Read This First

This programming manual applies to 9/PC CNC system users who use the part program graphic verification feature (release 3.01 or greater).

About Tool Path Graphics

The 9/PC CNC Tool Path Graphics application is designed to provide you with a pictorial means of plotting the path of your part program. Currently, this feature only operates while your axes are moving. Refer to the following sections for details about this utility.
Important User Information

Because of the variety of uses for the products described in this publication, those responsible for the application and use of this control equipment must satisfy themselves that all necessary steps have been taken to assure that each application and use meets all performance and safety requirements, including any applicable laws, regulations, codes and standards.

The illustrations, charts, sample programs and layout examples shown in this guide are intended solely for purposes of example. Since there are many variables and requirements associated with any particular installation, Allen-Bradley does not assume responsibility or liability (to include intellectual property liability) for actual use based upon the examples shown in this publication.

Allen-Bradley publication SGI-1.1, Safety Guidelines for the Application, Installation and Maintenance of Solid-State Control (available from your local Allen-Bradley office), describes some important differences between solid-state equipment and electromechanical devices that should be taken into consideration when applying products such as those described in this publication.

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Throughout this manual we use notes to make you aware of safety considerations:

| ATTENTION | Identifies information about practices or circumstances that can lead to personal injury or death, property damage or economic loss |

Attention statements help you to:

- identify a hazard
- avoid a hazard
- recognize the consequences

| IMPORTANT | Identifies information that is critical for successful application and understanding of the product. |

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Commonly Used Terms and Conventions

Below is a brief description of terms and conventions that may appear in this manual:

**9/PC** – A CNC PCI card that provides a full-featured open 9/ Series motion control solution.

**Abscissa** – Coordinate representing the distance of a point from the Y axis in a plane Cartesian coordinate system, measured along a line parallel to the X axis.

**Axis Origin** – The beginning point of any particular axis.

**BDS** – Basic Display Set. This software provides the user interface between your PC and CNC by emulating 9/ Series standard screens. The software allows you to control, program, position, and monitor your 9/PC.

**Cartesian Coordinate System** – A Two- or three-dimensional coordinate system in which the coordinates of a point are its distance from two intersecting, often perpendicular straight lines, the distance from each being measured along a straight line parallel to the other.

**CNC** – Computer numerical control

**Coordinate** – One of a set of numbers that determines the position of a point, line, curve, or plane.

**E-Stop** – Emergency stop

**Ordinate** – Coordinate representing the distance of a point from the X axis in a plane Cartesian coordinate system, measured along a line parallel to the Y axis.

**PCI** – Peripheral component interconnect. This is a means of connecting peripheral devices to your PC.

**Project** – A directory that stores configuration, interface, and motion control files for a particular control or application.

**Softkey** – A row of keys located directly below the operator panel screen on the BDS.

**X Axis** – The horizontal axis.

**Y Axis** – The vertical axis.
Additional Publications

The following Allen-Bradley® publications may be useful to you in the application of your 9/PC CNC Tool Path Graphics utility:

<table>
<thead>
<tr>
<th>Table A</th>
<th>Additional Publications</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Title</strong></td>
<td><strong>Publication Number</strong></td>
</tr>
<tr>
<td>9/PC CNC Software and Hardware Installation and Integration Manual</td>
<td>8520-RM091x-EN-P</td>
</tr>
<tr>
<td>9/PC CNC Logic Reference Manual</td>
<td>8520-RM092x-EN-P</td>
</tr>
<tr>
<td>9/PC CNC AMP Reference Manual</td>
<td>8520-RM093x-EN-P</td>
</tr>
<tr>
<td>9/PC CNC Lathe Operation and Programming Manual</td>
<td>8520-RM094x-EN-P</td>
</tr>
<tr>
<td>9/PC CNC Mill Operation and Programming Manual</td>
<td>8520-RM095x-EN-P</td>
</tr>
<tr>
<td>Offline Development System (ODS) Software User’s Manual</td>
<td>8520-UM051x-EN-P</td>
</tr>
</tbody>
</table>

Installing Tool Path Graphics

Before using Tool Path Graphics, you must install the Part Program Graphic Verification option from the Tool Path Graphics installation disk.

**IMPORTANT**

This procedure assumes you installed your 9/PC software in the default directory, C:\AB9PC.

To install Part Program Graphic Verification:

1. Make sure you close all Windows-related programs.

2. Insert the 9/PC CNC Tool Path Graphics disk in your floppy disk drive. Click the **Windows NT Start** button and select **Windows Explorer**.

