any changes made will be lost and need to be re-entered.

**Operation:** Press the key

Wait until "CLR OK" is displayed

**Display shows: "SRK. OFF" / "SRK. ON" Default: "SRK. OFF"**

**Function:** Used for mould making this setting enables/disables the DRO automatic Shrink compensation function.

**Operation:** Press the key to toggle between "SRK. OFF" and "SRK. ON"

LED Shows function is enabled

**Display shows: "RESOLUTE" Default: 0.005**

**Function:** Used to set the DRO resolution to that of the connected scales.

**Operation:** Press the key to enter the function. The axes windows will display their current resolution settings.

Press the axis key for the axis you want to change. e.g. X

This will toggle through the available options against that axis:

Options are: "0.005", "0.01", 0.001"

When set as required press the key to return to the main setup menu

note *Setup parameters are saved as you enter them. If you do make an error or wish to to change them you can go back and so so at any time.*

**Display shows: "R OR D" Default: 0 (radius)**

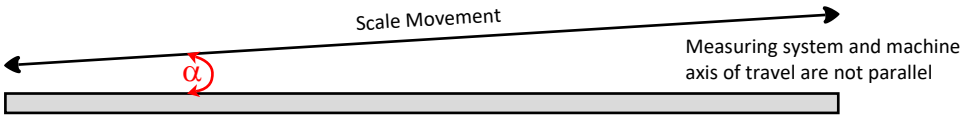
**Function:** Used to set enable an axis so it can display in Diameter mode.
Setting an axis to "1" means that axis will display double (diameter) when the DIA RAD is pressed in normal operating mode. This is important for Lathes where position needs to relate to the part diameter.

**Operation:** Press the ent key to enter the function.
The axes windows will display their current settings.
Press the axis key for the axis you want to change. e.g. X
This will toggle through the available options: "0" or "1"
When set as required press the ent key to return to the main setup menu

**Display shows: "LIN COMP" Default: 0.000**

**Function:** This is used to setup a linear compensation factor for scales that may not be mounted parallel to the axis of the machine.

**THIS SHOULD ONLY BE USED WHERE OBVIOUS LINEAR ERRORS ARE OBSERVED**




The function works by multiplying the measurement from the scale/encoder by a constant factor in PPM (Parts Per Million = microns/meter).

**Example:**

Scale measures 500.040 : True measurement is 500.000
error = 0.080mm over 1m, or 80PPM

**Operation:** Press the ent key to enter the function. The axes windows will display the current settings. Press the axis key for the axis you want to change. e.g.
Enter the value using the numeric keys
You can change the sign of the compensation using the ± key
Press the ent key when you have finished entering the compensation value.
Repeat for each axis.
When set as required press the ent key again to return to the main setup menu

**Display shows: "DIRECTE" Default: 0**

**Function:** This is used to define the positive direction of travel for the machine axis

**Operation:** Press the ent key to enter the function. The display will show "SEL AXIS".
Press the axis key for the axis you want to change. e.g. X
This will toggle between the options "0" and "1".
Setting to "1" will reverse the natural count direction from the scale.
When set as required press the ent key to return to the main setup menu

| Display shows: | "BEEP ON" / "BEEP OFF" | Default: "BEEP ON" |
|---|---|---|

**Function:** This is used to disable the key beep if so required

**Operation:** Press the ent key to toggle between "BEEP ON" and "BEEP OFF"

| Display shows: | "EXIT" | Default: "N/A |
|---|---|---|

**Function:** This is used to exit from Setup. Note any changes made will be saved

**Operation:** Press the ent key to exit back to normal operation mode.

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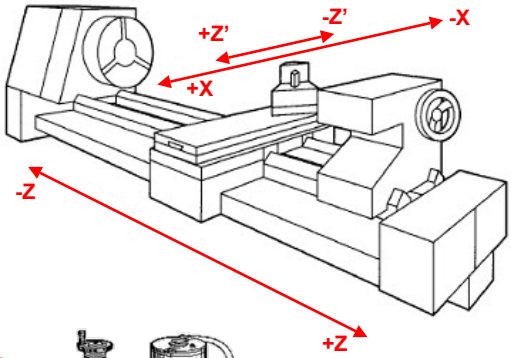
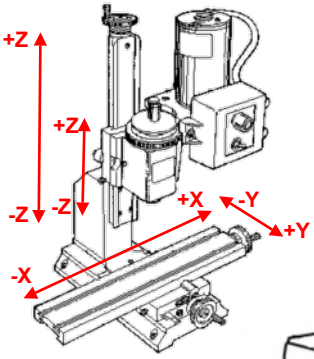
# Machine Axis Conventions




On a lathe we have an X-axis (being the cross-slide) and a Z-axis (the travel between centres).

The top-slide can be rotated from parallel to the X-axis to parallel with the Z-axis through any angle. This is known as the compound or Z' axis. See axis Summing later in this manual.

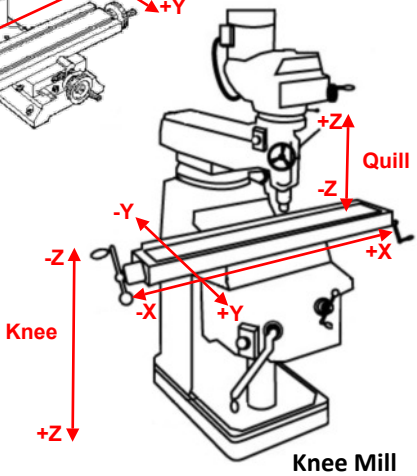



Mini Mill

With milling machines we have the X, Y and Z-axis. The X & Y-axis refer to the table movement left-right and in-out.

The Z-axis can be either the Quill axis, direct movement of the tool up-down or the Knee axis which is the movement of the whole table up-down.

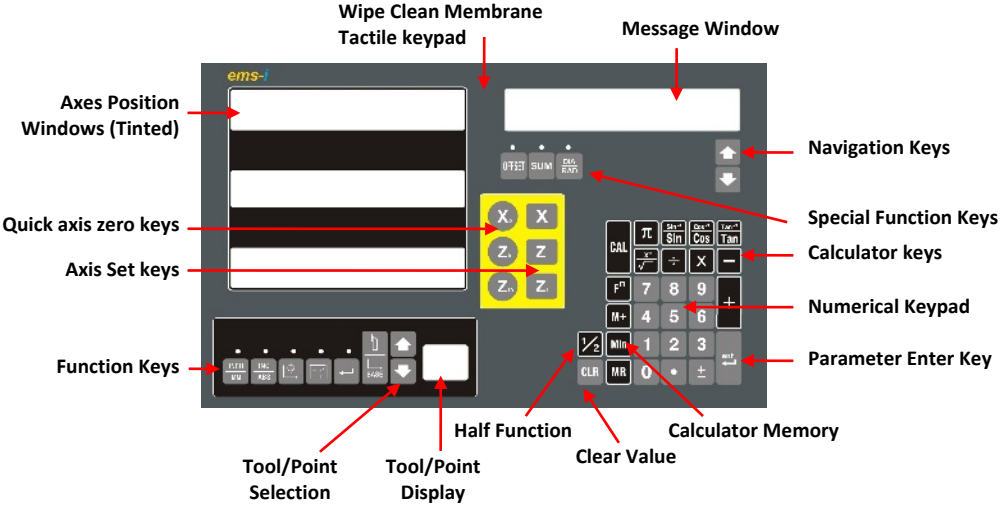
On smaller machines the Z-axis can also be the movement of the machining head up-down independent of the tool movement. As such it is quite possible for a milling machine, of all sizes, to have 4-axes of which two are vertical movement.

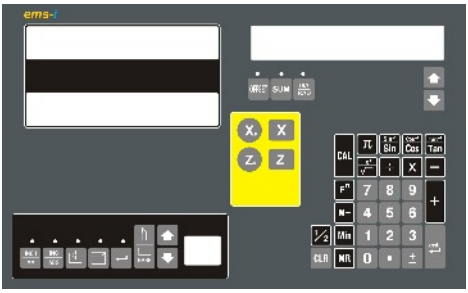



Knee Mill

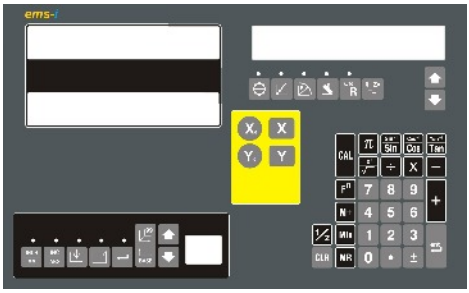
# Keypad Layout

The **EM200** DRO is available in 2-axes and 3-axes options in Lathe and Milling specific options. This allows for the functions specific to those machine types to be readily available whilst not overcomplicating the display keypad with buttons you will never use.

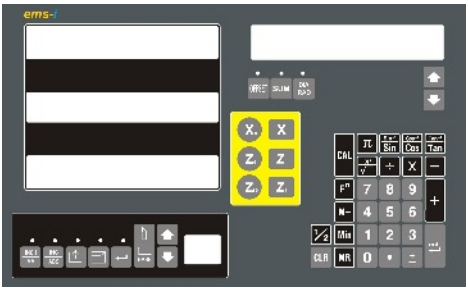


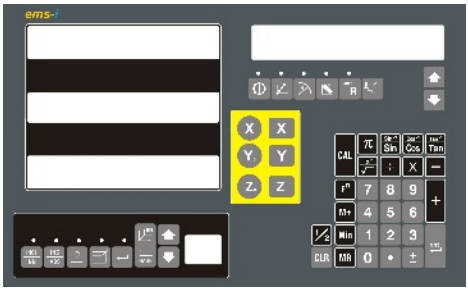
2-axes Lathe DRO



2-axes Milling DRO



3-axes Lathe DRO



3-axes Milling DRO

# Common Functions

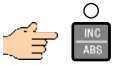
This section goes through the functions that are common between the Lathe and Mill DRO versions. Please read through this manual to ensure an understanding of these operations.

## Absolute / Incremental mode (ABS / INC)


Absolute mode displays the positions of all axes from a fixed datum. This is useful as it allows a defined datum for a given job. The Incremental mode displays each position relative to the last position. This is also known as point to point use. The red LED above the INC/ABS indicates the current selection of mode. The message window also shows the current mode.LED ON = Incremental Mode

***Note:*** *At the beginning of each working session, set the datum in Absolute Mode, and then switch the DRO to Incremental Mode. By using the DRO in this way, you can return the machine to its absolute datum at any time, simply by switching back to Absolute Mode.*


**Example: Switch from ABS to INC mode**

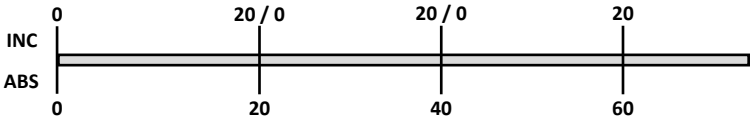





**For example.** Lets machine a simple linear series of holes 20mm apart.

- Set the absolute reference (ABS) to the end of a part to set our datum.
- Now switch to INC mode
- Zero the axis, Move 20mm and machine hole
- Zero the axis, Move 20mm and machine hole
- Zero the axis, Move 20mm and machine hole

The display in INC mode will show 20mm, the position of the last hole but if we toggle back to ABS mode the display will show 60mm being the total distance moved relative to the datum we set. As such we can easily move back to that datum or machine other features relative to it, such as PCD or curves etc.




