

## **Appendix I**

### **RS274-D format: Alphabets and their meanings.**

#### **ALPHABET ADDRESS FOR**

A	Angular dimension around X axis
B	Angular dimension around Y axis
C	Angular dimension around Z axis
D	Angular dimension around special axis/ 3rd feed function/function for tool compensation
E	Angular dimension around special axis/2nd feed function/function for tool compensation
F	feed function
G	Preparatory function
I	Interpolation parameter for thread lead parallel to X axis
J	Interpolation parameter for thread lead parallel to Y axis
K	Interpolation parameter for thread lead parallel to Z axis
M	Miscellaneous function
N	Sequence number
O	Sequence number for secondary head (for dual machines, e.g Mill-Turn machine.)
P	Third rapid traverse dimension
Q	Second rapid traverse dimension
R	First rapid traverse dimension/radius for constant surface speed calculations
S	Spindle speed
T	Tool function
U	Secondary motion dimension parallel to X axis
V	Secondary motion dimension parallel to Y axis
W	Secondary motion dimension parallel to Z axis
X	Primary X motion dimension
Y	Primary Y motion dimension
Z	Primary Z motion dimension
[EB]	This is the last character on each block, the <u>End-of-Block</u> character (usually the return, or newline character).

## Appendix II

### RS274-D: Useful Preparatory Functions

G00	Point to Point positioning	PTP positioning at rapid or assigned feedrate
G01	Linear Interpolation	Move in straight line at constant velocity
G02	Circular Interpolation, Arc CW (for 2D arcs in XY, XZ, or YZ planes)	Clockwise motion of tool with respect to workpiece, when viewing the plane of motion in -ve direction of the perpendicular axis
G03	Circular Interpolation, Arc CCW (for 2D arcs in XY, XZ, or YZ planes)	Counter-Clockwise motion of tool wrt w/p, when viewing the plane of motion in -ve direction of the perpendicular axis
G04	Dwell	a timed delay of programmed duration.
G06	Parabolic Interpolation	Programmed motion along a parabola; velocity of the axes is varied by the controller to maintain the feedrate as specified.
G08	Acceleration	Controlled velocity increase to programmed rate, starting immediately.
G09	Deceleration	Controlled velocity decrease to programmed rate.
G13-16	Axis Selection	
G17	XY plane selection	Used to identify plane for functions like circular interpolation, cutter compensation offset etc.
G18	XZ plane selection	
G19	YZ plane selection	
G33	Thread cutting, Constant lead	For machines equipped with thread cutting
G34	Thread cutting, Increasing lead	The lead increases at a constant rate (linear)
G35	Thread cutting, Decreasing lead	Decreases at constant rate (linear)
G40	Cutter compensation cancel, Offset cancel	
G41	Cutter compensation, Left	Cutter on left side of work surface, when viewing from cutter in the direction of relative cutter motion with displacement normal to the cutter path to adjust for the difference between actual and programmed cutter radii or diameters
G42	Cutter compensation, Right	As above..
G43	Cutter offset, inside corner	Displacement normal to cutter path to adjust for the difference between actual and programmed cutter radii or diameters. Cutter on inside corner.
G44	Cutter offset, outside corner	As above
G50-59	Reserved for adaptive control	
G70	programming units in inches	Will get cancelled by use of G71, M02, or M30
G71	programming units in metric	Will get cancelled by use of G70, M02, or M30
G72	3D Circular interpolation, CW	
G73	3D Circular interpolation, CCW	A mode where the cutter moves along a circular arc on the surface of a sphere. Velocities required to maintain feedrate are generated by the controller.
G74	Cancel multi-quadrant circular interpolation	
G75	Multi-quadrant circular interpolation	
G80	Cancel fixed cycle	
G81-89	Fixed cycles, Number 1, 2, .., 9	

G90	Absolute dimension inputs	Input data is in absolute coordinates
G91	Incremental dimension inputs	Input data is in form of incremental form, with respect to current position
G92	Preload registers (affects only the block in which it appears.)	
G93	Inverse Time Feedrate (V/D)	Data following the code is equal to the reciprocal of the time in minutes to execute the block; also equal to the velocity of any axis divided by the incremental move along that axis.
G94	Inches/mm per minute feedrate [Inches used if G70 was used earlier, mm if G71]	
G95	Inches/mm per spindle revolution feedrate	
G96	Constant surface speed, feet/meters per minute	
G97	Revolutions per minute (spindle speed)	