3. Find the file called “machplot.exe.” This is the file that enables Tool Path Graphics.

4. Make sure the “ab9pc” directory is visible in the **Windows Explorer** window.

5. Hold down the [CTRL] key while dragging the “machplot.exe” file to copy it to the “ab9pc” directory destination.
Currently, 9/PC only permits you to run a single copy of the Tool Path Graphics utility on your PC. Attempting to launch more than one copy of this program during a 9/PC session causes the following error to appear:

![Error Message](image)

**Tool Path Graphics Part Program Verification Basics**

In this release, Tool Path Graphics is the available method of plotting tool paths. Use Tool Path Graphics to plot the actual tool path on the screen while jogging axes or while executing a part program. In the latter case, the actual tool path will also be plotted in the axis inhibit and dry run modes. This feature is optional and you do not need to use it to run a program.

Once you set the sample rate (refer to *Tool Path Graphics Software* in this manual) to determine how often the CNC retrieves the axis position, the CNC is able to provide the tool path with the points generated by the part program. These points are temporarily stored in an internal buffer and displayed on the screen for you to check the profile using visualization features such as ZOOM and DIMENSION. The size of the internal buffer is 16384 points.
Figure 1
Tool Path Graphics Display

- Process Axis Position
- Display Area
- Softkeys
- Axis Position
Activating Tool Path Graphics

To run Tool Path Graphics:

1. Press the {PRGRAM MANAGE} softkey.

2. Select {ACTIVE PRGRAM}. Use the up and down cursors to choose a part program to activate.

3. Select {T-PATH GRAPH}.

OR

1. Press the {PRGRAM CHECK} softkey.

2. Select {T PATH GRAPH}.

The graphics display appears. The graphics you select remain active until you disable graphics.

3. Press the <CYCLE START> button to run the part program.
The control continues to plot tool paths, even if the graphics screen is not visible. The actual display of tool paths is only possible on the graphics screen. When the graphics screen redisplays, any new tool motions appear on the screen.

**IMPORTANT** If the graphic screen does not display the tool path you want, you may need to alter the graphic parameters.

### Tool Path Graphic Softkeys

Refer to the following section for an explanation of the softkeys associated with Tool Path Graphics.

**Level 1**

- **CONFIG** – Opens a data entry window to set all Tool Path Graphics parameters. This window also contains revision information.
- **PLOT** – Starts and stops the plotting phase for data acquisition and visualization.
- **CHECK** – Displays the points stored in the local plotting buffer. Selecting this softkey while you are in 2-D visualization mode activates the checking phase and a second level of softkeys appear. Refer to the following section entitled, **Level 2**.
- **CLEAR SCREEN** – Clears the plotted path from the screen.
- **EXIT** – Allows you to exit the application.

**Level 2**

- **DRAW PROFILE** – Restores the original set of points stored in the internal buffer after using the {ZOOM} softkey. This option is available during the checking phase only.
- **ZOOM**
- **DIMENS**
- **CLEAR PLOT**
- **EXIT**

Up Arrow – Stops the checking phase and allows you to access the previous softkey menu. The screen remains unchanged until the user selects the next operation.
ZOOM – Enlarges the portion of the profile selected by the zoom window. This option is available in the checking phase only. The “+” and “-” on the number pad of your keyboard change the size of the window. The arrow keys on the number pad of your keyboard allow you to move around on the display.

DIMENS – Provides the points belonging to the profile. This option is only available while you are in the checking phase and in 2-D visualization mode. The arrow keys on your keyboard allow you to move around on the display.

CLEAR PLOT – Clears the visualized path from the screen, while the Cartesian axes remain.

EXIT – Allows you to exit the application.

Configuring Tool Path Graphics Parameters

Before you begin plotting your tool path, you must configure the Tool Path Graphics parameters. The parameter screen always displays the last set of parameter values configured.

1. To access the parameters screen, press the {CONFIG} softkey.

A similar window appears.

2. Set your parameters by either using your left mouse button, by pressing [ALT] + the underlined character, or keying in the necessary information.
Once you set the Tool Path Graphics parameters for your particular solution, select [OK] or [ENTER] to save your changes and to exit this window. The system notifies you of any parameters that are set incorrectly. To exit this window without saving your changes, select [CANCEL] or [ESC]. The previously saved parameters remain valid.

The following sections provide details about Tool Path Graphics parameters.

Sample Rate

The CNC uses this parameter to update the axis position data for Tool Path Graphics. The sample rate (measured in fine scan time increments) ranges from 2 to 65,535 ms.

If the rate you use is not an exact multiple of the fine scan time, the utility automatically rounds up or down to the nearest incremental multiple of the sample frequency.

For a more detailed image, we recommend using a relatively low sample rate. The lower the sample rate, the greater the number of points the system retrieves. The system saves the last 16384 points. In the event that your plot exceeds this limit, the latest points override the older points.

Process 1/Process 2

This indicates the number of the visualized process. This parameter is always set to “Process 1” unless you operate a dual-process system.

Inch/Metric

These buttons allow you to select the units used by the Tool Path Graphics configuration parameters.

Horizontal axis name

This is the name of the axis that represents the abscissa.

Vertical axis name

This is the name of the axis that represents the ordinate.
Third axis name

This is the name of the third axis, normally represented by the Z axis, used in 3D programmed path visualization mode.

Visualization type

This parameter configures the plot type and the axis that displays on the screen, as a result. The following bulleted list describes the three plot types.

- **2D (2D programmed path visualization)** – This displays the programmed position for horizontal and vertical axes. In this mode, rapid moves appear in red and cutting motion in green.
- **2D + FE (2D programmed and actual path visualization)** – This plots two types of information: the Programmed Position, which is the programmed path, and the Programmed Position Plus Following Error, which is the actual plot (displayed in white).
- **3D (3D programmed path visualization)** – This type of visualization displays the programmed position for the horizontal, vertical, and third axes. In this mode, rapid moves appear in red and cutting motion in green. The {DIMENS} softkey is not available in this mode.

**EXAMPLE**

The Programmed Position shows the desired path, while the Programmed Position Plus Following Error depicts the actual path. For example, when programming a 90-degree corner, the Programmed Position shows the 90-degree change in direction. On the other hand, the Following Error plot shows the rounding of the corner, resulting from the following error that actually occurs on the machine.

- **2D axes orientation**

This defines the orientation of the visualized axes. Figure 2 for a graphical depiction of the axis directions.
Figure 2
2-D Axes Orientation

3D Horizontal Plane Rotation (alpha) Angle

This angle rotates the 3-dimensional coordinate system around the configured third axis. The allowed value ranges from -359.99999 to +359.99999. Make sure you select 3D as your visualization type to set this parameter.

IMPORTANT
Before setting the minimum and maximum axis limits, you must decide whether you want to view the entire profile or only a portion of it. If you choose to view the entire profile, make sure your limits include the minimum and maximum points reached by the machining process.
3D Vertical Plane Rotation (beta) Angle

This angle rotates the 3-dimensional coordinate system around the configured horizontal axis. The allowed value ranges from -359.99999 to +359.99999. Make sure you select 3D as your visualization type to set this parameter.

**Figure 3**
3-D Horizontal Plane Rotation Angle

Consider the "right-hand rule" to determine the rotation direction of the axis. If you wrap your right hand around the third axis with your thumb pointing in the positive direction along the axis, a positive rotation around this axis is the same direction in which your fingers are pointing. See Figure 3 for a visual example.
In Tool Path Graphics, the coordinate system is a box, but it is a transparent box. With no rotation, only movement in the Horizontal and 3rd axis will be seen. Once the coordinate system is rotated, movement along the Vertical axis will also be seen.

Figure 4 shows a plot with both Alpha and Beta angles equal to 45 degrees. Notice the diamond in the center of the plot.

**Example**

Imagine holding a box in front of you at eye level. Initially, the only visible side is the front. If you rotate the box counterclockwise, the left side is now visible. Now consider a rotating Alpha angle. This illustration has the same effect as if you changed the Alpha angle from 0 degrees to a positive value of 45 degrees. With the box at eye level, you are now able to see both the front and left sides. Rotating the box again to bring the front, top edge closer to you gives you the perspective of a positive Beta angle. Now, in addition to the front and left sides, the top of the box can be seen. See Figure 3 for details.
Selecting a Part Program

To use the Tool Path Graphics feature, you may want to have a part program running. If you did not select a program to execute, select one now, following these steps:

1. Press the {PRGRAM CHECK} softkey.

2. Select a program. Press {SELECT PRGRAM}. Use the up and down cursors to select a program.

Press {ACTIVE PRGRAM} to return to level 2 and activate the program.
Disabling Graphics

In the event that it is more convenient to operate without the Tool Path Graphics utility, you have the option to operate your 9/PC without it.

To disable graphics:

1. Press the **PRGRAM MANAGE** softkey on level 1.

2. Select the **ACTIVE PRGRAM** softkey on level 2.

3. Press the **T PATH DISABL** softkey:

Clearing The Graphics Screen

You can clear the screen if it becomes too cluttered because of many different tool paths. Clear the currently drawn tool paths by pressing the **CLEAR PLOT** softkey. Any tool paths on the screen are erased and the plot continues from the current tool location without stopping.
Tool Path Graphics Advanced Features

Once you finish setting up your graphics parameters, you should be ready to use the Tool Path Graphics utility. Be certain to review the following sections before you begin part program verification.

The Plotting Phase

Tool Path Graphics plots all position changes. If you choose to plot using an active program, select the part program that you want to monitor (Refer to Selecting a Part Program on page 15) and set the parameters as needed. During the plotting phase, the {PLOT} softkey displays in reverse video mode and only the {CLEAR PLOT} and {EXIT} options are available. To plot your profile:

1. Press the {PLOT} softkey to plot the desired profile.

2. Push <CYCLE START> to begin part program execution. The graphic appears in the display area. The data and tool path that appear in the window change as the cycle proceeds.

Figure 6
Using the Plot Softkey (3-D Visualization Type)
3. Press the {PLOT} softkey again at any time to stop plotting.

**ATTENTION**

Any blocks processed while Tool Path Graphics is inactive will not appear once you reactivate the utility using the {PLOT} softkey. Reactivating the utility in this manner also clears the last plot from the graphic display in order to plot your desired profile.

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**The Checking Phase**

Once you plot the cycle or portion of the profile you wish to monitor, press the {CHECK} softkey to initialize checking mode. The plot displays the last processed points (up to 16384) stored in the local buffer. If there are no points stored in the buffer, this error appears:

![Error Message]

Depending on the visualization type that you choose to operate with (2D or 3D), different softkeys are available to you. See Table 0.B for information about what softkeys are available with the different visualization types.

**Table G**

**Softkeys Available During the Checking Phase**

<table>
<thead>
<tr>
<th>Visualization Type</th>
<th>Softkeys</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(RE-DRAW PROFILE)</td>
</tr>
<tr>
<td>2D</td>
<td>●</td>
</tr>
<tr>
<td>2D + FE</td>
<td>●</td>
</tr>
<tr>
<td>3D</td>
<td>●</td>
</tr>
</tbody>
</table>

To stop this mode, press the softkey with the up arrow and the main menu softkey appears. The display area remains the same until you press the next softkey.

**Zooming Graphics**

You can take a closer look at a specified area of tool motion on the graphic display. This is helpful when you want a better view of the actual tool paths in that area or if the part being...
machined is too small to be easily seen on the current graphic display. After selecting \{CHECK\} softkey, press the \{ZOOM\} softkey to display a close-up of your plot. To return to the original coordinates, select the \{DRAW PROFILE\} softkey or continue plotting.

**Figure 8**
**Before and After Zoom**

To use the zoom window feature:

1. Select the \{CHECK\} softkey to enable the zoom feature.

2. Press the \{ZOOM\} softkey to change the display to the zoom display.

3. Use the cursor keys on your keyboard to move the center of the window around the screen.

**TIP**

After selecting the \{ZOOM\} softkey, the enclosed area becomes the center of the screen. You must move the window to the location that you want to zoom in on to make sure that it appears on your next screen. It is helpful to run the program first so that you can see the tool path. This helps you position the tool path within the window.
Figure 9
Selecting the Area to Zoom

To change the size of the window, use [+ or -] on your keyboard.

**IMPORTANT** The graphic display window cannot be moved. The cursor keys are dedicated to the zoom window only.

<table>
<thead>
<tr>
<th>Each time you press:</th>
<th>the zoom window:</th>
</tr>
</thead>
<tbody>
<tr>
<td>[+]</td>
<td>increases in size</td>
</tr>
<tr>
<td>[-]</td>
<td>decreases in size</td>
</tr>
</tbody>
</table>
If you configure Tool Path Graphics to use a 2-dimensional visualization mode with programmed and actual tool paths, the programmed path appears in yellow (G01) or red (G00), while the actual path appears in white (or in the case of manual motion, green). However, if the two profiles are difficult to view because they overlap, using {ZOOM} adds clarification to the visualized paths.

**Dimension**

The visualized profile can be used for capturing the coordinates of its points. Greater accuracy can be obtained if points are captured after the profile has been enlarged with the {ZOOM} option.

After pressing the {DIMENS} softkey, a cross cursor appears and the axes position window displays the position coordinates in the upper right corner of the screen.

**Figure 11**

**Using the {DIMENS} Softkey**

To move the cross to any point on the profile use the arrow keys. The cross moves by step and using the [+] and [-] keys it is possible to increase or decrease the step: with [+] the step is incremented and the cross moves faster but with less resolution; with [-], the step is decremented with the opposite effect.
Notes: