USE OF PMAC’S CIRCULAR INTERPOLATION FOR ELLIPSES, SPIRALS AND HELICES:

PMAC allows circular interpolation on the X, Y, and Z axes in a coordinate system. As with linear blended moves, TA and TS control the acceleration to and from a stop, and between moves. Circular blended moves can be either feedrate-specified (F) or time-specified (TM), just as with linear moves. It is possible to change back and forth between linear and circular moves without stopping.

PMAC’s circular interpolation routines are very flexible and will allow the execution of ellipses, helices, spirals etc.

Following, are some examples that describe how to accomplish these different curves using PMAC’s circular interpolation mode.

General Setup and definitions for circular interpolation:

1) Move segmentation time  
   Typical value: I13 = 10
2) Interpolation plane definition
   NORMAL {vector} {data} …
3) End Point definition mode
   ABS
   INC
4) Center vector definition mode
   ABS ( R )
   INC ( R )
   (if vector mode definition is used)
5) Circle direction
   CIRCLE 1
   CIRCLE 2
6) Circle commands
   X{Data} Y{Data} I{Data} J{Data}
   X{Data} Y{Data} R{Data}

Example:

I13=10 ;Move Segmentation Time
NORMAL K-1 ;X-Y Plane
INC ;Incremental End Point definition
INC ( R ) ;Incremental Center Vector definition
CIRCLE 1 ;Clockwise circle
X10 Y0 I-10 J0 ;180° Arc Move command

Ellipse definition and execution:

To execute an ellipse, it is necessary to specify a plane for PMAC’s circular interpolation that is inclined with respect to the plane in which the ellipse is desired (X-Y plane in our case). This is accomplished by tilting the normal vector with the NORMAL command.
To properly define the NORMAL command to execute the desired ellipse it is important to know the relation between the two radii of the ellipse. Use the following equation to calculate the appropriate angle for the normal plane.

\[ j = \tan(\text{angle}) \]

\[ k = 1 \]

\[ z = y \]

\[ x \]

\[ y \]

\[ x \]

\[ y \]

\[ z \]

**Example:** The NORMAL I0 J1 K1, would angle the normal plane 45° about the X-axis with respect to the X-Y plane.

**Example:** if angle=60°, the projection of \( y' \) in the X-Y plane is: \( y = y' \cos(60) = \frac{1}{2} y' \)

**Example:** The NORMAL I0 J(tan(Angle)) K1 would angle the normal plane 45° about the X-axis with respect to the X-Y plane.
With this setup PMAC will execute a regular circle in the plane indicated by the definition of its normal vector by the NORMAL command. As a result, on the X-Y plane, we will have an ellipse which corresponds to the projection of the circle executed in the normal plane onto the X-Y plane.

Note that any other combination of the X, Y and Z axes and planes is allowed.

**Example 1: Ellipse execution**

```
#1->1000X ;Axis definition
#2->1000Y
#3->1000Z
I13=10 ;Move segmentation time
OPEN PROG1 CLEAR
INC ;Incremental end point definition
INC(R) ;Incremental radius vector definition
NORMAL K-1 J(-TAN(60)) ;60° for 2:1 ellipse radius ratio
CIRCLE 1 ;Clockwise circle
X1 Y1.5 Z1 ;Ellipse starting point (linear move because no center specification)
X0 Y0 I1 ;Complete circle, becomes ellipse by NORMAL definition
CLOSE
```

Important Note: The vector speed of the path along the ellipse is not constant. The more oblong the ellipse, the more the speed varies. (The speed along the projected path in the circle plane is constant).
Spiral definition and execution:

To execute a spiral, it is necessary to offset the definition of the end point by the difference of the starting radius value and the desired end radius value. The following 2 diagrams show a 360° and 180° example of this idea.

Then, using this idea, it is possible to execute multi-turn spirals by successive increments of the radius and offsets.

**Example 2: Spiral execution**

```
I13=10 ;Move segmentation time
OPEN PROG1 CLEAR
ABS ;Absolute end point definition
INC(R) ;Incremental radius vector definition
HOME 1,2
NORMAL K-1 ;X-Y plane definition
CIRCLE 1 ;clockwise circle
P1=0 ;Defines offsets and changes in radius
WHILE (P1<100) ;While radius in less than 100
X(-P1) Y0 I(P1) ;executes curves of P1 radius and P1 end-point offsets
P1=P1+1 ;Increments radius and end-point offset for next spiral
ENDWHILE
CLOSE
```
Helix definition and execution:

To execute a helix, simply add a component to the move outside of the plane containing the vector from the start point to the center. For example, with the X-Y plane defined and no K component in the center vector, a right helix can be generated simply by adding a Z-component to the move command. The Z-axis will be linearly interpolated while X and Y are circularly interpolated, producing a helix.

**Example 3: helix execution**

```
I13=10 ; Move segmentation time
OPEN PROG1 CLEAR
INC ; Incremental end point definition
INC(R) ; Incremental radius vector definition
NORMAL K-1 ; X-Y plane definition
CIRCLE 1 ; Clockwise circle
P1=1 ; Counter for the number of helices
WHILE (P1<5) ; 4 helices for this example
  X0 Y0 Z1 I1 ; Does circle in X-Y plane, helices on space (Z is included)
P1=P1+1
ENDWHILE
CLOSE
```