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Produced by : - Applications
Travellers Lane, Hatfield, Herts, AL10 8XB, UK
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Simple Circular Interpolation with QD75MH:

Introduction

This document details how to configure and execute simple Circular Interpolation using the QD75MH Position Control module and MR-J3-B Servo Amplifiers.

It is assumed that the reader is knowledgeable and competent with Servo and PLC systems and is able to understand related terminology.

Only 2 Axis Circular Interpolation with Centre Point Designation is covered in this DataSheet.

The Meaning of Interpolation Control:

When using 2-axis circular interpolation control, control is carried out so that arc paths are drawn using a motor set in two to axis directions.
This kind of control is called "interpolation control".

In interpolation control, the axis in which the control system is set is defined as the "reference axis", and the other axis is defined as the "interpolation axis".

The QD75MH controls the "reference axis" following the positioning data set in the "reference axis", and controls the "interpolation axis" corresponding to the reference axis control so that an arc path is drawn

Setting the Required Positioning Data:

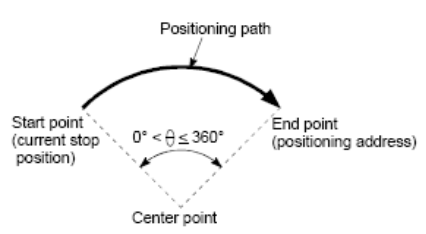
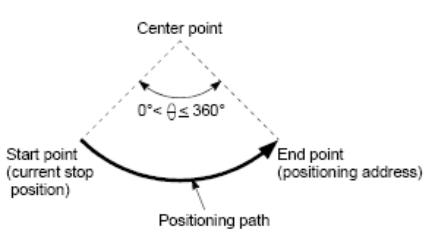
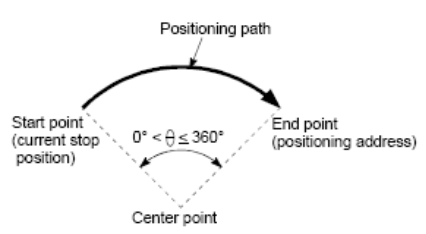
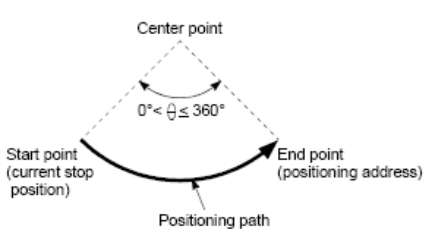
When executing Interpolation control the same positioning data table line numbers must be used for each Axis as they reference each other. For this example we will start at line 0 in both Axis 1 and Axis 2.

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2 Axis Circular Interpolation with Centre Point Designation:

There are 4 Control System Instructions for executing ARC/Circular interpolation:

Control system	Rotation direction	Arc center angle that can be controlled	Positioning path
ABS circular right	Clockwise	$0^\circ < \theta \leq 360^\circ$	
INC circular right			
ABS circular left	Counterclockwise		
INC circular left			

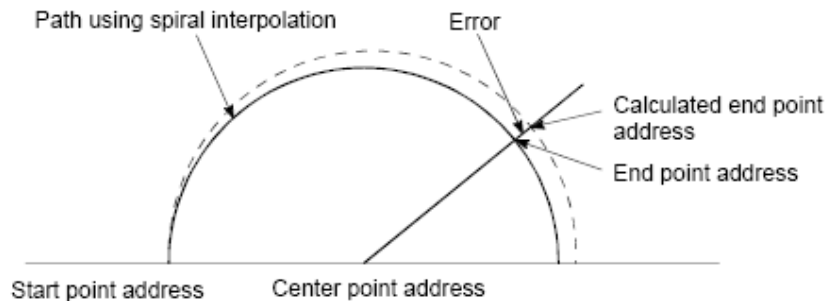
The INC instructions are Incremental Moves from the current position, the ABS Instructions are Absolute moves relating to the current home position.

Both Clockwise and Counterclockwise moves are possible.

Circular Interpolation Error Compensation:

When using Circular Interpolation the User must specify a **Position Address** (Target Address) and an Arc Address (Radius and Position of Centre Point).

This positional data **must** make an Arc when plotted on a graph within the **Allowable Circular Interpolation error Width (Pr.41)**.