## Explanatory Notes on Circular Interpolation

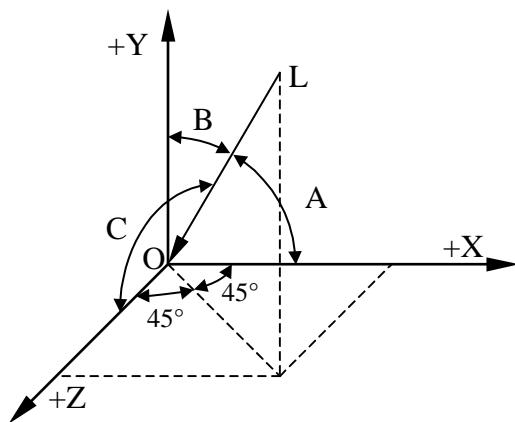
### 2D circular interpolation

1. Plane selection is done via the use of G17, G18, or G19.
2. The direction of the tool-center arc (CW or CCW) is selected by the G code (G02, G03)
3. Four dimension words are required per block. Two are used for defining the arc end point, and two for the arc center.
  - a. Linear dimensions parallel to the axes of motion for the location of the end of the arc are expressed in decimal inches (mm) preceded by the appropriate axis address letter and a + or - sign if needed. Absolute or incremental dimensions may be used.
  - b. for interchangeability, it is recommended the arcs be programmed in sufficient number of blocks such that no axis will reverse in direction during the segment. A good way to achieve this is to enforce single quadrant programming -- that is, the motion in any block must be contained within one quadrant of an axis system centered at the arc center.
  - c. When single quadrant programming is used, distance to the arc center is specified. The distance to arc center is expressed in dimensions parallel to the axes of motion. The address of interpolation parameters parallel to the X, Y Z axes is the I, J, K words respectively. These interpolation parameters shall be incremental distances from the beginning of the arc. Algebraic signs may be included if necessary.
4. If a machine can handle multiple quadrant interpolation in one block, this can be used to reduce the program size. Multi quadrant programming must be specified using a preparatory function (G75).
  - a. When using multi-quadrant programming, interpolation parameters shall be the coordinates of the arc center when using absolute dimensioning, or the signed incremental distance from the beginning point to the arc center when using incremental programming.
5. The feed function for all programmed motions in 2D circular interpolation shall be programmed in inches (mm) per min, or in inches (mm) per revolution.

### 3D circular interpolation

1. Direction of arc on surface of a sphere shall be selected by a preparatory function (G72, G73).
2. The direction of the arc, CW, or CCW is defined as it appears when viewed along a line splitting the first octant (line LO in figure below) when viewed in the negative direction of the three axes. This line has the angles =  $\cos^{-1}(1/\sqrt{3})$  with all the axes (In figure, A = B = C). When the plane of the defined circle contains this line, the control selects the shorter arc.

3. Six dimension words are needed. Three are used for defining the arc end ( $x$ ,  $y$ ,  $z$ ), and three for defining the arc center. The interpolation parameters shall be the coordinates of the arc center when absolute dimensions are used, and signed incremental distances to the arc center when incremental programming is used.



### Appendix III RS274-D: Useful Miscellaneous Functions

M00	Program stop	used in the last block of a program
M01	Optional (planned) stop	
M02	End of program	stops coolant, spindle, feedrate; resets the control/machine
M03	Spindle CW	will advance a right handed screw into workpiece.
M04	Spindle CCW	
M05	Spindle OFF	
M06	Tool change	
M07	Coolant No. 2 ON	Mist coolant
M08	Coolant No. 1 ON	Flood coolant
M09	Coolant OFF	
M10	Clamp	
M11	Unclamp	
M12	Synchronization code	
M13	Spindle CW and Coolant ON	
M14	Spindle CCW and Coolant ON	
M15	Motion +	
M16	Motion -	
M19	Oriented spindle stop	
M30	End of data	
M31	Interlock bypass	

M40-46 Gear changes, if assigned; otherwise unused.

M47    Return to program start

M48    Cancel M49

M49    Bypass override

M58    Cancel M59

M59    Bypass CSS updating

a function which holds RPM constant at its value.

M90-99 reserved for user-defined controls