## Inch / Metric Measurements


This function key toggles the displayed measurements between displaying in Inches or in millimetres (mm). This is particularly helpful when working to older drawings that may have been produced before decimalization. Equally many drawings from the United States are in Imperial measurement units. All axes are effected by this operation.


*As there are 25.400mm per Inch due to the limitations of any given display resolution some rounding of the conversion may result.*


**Example: Switch from mm to Inch mode**



# Zero an Axis Value

This function allows for the axis value to be quickly set to zero at any position. For this we can use the round Quick access axis zero keys. Can be used in both ABS and INC modes.

*If used in ABS mode a new datum will be established.*

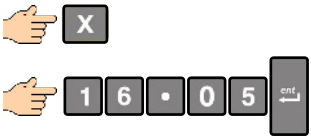

**Example: Set X-axis value to zero**


# Set an Axis Value

This function allows for a value to be entered in to any axis by selecting an axis key. Note that the entered value may be rounded to the nearest displayable resolution. Can be used in both ABS, INC and Inch Metric modes.

*To terminate the entry press the same axis key again. If used in ABS mode a new datum will be established.*


**Example: Set X-axis value to 16.05**

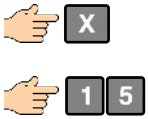




# Clear Entered Value

This function allows for an incorrectly entered value to be cleared so that a correct value can be entered.


**Example: Set X-axis value to 16.05**



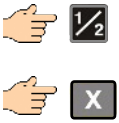
*New value can now be entered as above.*




# Half Function (Centre Find)

This function is used to find the centre of a work piece by halving the displayed distance on the selected axis.


**Example: Find the Centre of X-axis**





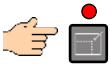
Move the axis to the display shows '0.000' and you will be at the calculated centre position. It is recommended to use this function in INC mode. If you press this key in ABS mode, it will change the datum point of the axis.

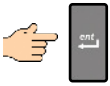
# Shrink Function

This function key allows for the programming of a scalar value that can be used to compensate for part shrinkage. . Whilst it can be used on Lathe DRO's it is primarily intended for use when machining mould tools on milling machines. All axes are effected by this operation.

*For this function to be active it needs to be enabled in the machine Setup.*


**Example: Set a compensation of 0.5%**







> **note**
> *All axes positions are multiplied by the entered scalar when SHRINK is enabled. As such the part will be made over-size such that it will contract to the desired final dimensions.*
>
> *To disable the function either turn-off in Setup or set the compensation value to 1.000.*

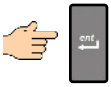
# Reference Function

This function allows user to set a machine zero datum and can be applied to each axis. With this machine zero point users can restore the work coordinates even if the machine is moved when the DRO is in OFF condition. Generally each encoder has reference marks present at periodic interval (for most ***ems-i*** scales this would be every 50mm) or at the scale centre of travel. These reference marks are used to recall the same datum point every time.

> **note** *For this function to be conducted on power-on where Segmented Error compensation has been set. Only use this function in ABS mode. The REF LED shows when the function is enabled.*


**Example: Find X-axis machine Reference**





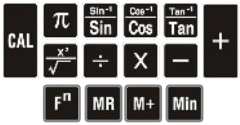

*The DRO is now looking for the reference signal from the scale…*


Move the axis towards the reference. The displayed axis value will NOT count. When the reference is detected the DRO will BEEP and the display will start counting. The scale/machine datum will be at 0.000.


> **note**
> *When scales with periodic references are used you must ensure that the same reference is used every time.*
>
> *This can be the first reference, from one end of travel, or alternatively by always starting the reference search from the same physical machine position.*

# Calculator Function

The **EM200** has a comprehensive set of calculator functions which also includes trigonometric calculations.
What makes this calculator more useful is that axis values can be selected as part of the calculation and the result can also then be transferred back in to a chosen axis.





**Enter the DRO Calculator:**


*The axes values are still displayed.*


**Examples:**


**Add & Subtract: 53 + 12 - 9 = 56**




**Use Trig: 100 COS (30) = 86.60254**




**Use Inverse Trig: Sin-¹ (0.5) = 30°**




**Use X-axis value: 25.4 x 3 = 76.2**




**Transfer Value offset to X-axis:**
**X = 25.4 : Value = 45.465**
**So in order to get to position 45.465 we need to move 25.400 - 45.465 = <u>-20.065</u>**


Move axis to 0.000 to get to 45.465 relative to the current ABS datum.


Exit the calculator function.


# Lathe Functions

The **EM200** DRO has a number of functions to assist in turning. These functions are described in more detail in this section.

## Radius / Diameter mode


Generally on a lathe we want to operate the cross-slide (X-axis) in Diameter mode as that reflects on the dimensions of the part being turned. The mode can be quickly changed by pressing the DIA RAD key. The operating display mode is shown by the status of the associated LED.


**Example: Set X-axis Diameter mode**



Radius Mode

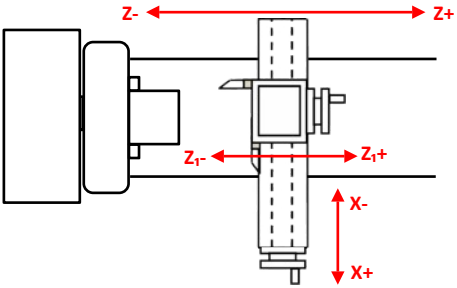

Diameter Mode



*The **EM200** DRO will return to the last setting of radius/Diameter mode after the DRO was switched off.*

## Axis Summing


The **EM200** has simple internal axis summation on 3-axes Lathe units. This allows for the bed axis (Z) and compound ($Z_1$) axis to be added together. For the values to be meaningful the compound axis must be rotated to be parallel with the bed axis.




Pressing the SUM key toggles between normal 3-axes display (X, Z, $Z_1$) and the summation display mode (X, Z, Z + $Z_1$). The summation result is shown in the $Z_1$ axis display window.

When in Summation mode the sum axis display is aligned to the left of the display window and the LED associated with axis summing is illuminated.



**Example: Enable Axis Summing**



Ordinary Mode

Summing Mode



Message window will briefly show the summing mode


*To exit Summing mode* 

*press the* 

*key again.*

*The **EM200** DRO will return to the last setting of summing mode even after the DRO was switched off.*

# Lathe Tool Offsets


Tools differ in length as well as in diameter, making compensation in slide movement necessary to accommodate the dimensional variation of the tools. This compensation is known as the tool offset. Once the tool offset is established, the slide movement is automatically adjusted according to the value that is set.

The **EM200** series DRO supports 99 such tool offsets for operation in ABS mode.

Whilst in many cases it is just as easy to datum each tool, as and when it is used, Tool Offsets allow for the pre-configuring of a tool post with multiple tools.

***Note:*** *It is recommended that only experienced operators use this function as if used incorrectly it can result in the introduction of significant machining errors.*

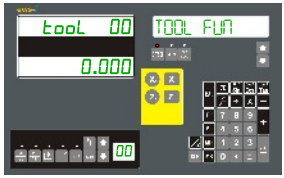
## How to define a Tool Offset:

Each tool will have its own offset and must be re-calibrated in the event of wear or where it has to be replaced due to breakage. The **EM200** stores Tool Offsets for the X-Axis only.

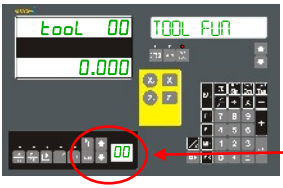
In order to set a tool offset it is recommended that you take the slim cut along outside diameter of the part or touch the tool to the surface of the part (if cylindrical). It is recommended that a scrap piece of material is used for this purpose.

Carefully move the tool away from the part in the Z-axis, without disturbing X-axis, and measure the Diameter of the part with a micrometer or similar. This will provide a known diameter, the centre of which would be the lathe axis turning centre-line. As such it is the **RADIUS** value that has to be entered. Now we can program the Tool Offset:

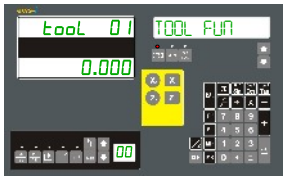


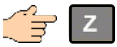

**Example: Set Tool-Offset to 10.5mm for Tool #1**




Use the Tool navigation keys




Note that any previously set offset will be shown, so may not be 0.000





Tool number now shown in Tool display

**Example: Set Tool-Offset to 10.5mm for Tool #1 (Continued)**



*The entered value is that of the measured* ***RADIUS****.*



The Tool Offset is now defined. Can repeat this procedure to set other Tool Offsets by simply selecting the next tool to set by using the Tool navigation keys.

**Exit the Tool Offset configuration:**





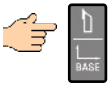
The last Tool is shown in Tool display and is actively being applied.

*If a value is shown other than "00" in the Tool display then that Tool Offset value is being applied.*

## Turn Off Tool-Offsets:

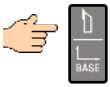
To turn off Tool-Offsets you can either use the tool navigation keys to Tool "00" or by simply pressing the  key.





## Selecting a Tool-Offset:



Tool Offsets are now operational but not yet applied as we are still at tool '00'

## Selecting a Tool-Offset: (Continued…)

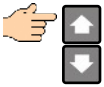
The desired Tool Offset can be selected using the Tool navigation keys or by typing the desired tool number in directly using the numeric keypad.


**Example: Select Tool #5**



There is no need to press the enter key as we are in Tool use mode.


**Example: Move from Tool #5 to Tool #6**




note *All normal functions such as Axis Summing, axis preset etc. continue to operate in Tool Offset mode.*

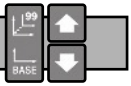
# Milling Functions

The **EM200** DRO has a number of functions to assist in Milling operations. These functions are described in more detail in this section.

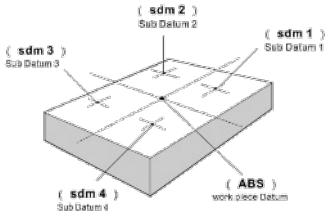
## Work-to-Zero

Before we start looking at the functions in depth it is worth noting that the **EM200** DRO, like all DRO operates on a principle, within functions, known as Work-to-Zero. Normally you may expect to zero an axis display and move to a number of your choosing, and for simple operations this is OK. However, as tasks get more complicated it is easier for the DRO to display the distance the tool is currently away from the desired position. Thus when you move to a position that is 0, 0 then you will have reached that desired location.

## Sub-datums (SDM)

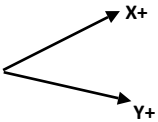


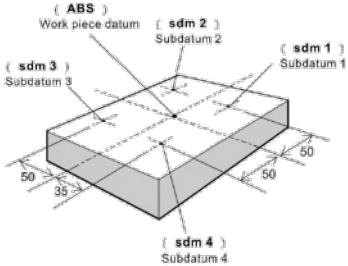

Sub-datums allow for workpiece reference positions to be defined that can then in turn be used as the start/centre co-ordinates for other functions, such as PCD, ARC contouring etc. These are especially useful when producing batches of components that are to be all the same. In this manner, once the workpiece ABS datum has been established, the sub-datums will automatically be set as they are relative to the ABS datum, wherever that may be.




*SDM's can either be Taught or entered directly:*

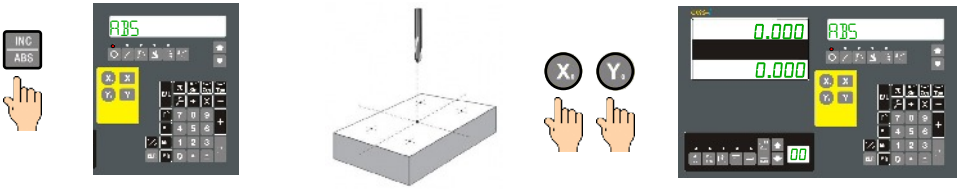
To best demonstrate these methods let us consider the part below. This has 4-SDM positions defined about a central ABS point.



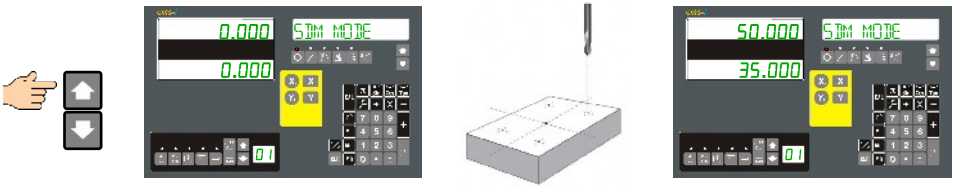




| #SDM | Co-ordinates |
|---|---|
| 1 | 50, 35 |
| 2 | 50, -50 |
| 3 | -50, -50 |
| 4 | -50, -35 |

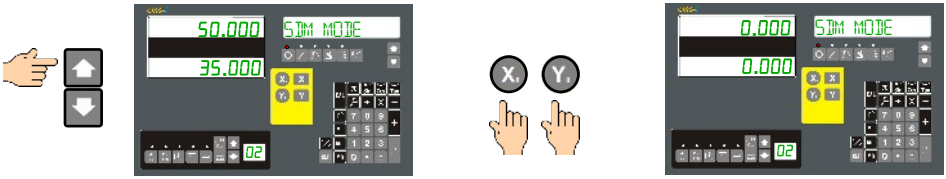
**Define a SDM pattern: (Teach method)**




Enter ABS mode, move to desired workpiece datum and set this as the datum by zeroing the axes.

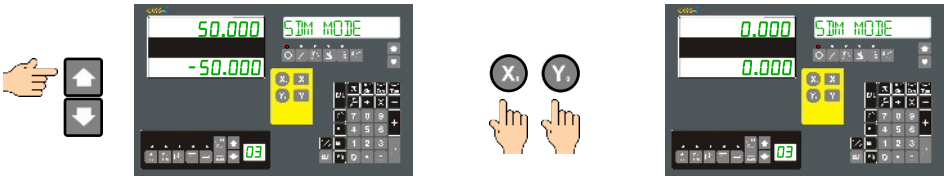



Select SDM #1, move to desired point.



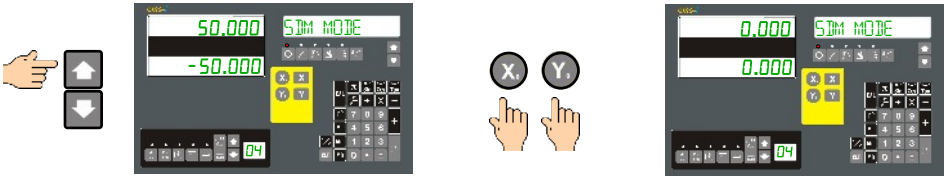

Select SDM #2, zero the axes and in so doing define the offset co-ordinate of SDM #1.


Still on SDM #2, move to the desired SDM #2 co-ordinate.

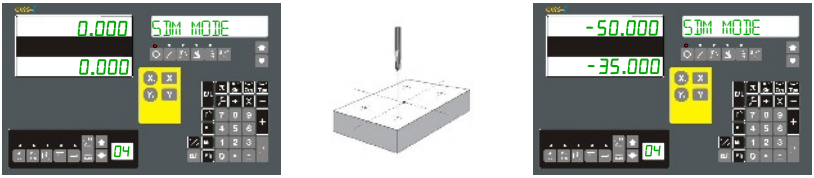



Select SDM #3, zero the axes and in so doing define the offset co-ordinate of SDM #2.

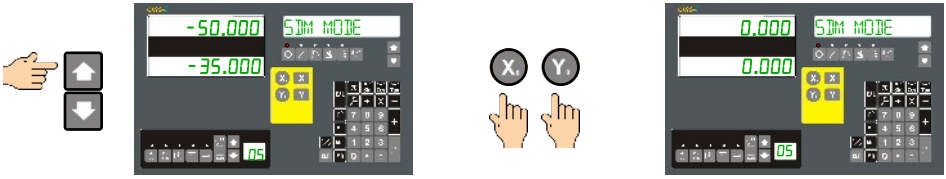

Still on SDM #3, move to the desired SDM #3 co-ordinate.




Select SDM #4, zero the axes and in so doing define the offset co-ordinate of SDM #3.

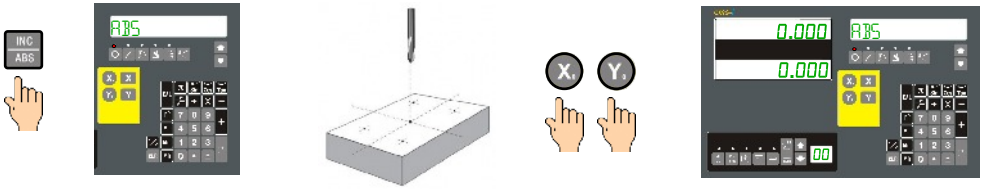



Still on SDM #4, move to the desired SDM #4 co-ordinate.

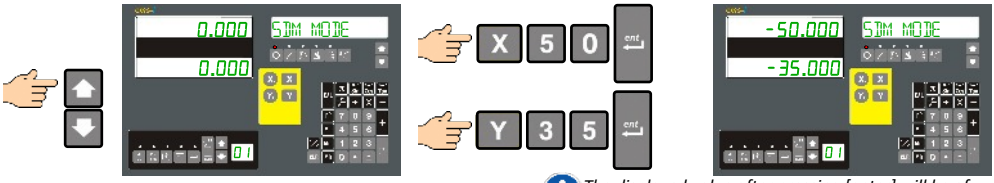



Select SDM #5, zero the axes and in so doing define the offset co-ordinate of SDM #4.

## Define a SDM pattern: (Direct Entry method)

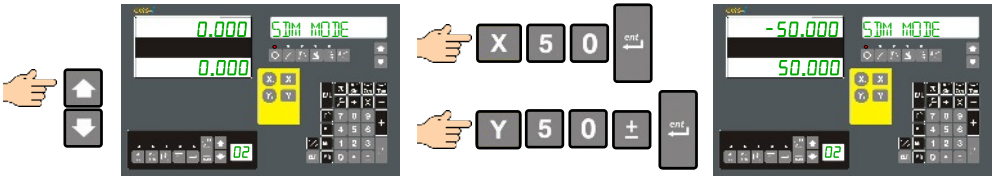



Enter ABS mode, move to desired workpiece datum and set this as the datum by zeroing the axes.

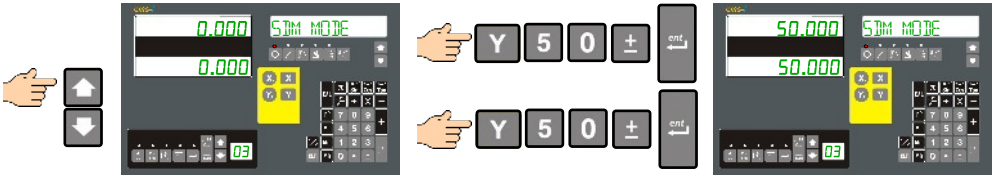



Select SDM #1, and enter the desired co-ordinate.

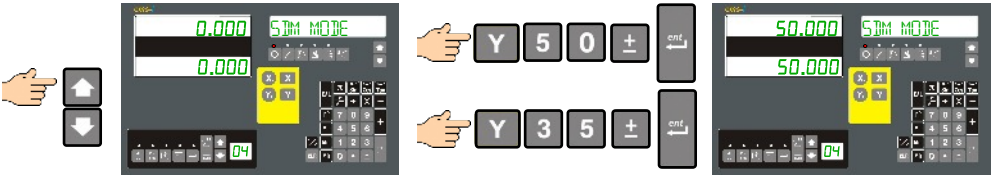
*The displayed value after pressing [enter] will be of opposite sign. This is because we are working-to-zero relative to the ABS datum and we are currently at 0, 0.*




Select SDM #2, and enter the desired co-ordinate.




Select SDM #3, and enter the desired co-ordinate.

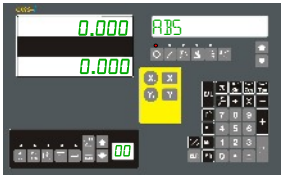



Once all the points have been entered you can now start using them straight away. As long as the Message window is displaying the text "**SDM MODE**", the axis displays are showing the current position of the tool from the SDM co-ordinate as displayed in the SDM window.

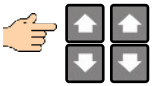
This direct entry of SDM co-ordinates is particularly useful when working on batch jobs or where centre or origin co-ordinates of features, to be machined, can be read from drawings.

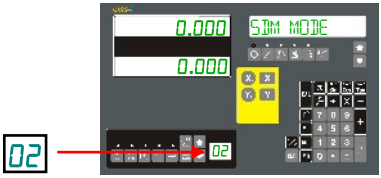
## Enable SDM Mode

Method #1: Use the SDM navigation keys. Pressing these keys will automatically enable SDM mode.



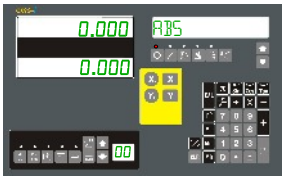

**Example: Select SDM #2**



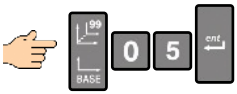



note *Navigating to SDM #0 will disable SDM mode.*

Method #2. Direct SDM selection




**Example: Select SDM #5**

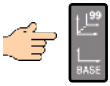




*The values in the axis will reflect the current offset-from zero for the selected datum. Above is only an example.*

## Disable SDM Mode

The SDM mode is automatically disabled if SDM #0 is selected.
However it is more common to simply re-press the [SDM] key, e.g.

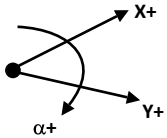




# PCD (Pitch Circle Diameter) / Bolt-Hole

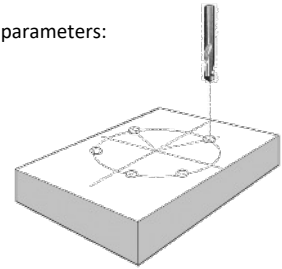
The **EM200** PCD calculator operates on the work-to-zero principle for the machining of a regular series of holes around a datum. This datum is entered as the centre of the circle to be machined. Complex hole patterns can be achieved easily without the need of detailed trigonometric calculations as these are all performed by the DRO.

To achieve these calculations the DRO needs to be configured with the following parameters:

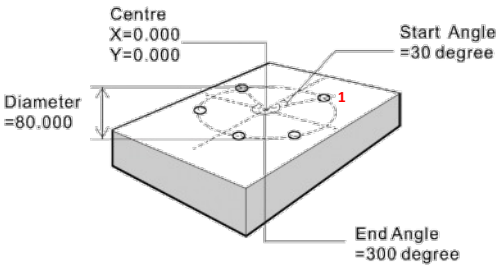
- Centre of the circle
- Diameter of the circle
- Number of holes required
- Start angle of the first hole
- End angle of the last hole




Angles are positive clockwise



To best demonstrate these methods let us consider the part below as by way of example.

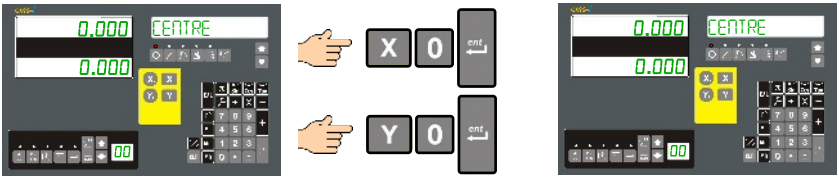



| Parameter | Value |
|---|---|
| Centre co-ordinates | 0.000, 0.000 |
| Diameter | 80mm |
| Number of Holes | 5 |
| Start Angle | 30° |
| End Angle | 300° |

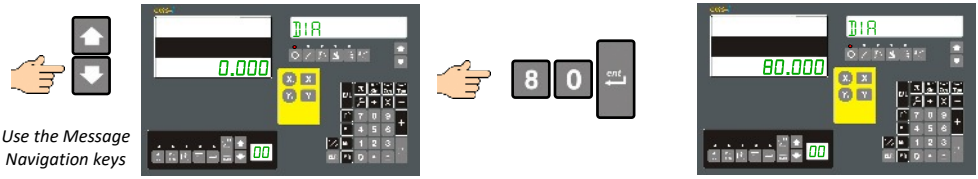
*If a full circle is needed:*
- *Start Angle = 0°*
- *End Angle = 360°*

Enter the PCD function by pressing the key. The key LED will be illuminated showing the function is active.


Enter the co-ordinates of the centre of the PCD circle.



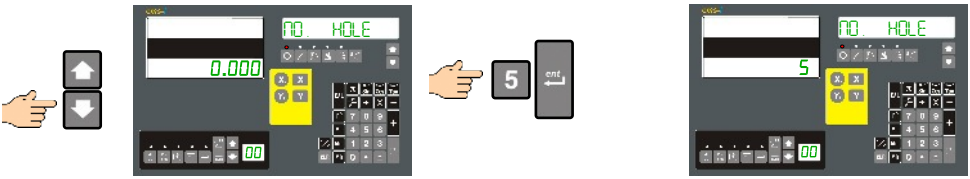

Move to Diameter entry and enter value.



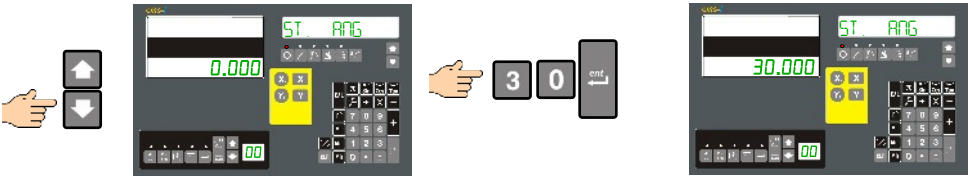

*Use the Message Navigation keys*

## PCD (Pitch Circle Diameter) / Bolt-Hole: Continued…

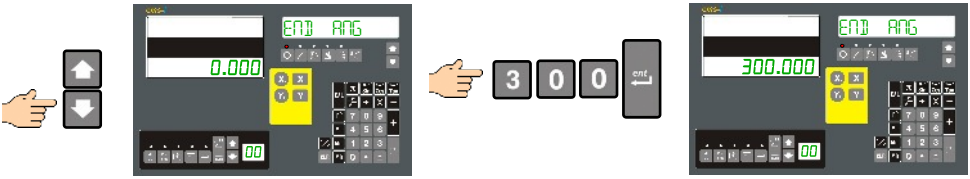
Move to Number of Holes entry and enter value.




Move to Start Angle entry and enter value.



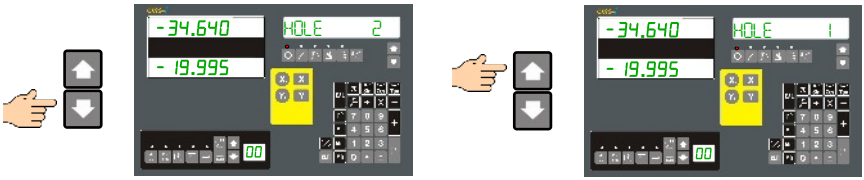

Move to Start Angle entry and enter value.




Once all the parameters have been entered you can check them by going back through them using the navigation key . Alternatively you can also start using the PCD immediately by pressing the key once more.


The message window will show the current selected Hole number and the X and Y-axis will show the offset to the centre of that hole. By moving the axes until they are both showing 0.000 you will now be at the calculated hole centre.

Navigate between holes using the Message navigation keys.



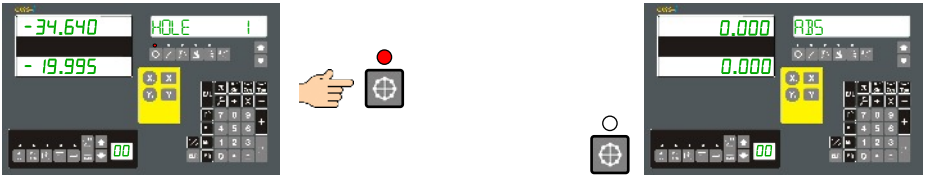

## Check ABS position whilst in PCD Function

If at any time whilst in the PCD function you would like to check the standard ABS position, relative to the workpiece datum this can be done using the key. The PCD function is still active in the background. Once you have checked the positions re-enter the PCD offset display by again pressing the key.

### Exit from PCD Function

To exit from the PCD function simply press the key again.

*The parameter values programmed in to the PCD function are saved to the DRO memory so that they can be recalled even after the DRO has had the power turned off. Simply reselect the PCD function and you can then simply check the parameters, or edit them as may be required for a new pattern.*

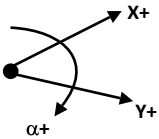


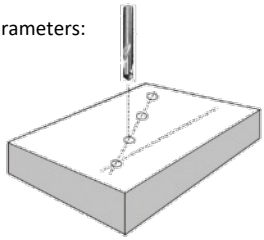

# Line-Hole Function

The **EM200** Line-hole calculator operates on the work-to-zero principle for the machining a regular line of holes from the current tool position, which could be a SDM datum. Lines can be at any angle with out the need of detailed trigonometric calculations as these are all performed by the DRO.

To achieve these calculations the DRO needs to be configured with the following parameters:

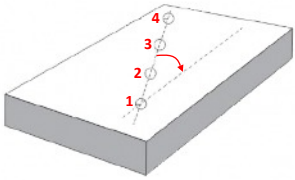
- Length of Line
- Angle of the Line
- Number of Holes



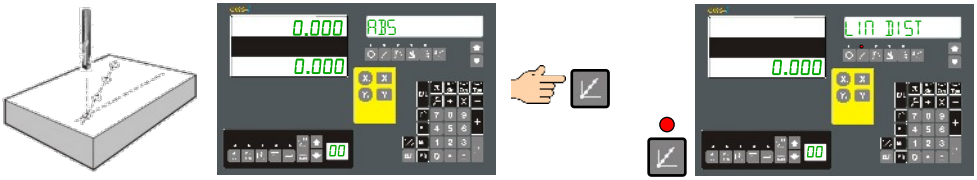
Angles are positive clockwise

To best demonstrate these methods let us consider the part below as by way of example.

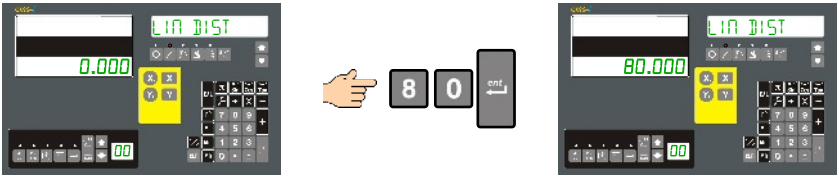



| Parameter | Value |
|---|---|
| Length of Line | 80mm |
| Angle of Line | 30° |
| Number of Holes | 4 |

Move to the position of the first hole in the line and then enter the Line-Hole function by pressing the key. The key LED will be illuminated showing the function is now active.

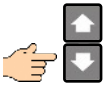



Enter the length of line of holes (first to last hole centres).

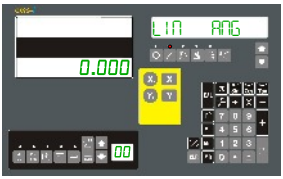


## Line-Hole Function: Continued…

Enter the line angle.

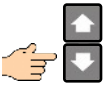


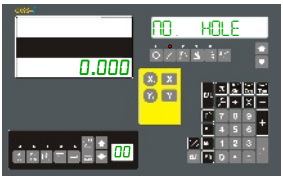
*Use the Message Navigation keys*





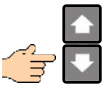

Enter the line number of holes.

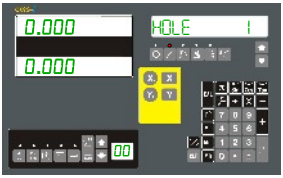






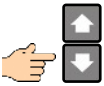

Once all the parameters have been entered you can check them by going back through them using the navigation key . Alternatively you can also start using the PCD immediately by pressing the key once more.

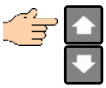


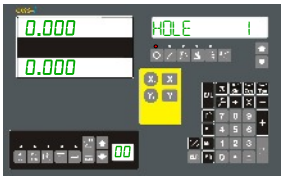



The message window will show the current selected Hole number and the X and Y-axis will show the offset to the centre of that hole. By moving the axes until they are both showing 0.000 you will now be at the calculated hole centre.

Navigate between holes using the Message navigation keys.

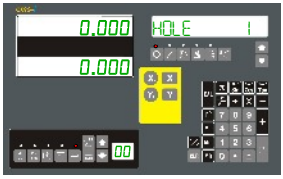





## Check ABS position whilst in the Line-Hole Function

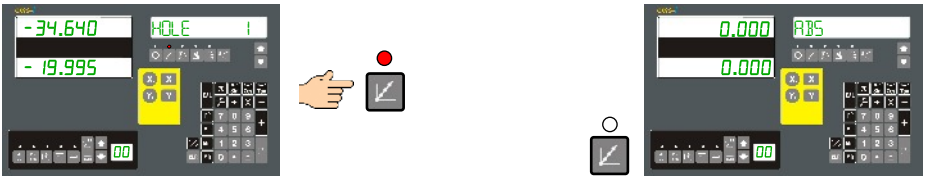
If at any time whilst in the Line-Hole function you would like to check the standard ABS position, relative to the workpiece datum this can be done using the key. The Line-Hole function is still active in the background. Once you have checked the positions re-enter the function offset display by again pressing the key.


### Exit from the Line-Hole Function

To exit from the Line-Hole function simply press the key again.

*The parameter values programmed in to the Line-Hole function are saved to the DRO memory so that they can be recalled even after the DRO power is turned off. Simply reselect the Line-Hole function and you can then simply check the parameters, or edit them as may be required for a new pattern.*



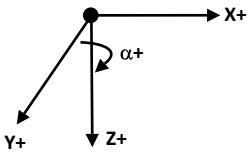

# Inclined Machining

The **EM200** Line-hole calculator operates on the work-to-zero principle for the machining an inclined plane.

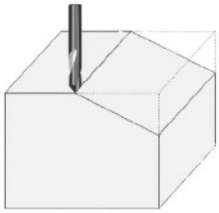
To achieve these calculations the DRO needs to be configured with the following parameters:

- Plane to machine
- Angle
- Max Cut step size

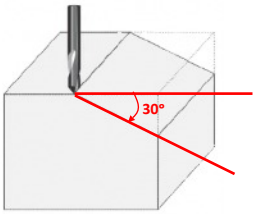
*Plane options: XY, XZ, YZ*




Angles are positive clockwise



To best demonstrate these methods let us consider the part below as by way of example.





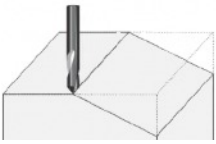
*The finer the step the smoother the finish*

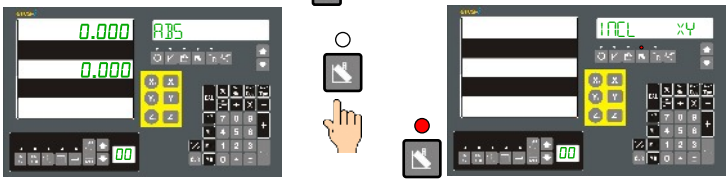
| Parameter | Value |
|---|---|
| Plane | XZ |
| Angle of Line | 30° |
| Max. Cut | 0.5mm |

In this example in order to machine a 30° angle for every 0.5mm in Z we would need to move 0.865mm steps in X.

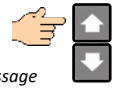
I.e. $\text{Xstep} = \frac{0.5}{\text{Tan}(30)}$

Move the tool to the start position of the incline to be machined. You may wish to set this as a datum but it could be any value or even an SDM point. Then enter the function using the key.

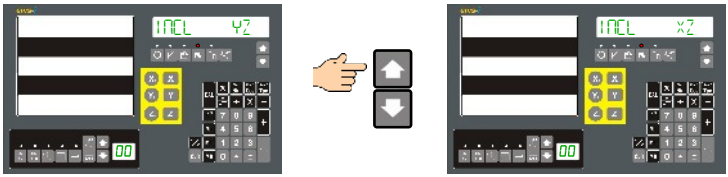





Navigate to the required plane.

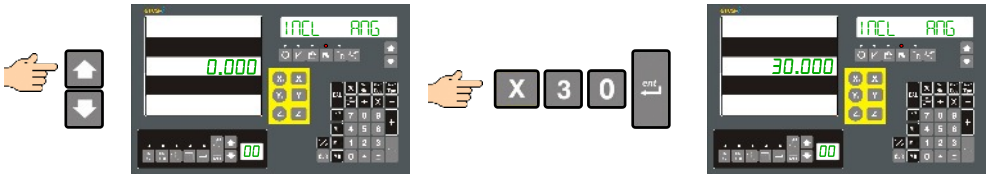


*Use the Message Navigation keys*

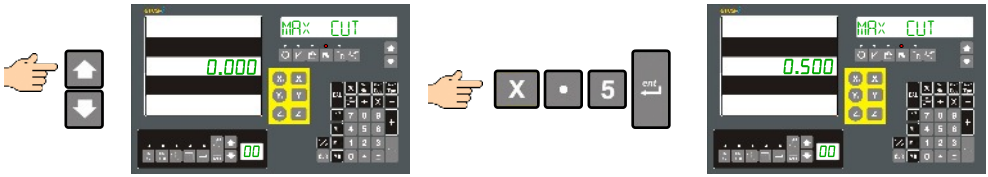


## Inclined Machining: Continued…

Navigate to the plane Angle entry and enter the required value.




Navigate to the Max Cut entry and enter the required value.



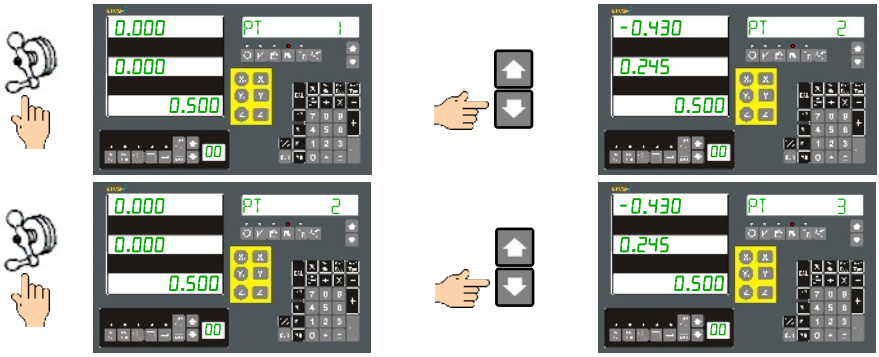

Once all the parameters have been entered you can check them by going back through them using the navigation key . Alternatively you can also start using the function immediately by pressing the key once more.

note *The execution of the function varies between 2-axes and 3-axes DRO for the YZ & XZ planes as we have to use the Z-dial calibration performed in Setup to simulate the Z-axis on 2-axes DRO systems.*

**The following is only required for the XY Plane. (2-axis and 3-axis DRO)**

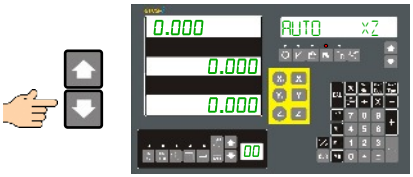

The message window will show the first machining Point with the X & Y-axis displays left aligned to indicate that it is operating in a special mode.

Move the X-axis and Y-axis to 0.000. Then press the key to move to the next next point and repeat the process until the ARC machining operation is completed. You can navigate through the points using the keys



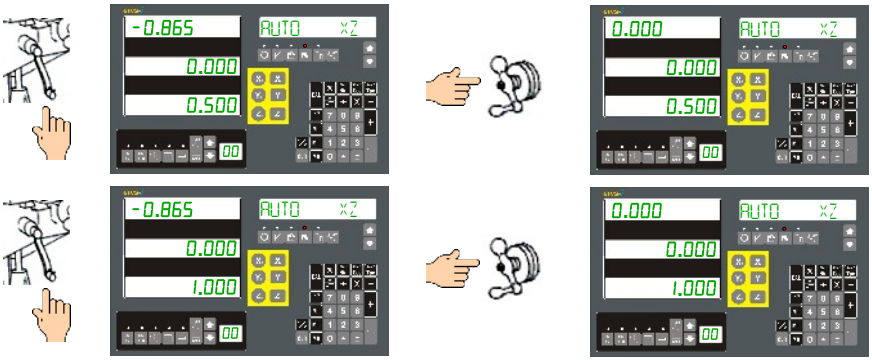

Repeat as required…

## The following is the operating mode on XZ & ZY Plane on 3-axes DRO.




The message window will show the current plane of operation and the X-axis display is left aligned to indicate that it is operating in a special mode. 0.000

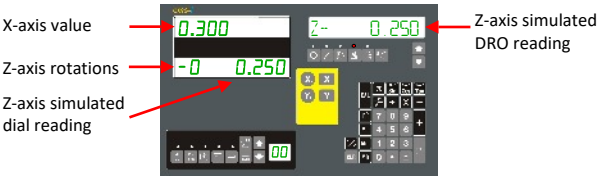
Move the Z-axis by the programmed Max-Cut value. This will cause the X-axis display to also change. When the Y-axis move is complete, then move the X-axis until the X-axis shows 0.000. This process can be repeated until the inclined machining operation is completed.




Repeat as required…

note *The Y-axis position increments by the Max-Cut value each time. As the machining is at a given angle the X-axis value will be the same for each step and will depend on the angle of cut.*

## The following is the operating mode on XZ & ZY Plane on 2-axes DRO.




The DRO will simulate a Z-axis position based on the DIAL INC and Z DIAL values configured in Setup. It is the operators responsibility to move the dials as per the DRO display.

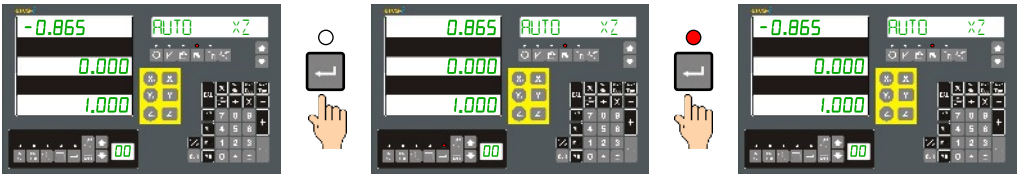
Move X-axis to zero and then move the Z-axis. When you have moved the Z-axis use the message navigation keys to inform the DRO that the movement has been completed, and move to the next point. This process can be repeated until the inclined machining operation is completed.


Repeat as required…

Press the Function key to exit when the operation is complete.

**Check ABS position whilst performing Inclined Machining (ALL DRO)**

If at any time whilst in the Inclined Machining function you would like to check the standard ABS position, relative to the workpiece datum this can be done using the ↵ key. The function remains active in the background. Once you have checked the positions re-enter the Inclined machining function mode by again pressing the ↵ key.




# Machining a Radius

The **EM200** has two functions for machining a radius or arc. These are:

- Simple Radius (R-Function)
  The R-Function will allow for the machining of any one of the eight standard arcs that are most common. This as the name suggests is the simplest method but is limited to simple 90° arcs. There is no need for any user calculations and it is simple to operate.

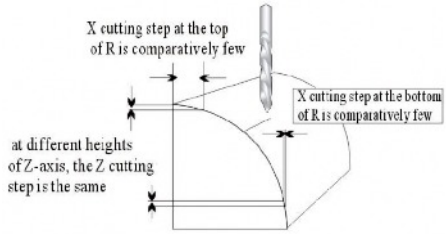
- Auto Radius (ARC-Function)
  The ARC-Function is a more powerful mechanism allowing for a broad range of arcs to be defined. To achieve this more parameters need to be entered for which the operator may need to do some calculations.

*Before attempting to machine a workpiece on an actual job it is highly recommended to practice on a scrap part to get the 'feel' of the process.*

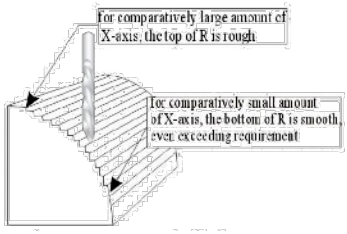
# Setting the Z-Step Method

The **EM200** allows for two methods of operation for controlling the finish of the ARC being machined and this is controlled by the key.

If we consider the XZ plane then, as we move around an ARC the rate of change in Z increases for a consistent change in Z. Thus in order to get a smooth finish the DRO can automatically compensate for this. However, this can require many, many small movements to produce the required ARC. This is known as the Smooth ARC. Alternatively, if we keep the step size constant then the arc can become more stepped, especially on smaller arcs. This is the Stepped ARC. The mechanism to control which mode is employed is controlled by the key.




**Smooth ARC**




**Stepped ARC**

How to Toggle between Smooth ARC and Stepped ARC.


MAX. MD = Smooth ARC

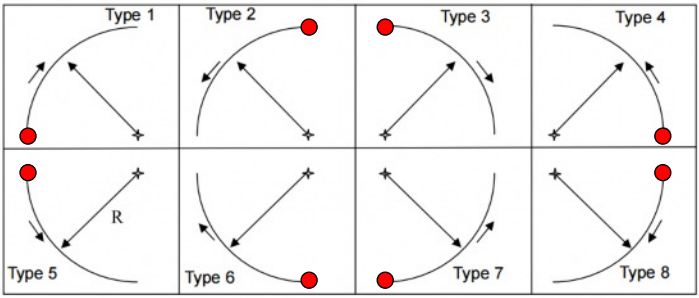

STEP MD = Smooth ARC

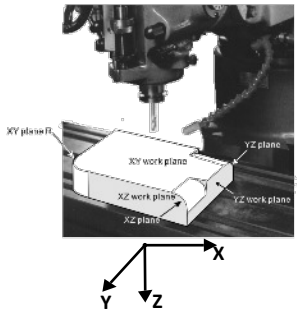
The Message window will briefly flash the current mode before returning to normal display mode. Ensure the required mode is selected ***BEFORE*** using an ARC function.

# Simple Radius Function (R-Function)

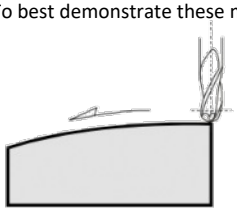
The **EM200** R-Function operates on the work-to-zero principle for the machining an radius. This is the simplest method for machining one of the eight most common arcs. For more complex arcs see the Auto-R Radius Function.

The common types of arc are shown below. The operation of the R-Function assumes the tool is located at the start of the arc as depicted by ●. These are all circular arcs with a user defined radius.



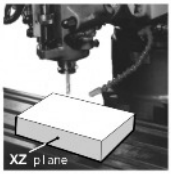




To best demonstrate these methods let us consider the part below as by way of example.



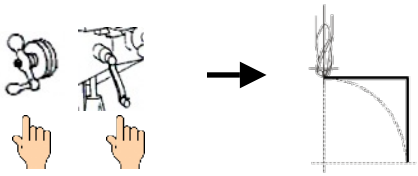
Position tool at the start of the arc.

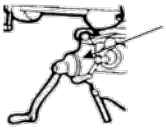
| Parameter | Value |
|---|---|
| Plane of Operation | XZ |
| ARC Type (1-8) | 2 |
| Radius of ARC | 200mm |
| Tool Diameter | 6mm |




***Set the Z-STEP to the required machining mode using the key <u>BEFORE</u> entering the R-Function***

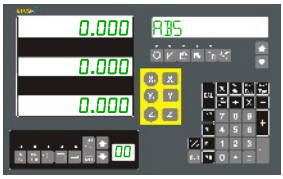
Move the Tool to the start of the ARC. It is also possible to machine in the Z plane on a 2-axes XY DRO on Mills. To do this we will need to use the Knee axis Z-dial for as a manual reference.

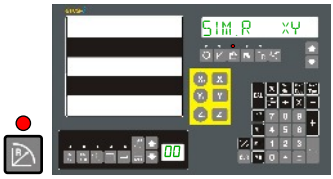




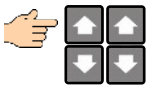
When the tool has been positioned at the start of the ARC zero the Z-axis dial (2-axis DRO Only)

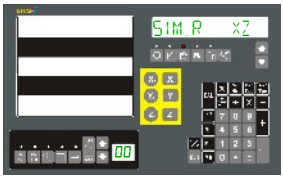
Enter the R-Function by pressing the key. The key LED will be illuminated showing the function is now active.

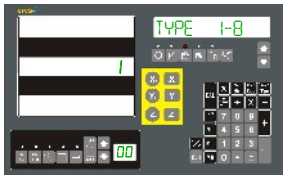



Navigate to the plane required and press key. The display will move to the ARC type entry automatically.

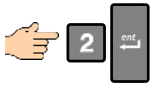


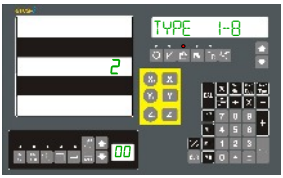


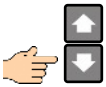
## Simple Radius Function (R-Function): Continued…

Enter the required ARC type with reference to the ARC Table.

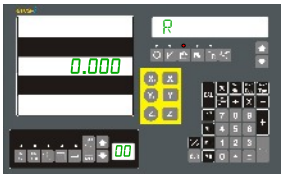


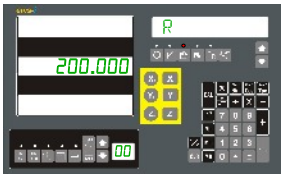

Navigate to the Radius entry and enter the ARC Radius.



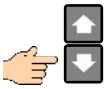
*Use the Message Navigation keys*

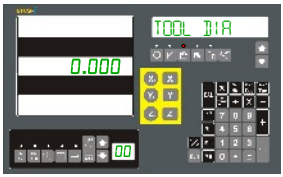




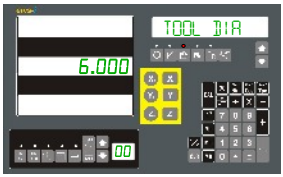



Navigate to the Tool Diameter entry and enter the Tool Diameter. (This can be 0.000 if cutting with tool tip)



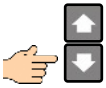


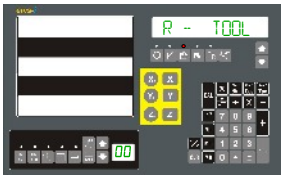


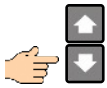


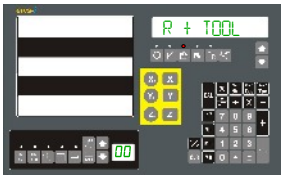

**<u>The following parameters may not appear on ALL plane selections / DRO types (2x / 3x).</u>**

Navigate to the Tool compensation entry and enter the Tool Cut edge.





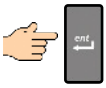



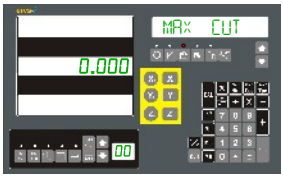



R - TOOL

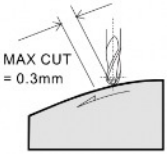
R + TOOL

Next set the MAX CUT value.





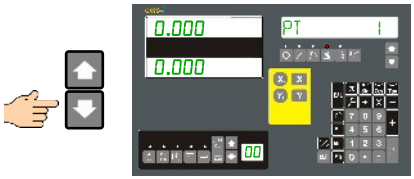

The **EM200** will use this as the maximum step value and automatically calculate the best possible axis increment according to the curvature of the ARC to be approximately equal to the MAX CUT value.

## Simple Radius Function (R-Function): Continued…

Once all the parameters have been entered you can check them by going back through them using the navigation key . Alternatively you can also start using the function immediately by pressing the key once more.

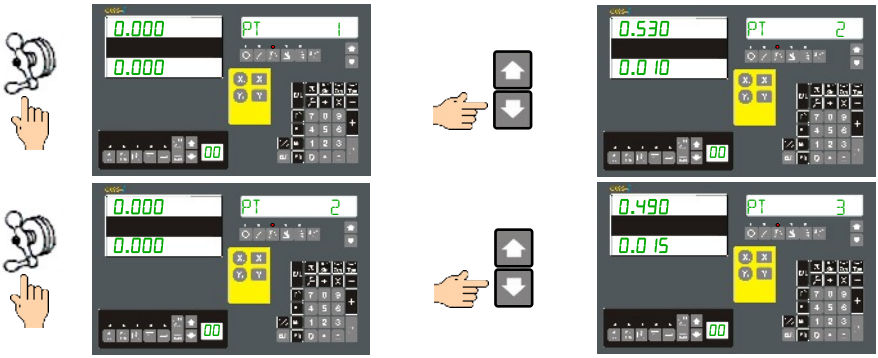
*The execution of the function varies between 2-axes and 3-axes DRO for the YZ & XZ planes as we have to use the Z-dial calibration performed in Setup to simulate the Z-axis on 2-axes DRO systems.*

### The following is only required for the XY Plane. (2-axis and 3-axis DRO)




The message window will show the first machining Point with the X & Y-axis displays left aligned to indicate that it is operating in a special mode.

Move the X-axis and Y-axis to 0.000. Then press the key to move to the next next point and repeat the process until the ARC machining operation is completed. You can navigate through the points using the keys




Repeat as required…

### The following is the operating mode on XZ & ZY Plane on 2-axes DRO.


The DRO will simulate a Z-axis position based on the DIAL INC and Z DIAL values configured in Setup. It is the operators responsibility to move the dials as per the DRO display.

Move X-axis to zero and then move the Z-axis. When you have moved the Z-axis use the message navigation keys to inform the DRO that the movement has been completed, and move to the next point. This process can be repeated until the inclined machining operation is completed.


Repeat as required…

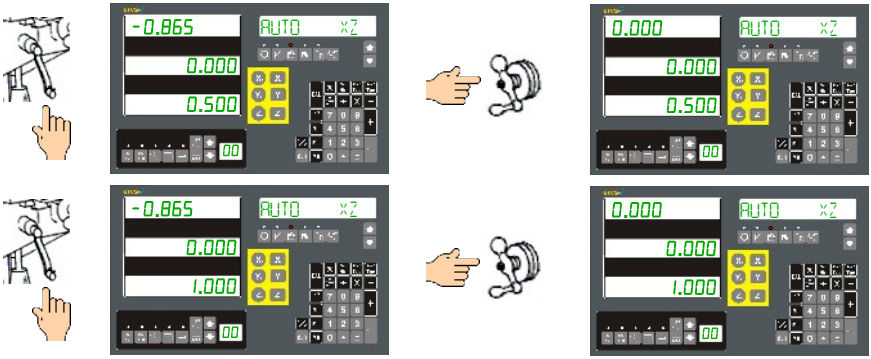
## Simple Radius Function (R-Function): Continued…

**The following is the operating mode on XZ & ZY Plane on 3-axes DRO.**


The message window will show the current plane of operation and the X-axis display is left aligned to indicate that it is operating in a special mode. 0.000

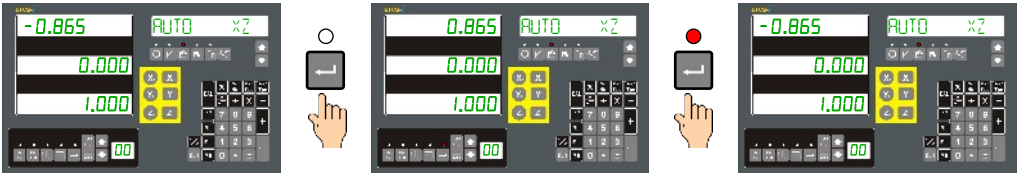
*If the message window displays "**Z OU LI**" it means that the Z-axis is outside of the line of the calculated ARC.*

Move the Z-axis by the programmed Max-Cut value. This will cause the X-axis display to also change. When the Y-axis move is complete, then move the X-axis until the X-axis shows 0.000. This process can be repeated until the inclined machining operation is completed.



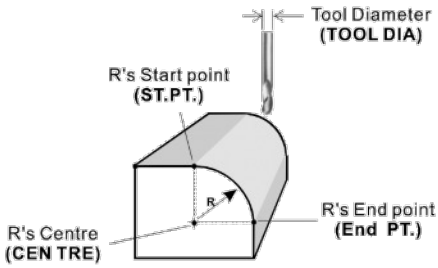

## Check ABS position whilst performing R-Function Machining (ALL DRO)

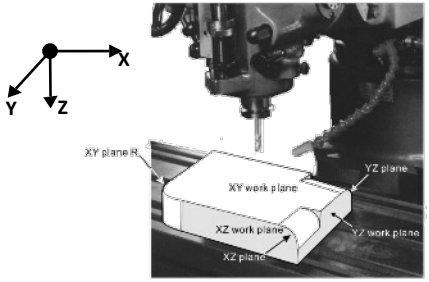
If at any time whilst in the R-Function you would like to check the standard ABS position, relative to the workpiece datum, this can be done using the ↵ key. The function remains active in the background. Once you have checked the positions re-enter the R-Function mode by again pressing the ↵ key.



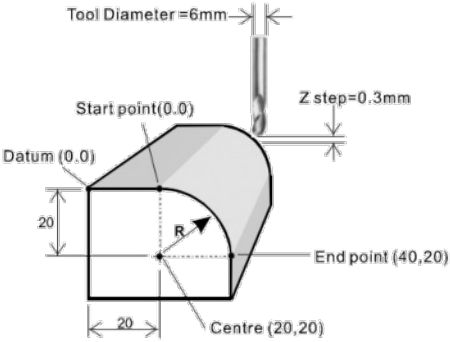
# Enhanced Radius Function (Auto-R)

The **EM200** Auto-R function operates on the work-to-zero principle for the machining an radius. This mechanism if far more flexible than the R-Function but can be more complex to configure as the operator may need to perform some trigonometric calculations in order to determine some of the parameters needed by the function.

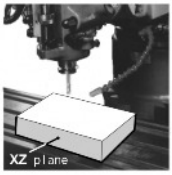



To best demonstrate these methods let us consider the part below as by way of example.

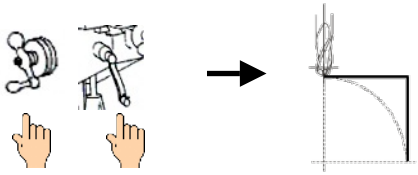


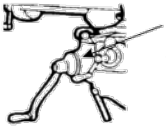

| Parameter | Value |
|---|---|
| Plane of Operation | XZ |
| Centre Co-ords | X: 20.000<br>Z: 20.000 |
| Radius of ARC | 200mm |
| ARC Start | X: 20.000<br>Z: 0.000 |
| ARC End | X: 40.000<br>Z: 20.000 |
| Tool Diameter | 6mm |
| Tool Compensation | R+ |
| Max Step | 0.3mm |




***Set the Z-STEP to the required machining mode using the key <u>BEFORE</u> entering the R-Function***

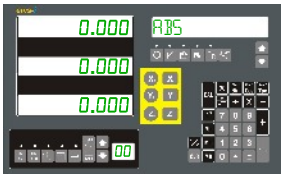
Move the Tool to the start of the ARC. It is also possible to machine in the Z plane on a 2-axes XY DRO on Mills. To do this we will need to use the Knee axis Z-dial for as a manual reference.

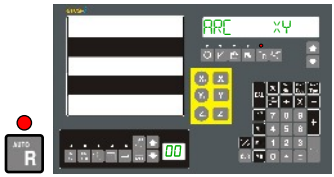




When the tool has been positioned at the start of the ARC zero the Z-axis dial (2-axis DRO Only)

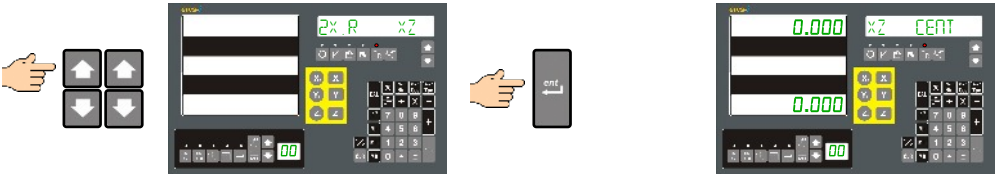
Enter the Auto-R Fⁿ by pressing the key. The key LED will be illuminated showing the function is now active.



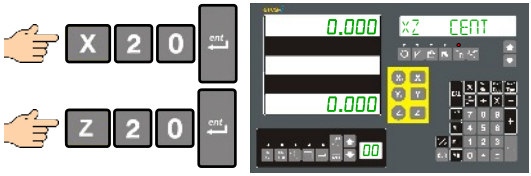
## Enhanced Radius Function (Auto-R): Continued…

Navigate to the plane required and press key. The display will move to the ARC centre entry automatically.

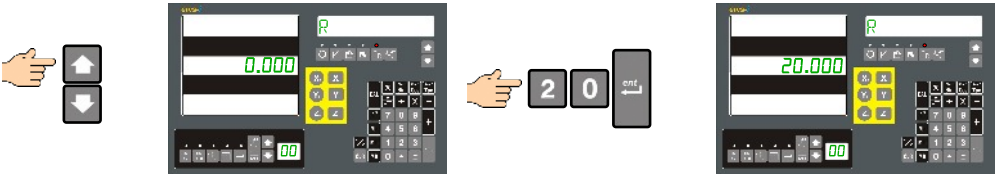



Enter the centre co-ordinates for the ARC and press .

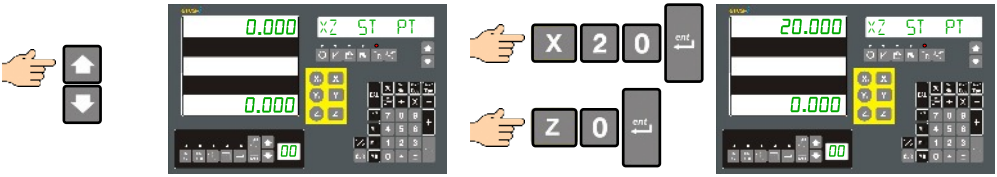
*On 2-axes Mill the Z-axis entry is made in to the Y-axis*



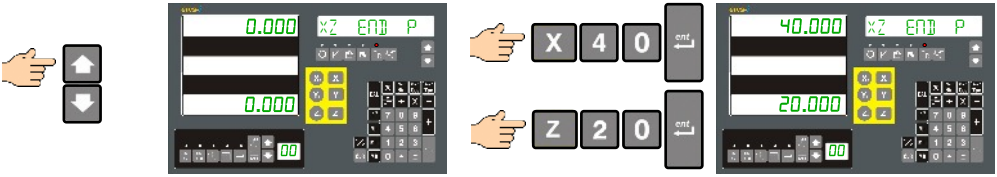

Navigate to the ARC Radius entry and enter the required value and press.



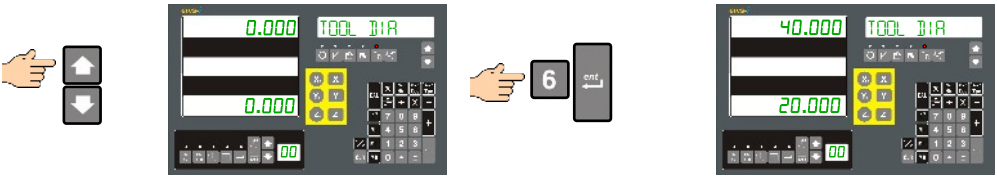

Navigate to the ARC Start entry and enter the required value.



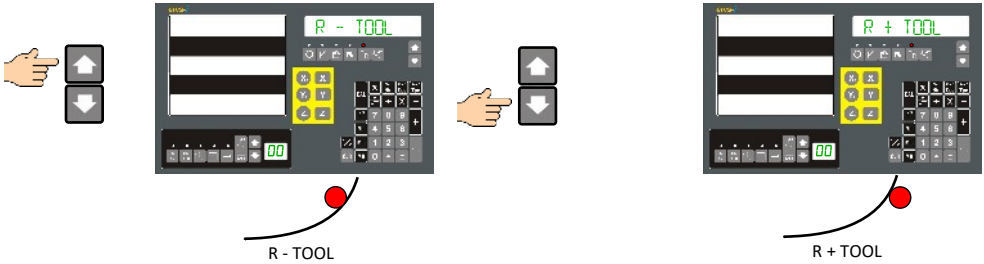

Navigate to the ARC end entry and enter the required value.




Navigate to the Tool Diameter entry and enter the required value.



Navigate to the Tool compensation entry and select the Tool Cut edge.

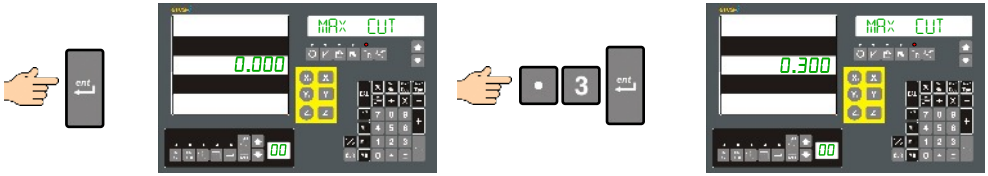


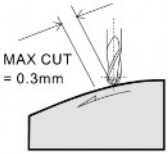

*If you have a 3-axes Mill all the parameters have now been entered.*

*Press the key to enter machining mode.*

**<u>The following parameters may not appear on ALL plane selections / DRO types (2x / 3x).</u>**

Navigate to the Max Cut entry and enter the required value.




The **EM200** will use this as the maximum step value and automatically calculate the best possible axis increment according to the curvature of the ARC to be approximately equal to the MAX CUT value.

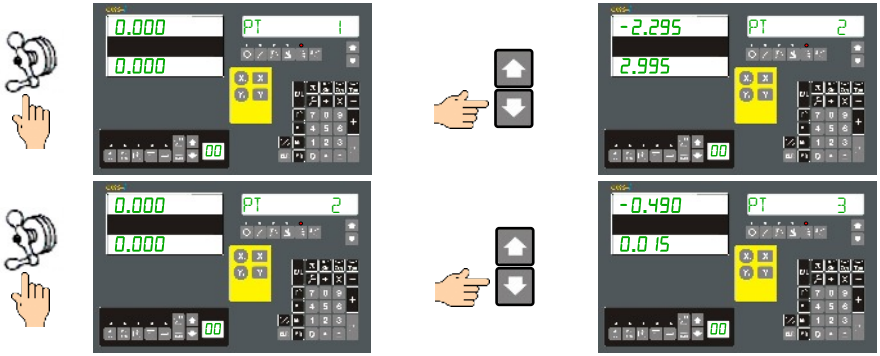
Once all the parameters have been entered you can check them by going back through them using the navigation key . Alternatively you can also start using the function immediately by pressing the key once more.

*The execution of the function varies between 2-axes and 3-axes DRO for the YZ & XZ planes as we have to use the Z-dial calibration performed in Setup to simulate the Z-axis on 2-axes DRO systems.*

**The following is only required for the XY Plane. (2-axis and 3-axis DRO)**

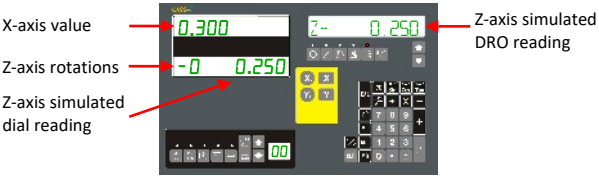

The message window will show the first machining Point with the X & Y-axis displays left aligned to indicate that it is operating in a special mode.

Move the X-axis and Y-axis to 0.000. Then press the key to move to the next next point and repeat the process until the ARC machining operation is completed. You can navigate through the points using the keys




Repeat as required…

**The following is the operating mode on XZ & ZY Plane on 2-axes DRO.**



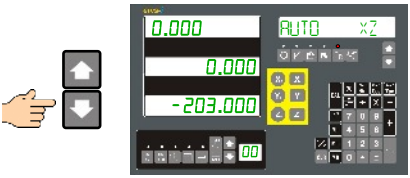

The DRO will simulate a Z-axis position based on the DIAL INC and Z DIAL values configured in Setup. It is the operators responsibility to move the dials as per the DRO display.

Move X-axis to zero and then move the Z-axis. When you have moved the Z-axis use the message navigation keys to inform the DRO that the movement has been completed, and move to the next point. This process can be repeated until the inclined machining operation is completed.


Repeat as required…

## Enhanced Radius Function (Auto-R): Continued…

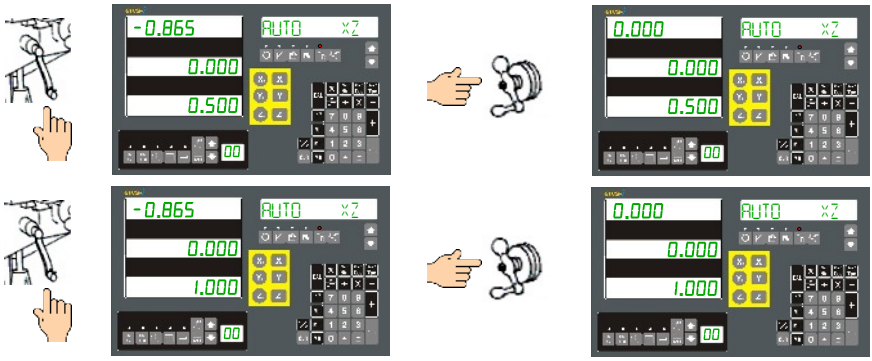
**The following is the operating mode on XZ & ZY Plane on 3-axes DRO.**




The message window will show the current plane of operation and the X-axis display is left aligned to indicate that it is operating in a special mode. 0.000

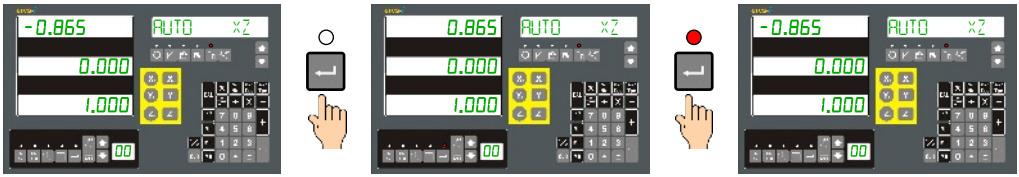
*If the message window displays "**Z OU LI**" it means that the Z-axis is outside of the line of the calculated ARC.*

Move the Z-axis by the programmed Max-Cut value. This will cause the X-axis display to also change. When the Y-axis move is complete, then move the X-axis until the X-axis shows 0.000. This process can be repeated until the inclined machining operation is completed.




## Check ABS position whilst performing R-Function Machining (ALL DRO)

If at any time whilst in the R-Function you would like to check the standard ABS position, relative to the workpiece datum, this can be done using the ↵ key. The function remains active in the background. Once you have checked the positions re-enter the R-Function mode by again pressing the ↵ key.



# Common keys

Below is a list of keys that can be found on both Lathe and Mill versions of the **EM200** DRO.

| Key | Description |
|---|---|
| 0 ··· 9 | Number keys [0] through to [9] |
| • | Decimal point. Used with the number keys to enter a non-integer value, |
| ± | Used to change the sign of an entered number. |
| CLR | Clear an entered value.<br>Clear DRO “ERROR” message |
| X Y Z Z | Axis Zero keys. These will set the selected axis to 0.000 |
| X Y Z Z | Axis pre-set keys. Use with the numeric keys to set an axis value. |
| INCH MM | Toggle the axis display between metric and imperial measurements. |
| INC ABS | This toggles the axis position display between incremental and absolute, relative to a datum, modes. |
| | Used to set a datum for a operation or for the workpiece |
| | This function allows for programming of a multiplier to the axes such that the machined part id ‘oversize’ by a set amount. Most useful when machining mould tools. |
| ↵ | This key is used to confirm a selection. Used in set functions such as setting a reference. Not the same as [Ent] |
| ent | This is the main ENTER key and used for confirming entry of all main parameters, such as setting an axis value. |
| ⬆ ⬇ | This is navigation key by the message window and is used to move between options. |
| ⬆ ⬇ | This is navigation key in the functions section (bottom left) of the display and is used to move between points or tools. |
| CAL π Sin⁻¹ Sin Cos⁻¹ Cos Tan⁻¹ Tan + x² √ ÷ X − | Keys used by calculator function |
| Fⁿ | Used to access the calculator 2nd inverse functions |
| MR M+ Min | Calculator memory functions, Recall, Save/Add, Subtract |
| 1/2 | Centre Find or Half function used with axis keys |

# Machine Specific Keys

Below is a list of keys that are specifically for the enhanced operation of the Lathe version of the **EM200** DRO.

## Lathe Functions

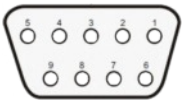
| Key | Description |
|---|---|
| OFFSET | Used to set a Tool Offset compensation value |
| SUM | Enable internal axis summing (3-axes DRO only) |
| DIA RAD | Toggle display between Radius and Diameter mode |
| BASE | Used to enable/disable Tool-offset mode |

## Mill Functions

| Key | Description |
|---|---|
| | Bolt-hole (PCD) calculator function |
| | Line-hole function |
| | Inclined Machining function |
| | Arc machining function |
| | Arc machining step size |
| AUTO R | Simplified arc machining function |
| 99 BASE | Setting of sub-datums or auxiliary co-ordinates to aid multiple operations on a single workpiece (max 99) |

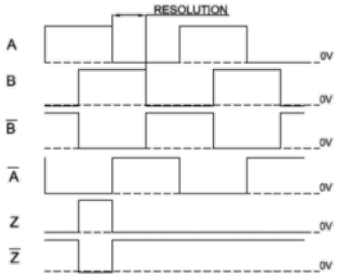
# Encoder Connections

All ***ems-i*** DRO and linear encoders (apart from special products) have the same encoder connection specification and pin-out. As such any ***ems-i*** encoder can work on any ***ems-i*** DRO. In addition, all of these DRO and encoders are full industrial EIA 422 differential and screened to ensure the highest levels of noise immunity and performance.




9 Pin 'D' type Plug connector

| Pin | Signal |
|---|---|
| 1 | Z (ABS reference) |
| 2 | /Z (/ABS reference) |
| 3 | VCC (+5VDC) |
| 4 | Shield |
| 5 | GND (0V) |
| 6 | Phase A |
| 7 | Phase /A |
| 8 | Phase /B |
| 9 | Phase B |




# Power-up Sequence

On power-up the **EM200** DRO will make a few 'BEEPS' and all the axis windows will cycle through the LED numbers 1, 2, 3, 4, 5, 6, 7, 8, 9, 0 and the message windows will show EMS-I.

This is to test the beep and the LED displays. It also puts the DRO under maximum current load. As such if there is an issue with the DRO supply the DRO will most likely have an issue during this process. If this occurs please consult the Troubleshooting section for assistance.

# EM200 Models

The **EM200** DRO is available in 4-versions, each machine type specific.

- 2-axes Lathe
- 3-axes Lathe
- 2-axes Milling
- 3-axes Milling

***ems-i*** have a full range of DRO available for all machine applications from simple saws and 1-axis options through to 5-axes and full TFT LCD displays. As such whatever your requirement you will be able to find a solution with ***ems-i***.

# Trouble Shooting

Below we list some of the occasional issues that can arise and some guidelines of what to check. At no time open the DRO or encoders as this would void any warranty.

| Observed Problem | Guidelines |
|---|---|
| No Display or display flashes and goes blank | • Check there is a mains supply present and the unit is switched on<br>• Ensure the supply is within the range of the DRO (110 -230VDC)<br>• Ensure the Fuse in the DRO is intact |
| Position does not repeat or Incorrect readings | • Check encoder connections<br>• Check alignment of the scale is within specification<br>• Check brackets to ensure there is no play and screws etc. are tight.<br>• Swap axes over and see if the fault stays with that encoder on on the same axis on the DRO. I.e. identify if it is an encoder or DRO issue. |
| Last digits of display are unstable | This is generally caused by RF or electrical noise entering the system.<br>• Add the equipotential connection from the DRO to the Machine body.<br>• Ensure encoder cables are not close to drive or lighting cables that can be electrically noisy.<br>• Vibration in brackets can also be a cause, so check all mountings are tight and free from play.<br>• Connect to a different power socket, or if connected to a machine supply try connecting to a standard wall socket with an IEC lead |
| Axis is counting double/half | • Check if in (or not in) Radius or Diameter mode<br>• Check axis resolution setting (5um or 10um) |
| Counting Direction is wrong | • Change direction using Setup (See Quick Setup in this guide) |
| Missing LED segments | • Unfortunately from time to time an LED can develop a fault. Please consult ems-i for a repair or replacement. |

If you experience any problems please contact ***ems-i*** and we will be glad to work with you on resolving any issues you may have.

***ems-i*** are committed to providing first class customer service and support.

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