If the user specified positional data does not make an Arc within the allowable error then the QD75MH card will return an error as it will not be able to plot the Arc. (**Error 506**)

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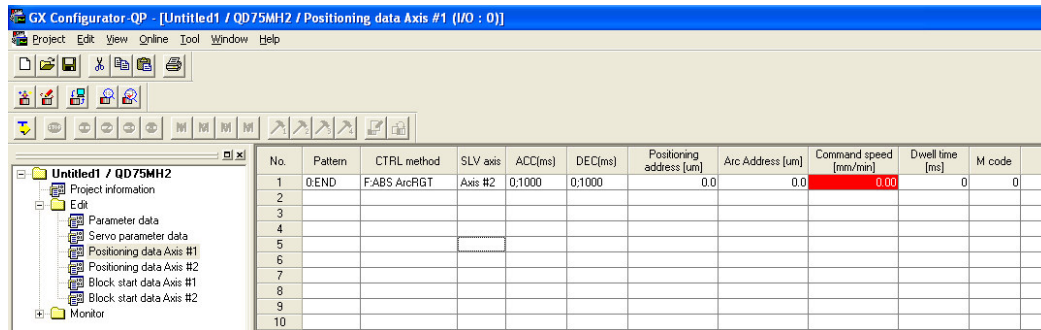
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Instructions:

2-axis circular interpolation control with center point designation (ABS circular right, ABS circular left)

When using Absolute address mode all Positioning and Arc Addresses are with reference to the established OPR or zero point.

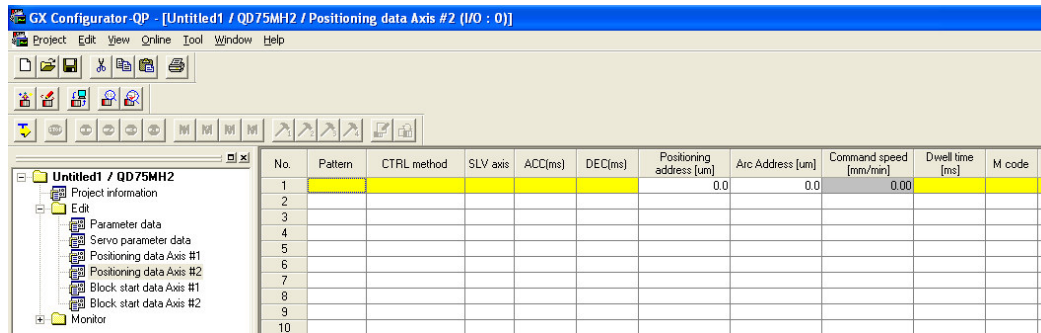
Positioning is carried out from the current servo stop position to the End Point Address:



No.	Pattern	CTRL method	SLV axis	ACC(ms)	DEC(ms)	Positioning address [um]	Arc Address [um]	Command speed [mm/min]	Dwell time [ms]	M code
1	0.END	FABS ArcRGT	Axis #2	0.1000	0.1000	0.0	0.0	0.00	0	0
2										
3										
4										
5										
6										
7										
8										
9										
10										

Here, for Axis 1, the user needs to specify a **Positioning Address**, the **Arc Address** and of course a **Command Speed**.

For Axis 2, the same table line number is used, therefore it is coloured yellow to identify that it is a reference Axis and only the variables are available to enter:



No.	Pattern	CTRL method	SLV axis	ACC(ms)	DEC(ms)	Positioning address [um]	Arc Address [um]	Command speed [mm/min]	Dwell time [ms]	M code
1						0.0	0.0	0.00		
2										
3										
4										
5										
6										
7										
8										
9										
10										

The User still needs to specify a **Positioning Address** and an **Arc Address**, but no Command speed is required as this is calculated by the QD75MH Card.

So, in summary:

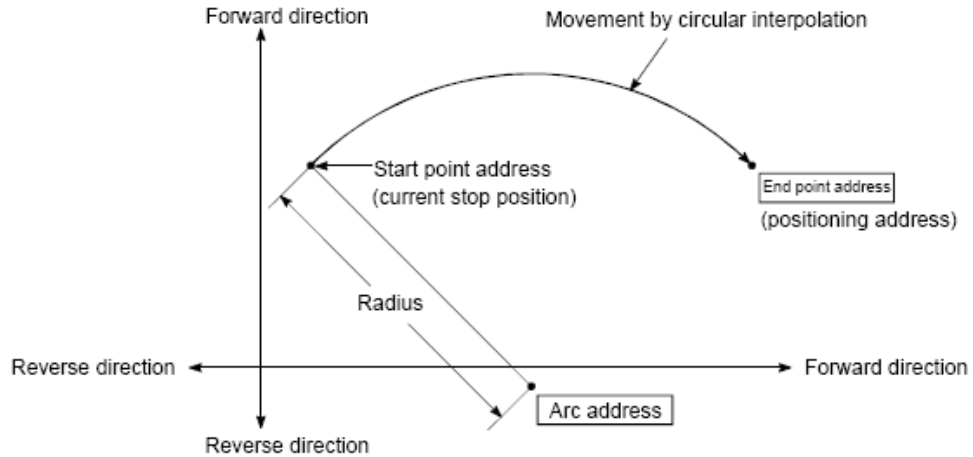
The Current position of the Servo Motors are the start position of the Arc.

The Positioning Address of Axis 1 and Axis 2 make up the Co-ordinates of the end of the Arc.

The Arc Address of Axis 1 and Axis 2 make up the Co-ordinates of the Arc Address, which of course is the point around which the Arc will be drawn, or pivot if you like. This of course by default also specify the Radius of the Arc by it's linear distance from the Start Position:

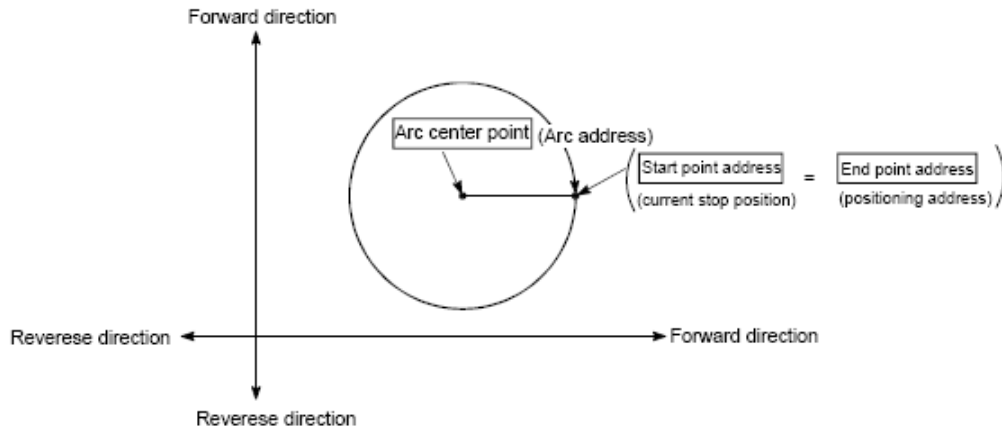
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Complete 360 Degree Circles:

Positioning of a complete round circle with a radius from the start point address to the arc center point can be carried out by setting the end point address (positioning address) to the same address as the start point address:

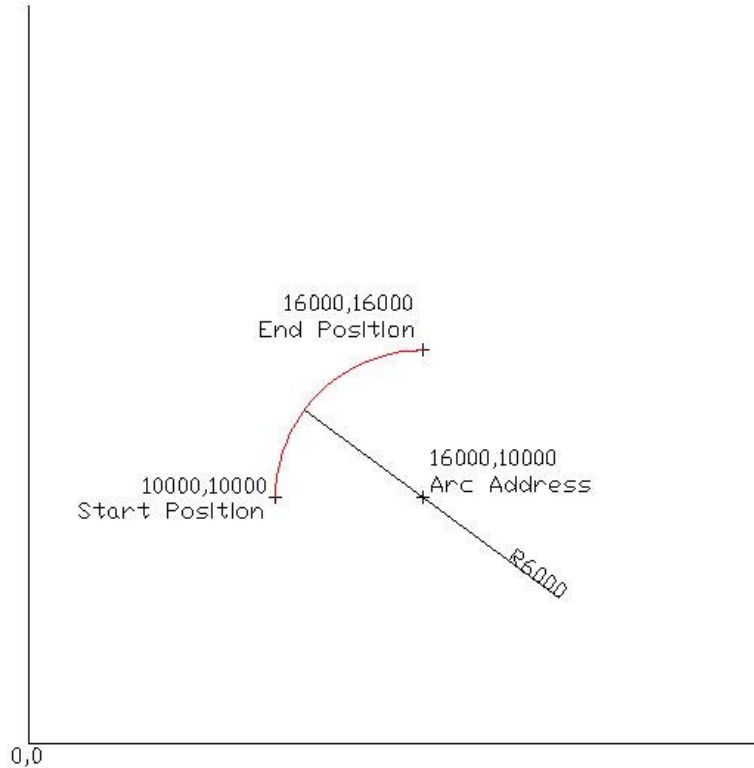


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Example:

If we wanted to draw a quarter of a circle (45 Degrees), starting at '9 O'Clock' and ending at '12 O'Clock' with a Radius of 6mm (6000 um) we would have a graphical representation as follows:



Using the Absolute Address mode, our **Start Position** is Axis 1 10,000um (10mm) and Axis 2 10,000um (10mm). (The Start Position is not specified in the Table, it is the current position of the Servo motors)

Our required **Radius** is 6000um (6mm) therefore our **Arc Address** is Axis 1 16,000um and Axis 2 10,000um

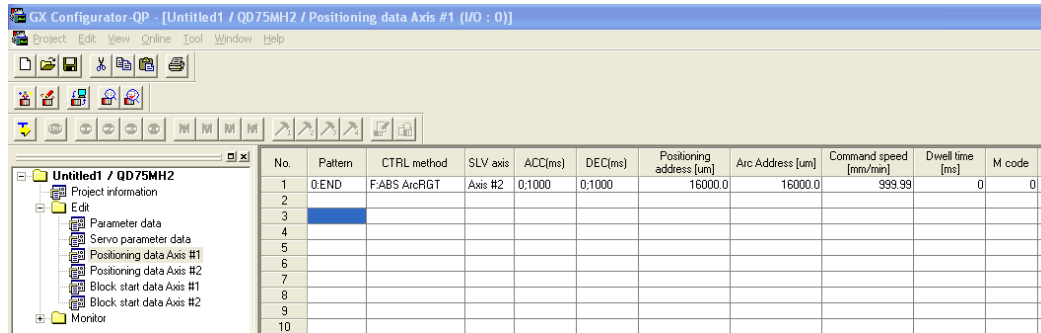
Since we are doing 45 Degrees of a circle the maths is easy as the required End Address is simply the current address plus the Radius in both Axis, therefore our intended **End Position** is +6mm in both the X (Axis 1) and Y (Axis 2) Axis, therefore Axis 1 16,000um and Axis 2 16,000um.

Entered into the Table the above move would look like:

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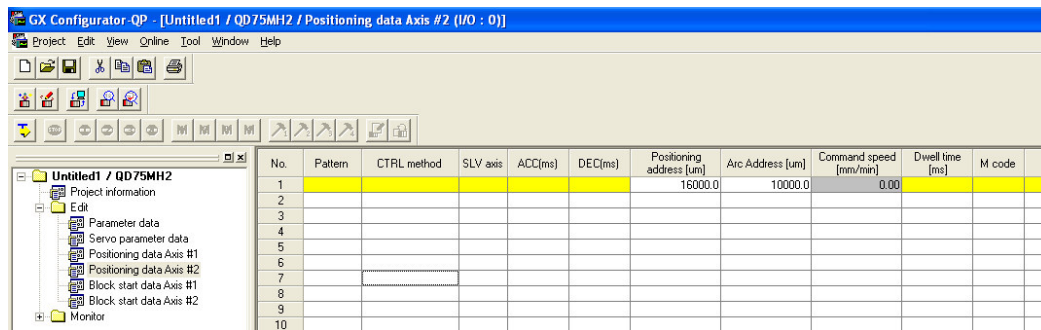
Axis 1:



No.	Pattern	CTRL method	SLV axis	ACC(ms)	DEC(ms)	Positioning address [um]	Arc Address [um]	Command speed [mm/min]	Dwell time [ms]	M code
1	0.END	F.ABS ArcRGT	Axis #2	0.1000	0.1000	16000.0	16000.0	999.99	0	0
2										
3										
4										
5										
6										
7										
8										
9										
10										

The Speed is irrelevant for this example.

Axis 2:



No.	Pattern	CTRL method	SLV axis	ACC(ms)	DEC(ms)	Positioning address [um]	Arc Address [um]	Command speed [mm/min]	Dwell time [ms]	M code
1						16000.0	10000.0	0.00		
2										
3										
4										
5										
6										
7										
8										
9										
10										

Calculating Co-ordinates:

The Difficulty arises when we require arcs which are parts of a circle, perhaps even fractions of a degree, such as 22.5 or 36.7 etc.

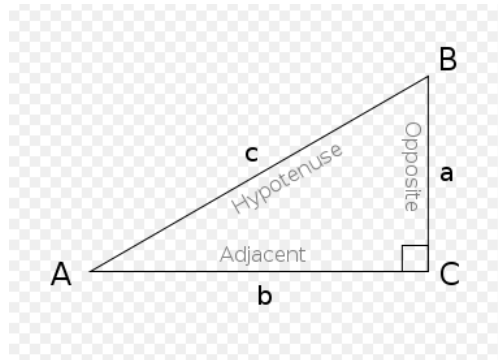
In these situations we need to derive the End Position Address and Arc Address so that we draw the ARC within the allowable tolerance.

Methods are multiple, perhaps using CAD software or other drawing methods for fixed products or moves, or measuring the Co-ordinates from the physical manifestation.

However, the most flexible method is to use Maths, Pythagoras' Theorem and Trigonometry:

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$$\text{Hypotenuse}^2 = \text{Opposite}^2 + \text{Adjacent}^2$$

- The **sine** function (sin), defined as the ratio of the side opposite the angle to the hypotenuse.

$$\sin A = \frac{\text{opposite}}{\text{hypotenuse}} = \frac{a}{c}.$$

- The **cosine** function (cos), defined as the ratio of the adjacent leg to the hypotenuse.

$$\cos A = \frac{\text{adjacent}}{\text{hypotenuse}} = \frac{b}{c}.$$

- The **tangent** function (tan), defined as the ratio of the opposite leg to the adjacent leg.

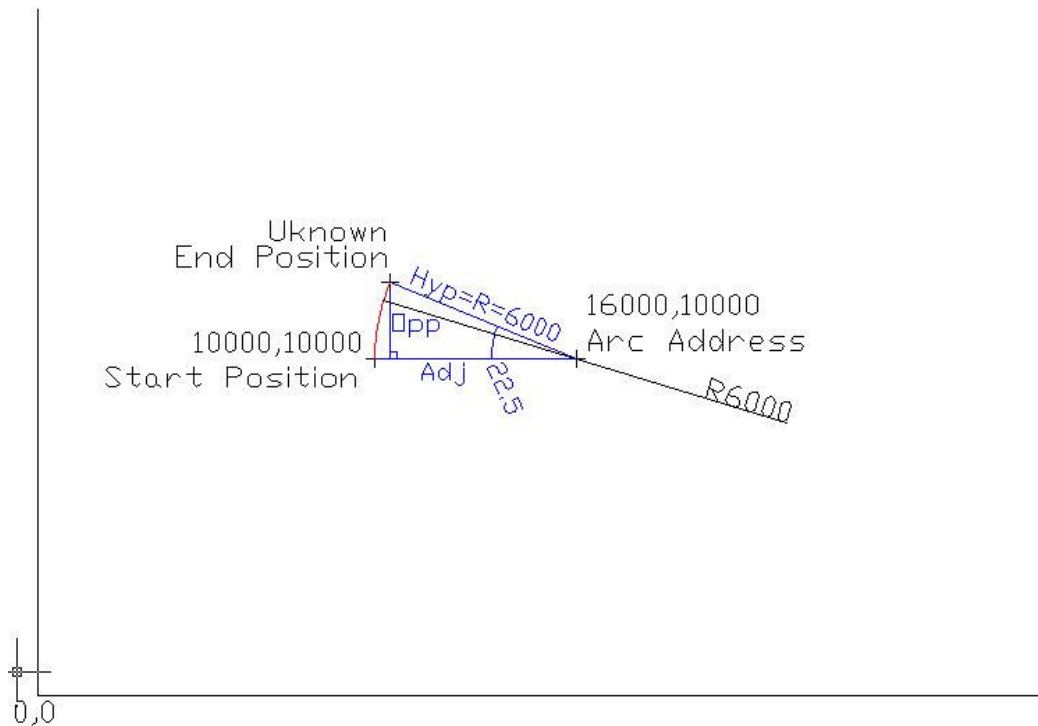
$$\tan A = \frac{\text{opposite}}{\text{adjacent}} = \frac{a}{b} = \frac{\sin A}{\cos A}.$$

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Example:

Let us imagine we are doing the same circle as before, but instead of 90 degrees, we are looking to rotate 22.5 degrees:



We have a start position (Current Motor Position)

We know the Arc Address and the Radius (6000), therefore we know the Hypotenuse.

We know the Angle, 22.5 Degrees.

We need to Calculate the Opposite and the Adjacent.

Adjacent:

Using:

$$\cos A = \frac{\text{adjacent}}{\text{hypotenuse}} = \frac{b}{c}$$

We know that the Adjacent = COS A x Hypotenuse

Therefore: **Adjacent = COS 22.5 x 6000 = 5543.2um**

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Opposite:

Using:

$$\sin A = \frac{\text{opposite}}{\text{hypotenuse}} = \frac{a}{c}.$$

We know that the Opposite = Sin A x Hypotenuse

Therefore: **Opposite = SIN 22.5 x 6000 = 2296.1um**

When we apply these figures to the Triangle in the ARC and add them to the Absolute Positions we will get the following:

Axis 1:

Current Position is **10000um.**

The Length of the Adjacent side is **5543.2um**

The Radius of the Circle is **6000um**, therefore the additional amount the X Axis will have to move is the Radius minus the calculated Adjacent side:

$$6000\text{um} - 5543.2\text{um} = 456.8\text{um}$$

Therefore the ABS Address for Axis 1 Position Address is 10000um + 456.8um = **10456.8um**

Axis 2:

Current Position is **10000um.**

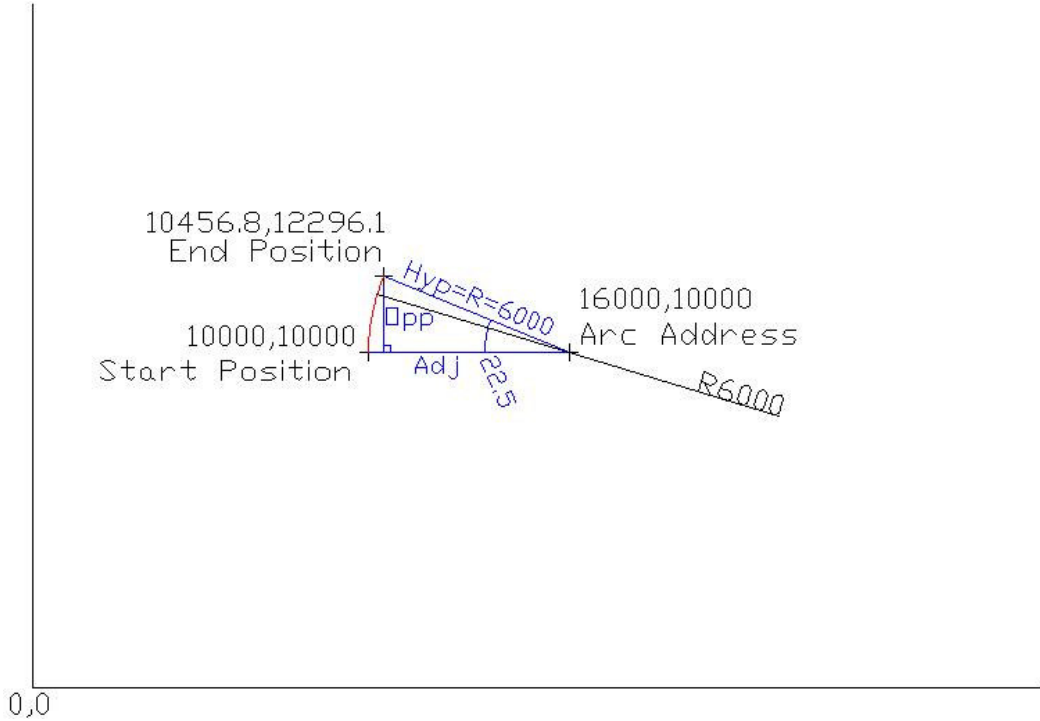
The Length of the Opposite side is **2296.1um**

So the ABS Address for Axis 2 Position Address is 10000um + 2296.1um = **12296.1um**

Now we can apply these new calculated co=ordinates to the graphical representation:

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And then into the GX Configurator QP Software:

Axis 1

GX Configurator-QP - [Untitled1 / QD75MH2 / Positioning data Axis #1 (I/O : 0)]

No.	Pattern	CTRL method	SLV axis	ACC(ms)	DEC(ms)	Positioning address [um]	Arc Address [um]	Command speed [mm/min]	Dwell time [ms]	M code
1	0.END	FABS ArcRGT	Axis #2	0,1000	0,1000	10456.8	16000.0	999.99	0	0
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										

Axis 2

GX Configurator-QP - [Untitled1 / QD75MH2 / Positioning data Axis #2 (I/O : 0)]

No.	Pattern	CTRL method	SLV axis	ACC(ms)	DEC(ms)	Positioning address [um]	Arc Address [um]	Command speed [mm/min]	Dwell time [ms]	M code
1						12296.1	10000.0	0.00		
2										
3										
4										
5										
6										
7										
8										
9										
10										

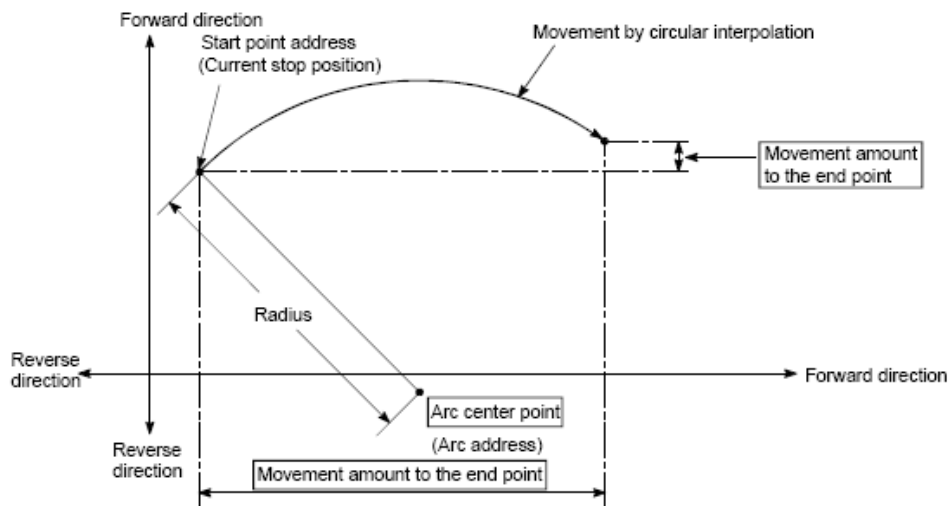
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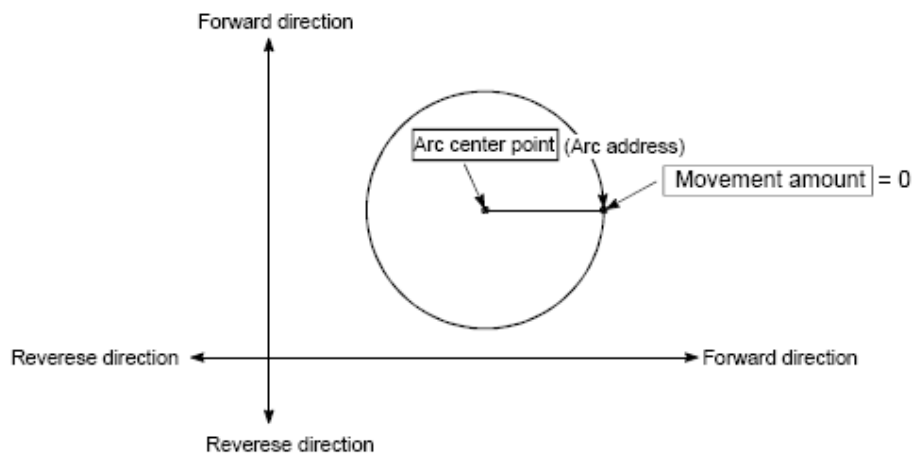
The ARC address and therefore the Radius remains the same.

2-axis circular interpolation control with center point designation (INC circular right, INC circular left)

The same circular interpolation can be carried out using the Incremental Address system. In this case, Positioning is carried out from the current stop position (start point address) to a position at the end of the movement amount set in the Positioning address/movement amount in an arc path having as its center the address (arc address) of the center point set in the Arc address.



Again, Positioning of a complete circle with a radius of the distance from the start point address to the arc center point can be carried out by setting the movement amount to "0":

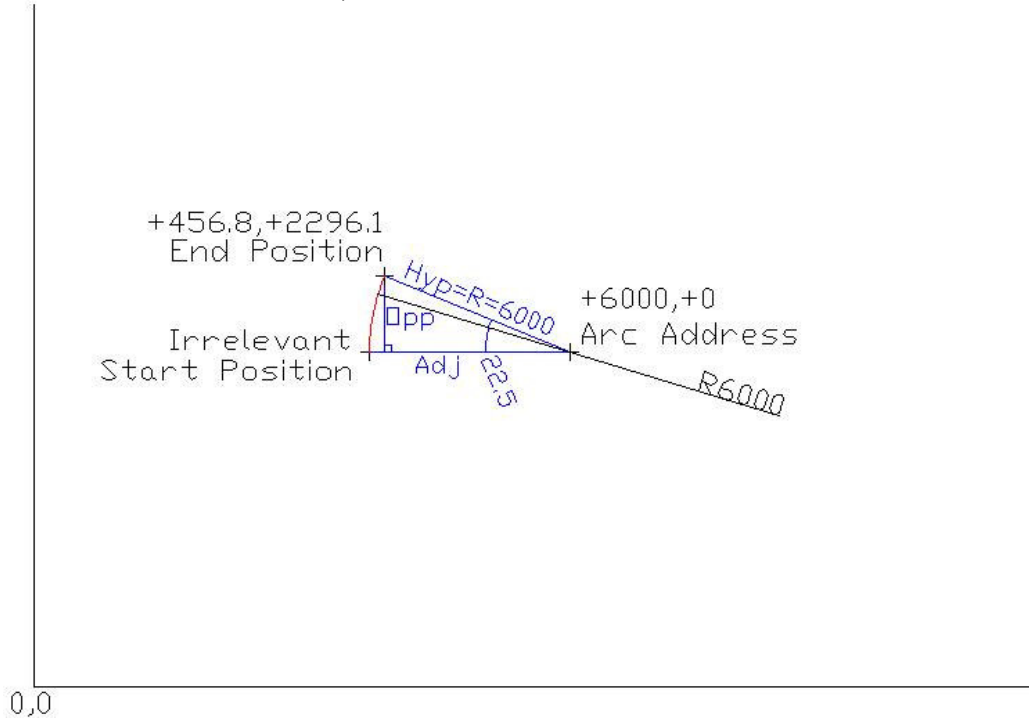


The Same Mathematics should be used to determine the Incremental Address to part Circles.

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So, for example if we consider our 22.5 degree ARC that we calculated previously and convert it to Incremental Address mode, it would look like:



Axis 1

GX Configurator-QP - [Untitled1 / QD75MH2 / Positioning data Axis #1 (I/O : 0)]

No.	Pattern	CTRL method	SLV axis	ACC(ms)	DEC(ms)	Positioning address [um]	Arc Address [um]	Command speed [mm/min]	Dwell time [ms]	M code
1	0:END	H:INC ArcRGT	Axis #2	0:1000	0:1000	456.8	6000.0	999.99	0	0
2										
3										
4										
5										
6										
7										
8										
9										
10										

Axis 2

GX Configurator-QP - [Untitled1 / QD75MH2 / Positioning data Axis #2 (I/O : 0)]

No.	Pattern	CTRL method	SLV axis	ACC(ms)	DEC(ms)	Positioning address [um]	Arc Address [um]	Command speed [mm/min]	Dwell time [ms]	M code
1						2296.1	0.0	0.00		
2										
3										
4										
5										
6										
7										
8										
9										
10										

Title:

Keywords: