GIBBSCAM® 14

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Advanced CS

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Introduction

The Advanced CS option provides additional functionality for the Mill Module. The Advanced CS option allows users to work with multiple coordinate systems in order to create and machine geometry in more "advanced" ways than the Mill or Polar & Cylindrical Milling options provide.

A Coordinate System is a plane in space with an origin and three axes. For detailed definitions and examples, see " Coordinate Systems" on page 8.

This guide includes step-by-step instruction on how Advanced CS incorporates multiple coordinate systems into the Production Mill Module. The Production Mill Module contains 2 and 2 1/2 axis capabilities, but does not include support for Advanced CS or SolidSurfacer. Strategies and suggestions for creating part geometry in 3D space using multiple coordinate systems are also provided.

Overview of Features

What does Advanced CS offer compared to the Mill or Polar & Cylindrical Milling modules? The Mill module features 4th axis positioning around 0 (A-axis or B axis rotations). The Polar & Cylindrical Milling module allows 4th axis rotary machining, machine while rotating a rotary axis. Advanced CS offers the ability to work with 3D CAD workplanes (coordinate systems), machine multi-sided parts with rotary axes, and do 4th-axis and 5th-axis positioning.

The additional functionality of Advanced CS can be used in several different ways to maximize the programming capabilities of the system, including:

- Multiple coordinate systems for 3D geometry creation

- 4th-axis and 5th-axis rotary positioning

- Tombstone machining

- Use of work fixture offsets to machine multiple parts and/or multiple sides in a single program

- Bottle Molds

- Mill/Turn and MTM to include C-, Y-, and B-axis positioning

- Z plane machining, G18, G19

These functions provide many additional capabilities to the system including acting as the foundation for using the solid modeling and full 3-axis surfacing. It is essential that the user understands the concepts presented in this guide before proceeding to other guides, such as the *SolidSurfacer* guide, which outlines solid modeling and full 3-axis machining.

How To Use This Guide

Before using the Advanced CS module you should be familiar with the basic GibbsCAM Mill module. If you have not read at least the *Geometry Creation* and *Mill* guides, please do so before continuing with this product. This guide will only briefly refer to items that are detailed in other guides. It assumes proficiency with the basic geometry creation and machining techniques of the system.

Rotary Positioning

Customers who will be using the Advanced CS option to produce fourth and fifth axis positioning moves on their rotary machines will need to use an Advanced CS Post Processor to generate the necessary A and B moves. These users are encouraged to review this entire guide.

Machining with Coordinate Systems

The Advanced CS option can be a very powerful addition to the Milling module for uses on a 3-axis machine. The ability to create and work with multiple coordinate systems allows users to define part geometry in non-XY planes and provide for accurate posted output. Some examples that are provided are for bottle molds and Z plane machining. Multiple coordinate systems can also be used to utilize work fixture offsets to machine multiple parts and/or multiple sides of parts in a single program. An Advanced CS Post Processor is required to produce posted output that utilizes work fixture offset (WFO). Users who wish to use the Advanced CS option for use with a 3-axis machine need to review only the first three chapters of this guide.

Solids

The Advanced CS option is a necessary component for the full 3D capabilities available with the SolidSurfacer option, including solid modeling and full 3-axis machining of solids and complex surfaces. Users who have purchased the Advanced CS option as a part of the 3D Milling package and do not intend to use it for the rotary positioning, only need to review the first two chapters of this guide, primarily the Multiple Coordinate Systems Chapter. This chapter outlines how the system handles the creation, modification and utilization of multiple coordinate systems, which is essential to creating complex solid and surface model parts.

⌎ Coordinate Systems

The Advanced CS option adds the ability to create and work with multiple planes or coordinate systems. This chapter provides an introduction to working in 3D space, including creating and modifying different coordinate systems and creating geometry based on these different coordinate systems. Geometry can be created in any primary plane (XY, XZ and YZ) as well as any other planar orientation. The foundation for using the solid modeling, full 3-axis surfacing and the rotary positioning capabilities of the system is contained in this chapter. It is essential that the user understands these concepts before proceeding to the subsequent chapters of this guide or the *SolidSurfacer*, which outlines solid modeling and full 3-axis machining.

> ⓘ The terms coordinate system, plane, and CS are used interchangeably.

What is a Coordinate System?

• A Coordinate System is a plane in space with an origin and three axes.

The origin is the point at which the axes intersect and serves as a zero reference point. The three axes are the horizontal, vertical and depth axes. In the standard XY Plane, the X axis is the horizontal axis, the Y axis is the vertical axis and the Z axis is the depth axis.

• A Coordinate System is NOT a Workgroup.

Coordinate systems are completely independent of workgroups. Multiple coordinate systems can be used in one workgroup and the same coordinate system can be used in multiple workgroups. Often times it is helpful to have one coordinate system per workgroup, however that is only a convenience, not a rule.

• A coordinate system is an attribute of geometry elements (points, lines, circles, and so forth).

Geometry is not contained in a coordinate system the way it is contained in a workgroup. When geometry is created, dimensional information must be entered to indicate where the geometry should be located. There must be a referencing system that makes the dimensional data meaningful. This is the role of a coordinate system in the creation of geometry.

> ⓘ When using the Production Mill module, all geometry is created based on the coordinate system defined as the XY Plane, which is CS1.

CS1: The XY Plane

The XY plane is the standard default plane. It is always CS1 and cannot be modified. The XY plane has X as the horizontal axis, Y as the vertical axis and Z as the depth axis. The origin for this plane is located at X0, Y0, Z0 which is based on the values entered for the stock size in the Document

Control dialog. While working in CS1, the buttons in the CS palette, which allow the user to modify coordinate systems, are grayed out because CS1 cannot be modified. In order for the buttons in the CS palette to become active, a new coordinate system must be created.

The CS palette is inactive (grayed-out) when the XY plane is the current CS

Multiple Coordinate Systems

Typically, a user will need more than one coordinate system. Multiple coordinate systems are used for:

- 3D geometry creation

- Rotary part orientation for machining

- Multiple work fixture offsets

- Slicing planes

- Body and sheet creation with solid and surface modeling tools

- View saving

HVD vs. XYZ

These letters are reference labels for the axes of a coordinate system. Every coordinate system must have a horizontal, vertical and depth axis, which is what H, V, and D stand for respectively. X, Y and Z are the labels used for the horizontal, vertical and depth axes of the standard XY plane. The labels X, Y and Z will be used as the axis labels if any or all of the axes align with the standard XY plane. The labels used in the dialog may vary when the current coordinate system aligns with one of the primary planes. The labels X, Y and Z will be used instead of H, V and D. These text boxes may be labeled X, Y or Z if the current coordinate system aligns with one of the primary planes. Dialog boxes use the appropriate letters. Regardless, the values always appear in the same order in the dialog boxes, horizontal, vertical and then depth.

Creating Coordinate Systems

New coordinate systems are created in one of three basic ways —by using the CS Dropdown, the CS list dialog, or the CS list context menu.
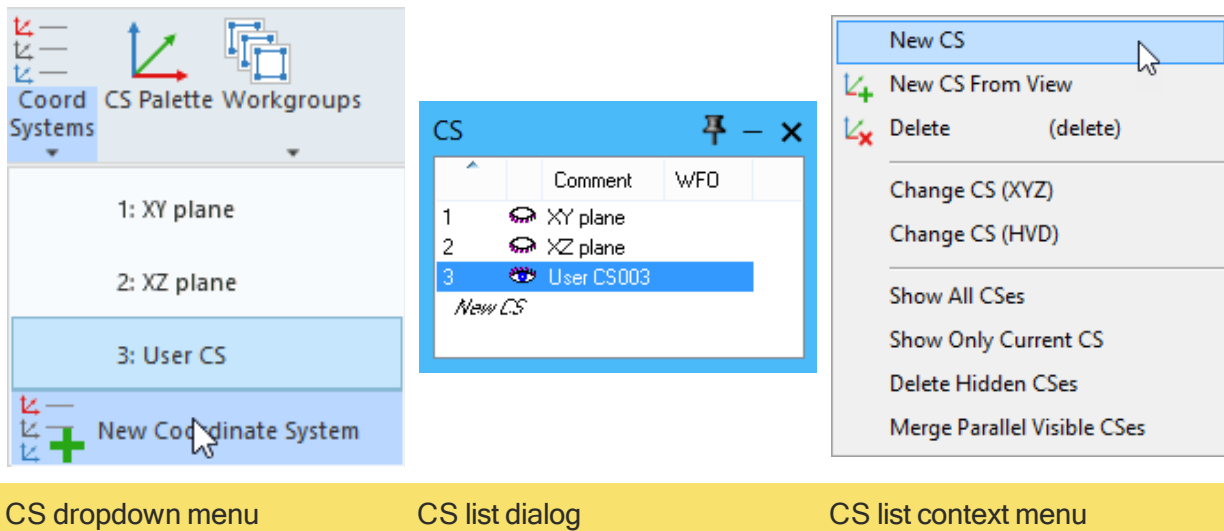
| CS dropdown menu | CS list dialog | CS list context menu |

The CS list is accessed from the Coordinate Systems button in the Command Toolbar menu. Clicking the dropdown arrow button will open the CS dropdown menu. The CS list dialog (discussed in detail in " Coordinate System List" on page 22) allows users to create and delete coordinate systems. New coordinate systems are created by choosing New Coordinate System. The CS list also indicates the current coordinate system by highlighting it in the CS list.

When a new coordinate system is created, it will be a duplicate of the current coordinate system. For example, if CS1 (which is the XY plane) is the current coordinate system when the New Coordinate System item is clicked, the system will create another CS which is an exact duplicate of the XY plane. The new CS will have the same origin, orientation, etc. Once a new coordinate system is created, the buttons in the CS palette become active so the new coordinate system can be modified.

Steps For Creating and Modifying Coordinate Systems

1. Create a new coordinate system by clicking on the New Coordinate System item in the CS list (For details, see " Coordinate System List" on page 22.) Label the CS with an identifying name.

2. Modify the new CS to the proper planar orientation. (For details, see " Align CS" on page 29.)

   Coordinate systems can be oriented by selecting defining planar geometry or by using the Align CS dialog. The Align CS dialog allows the user to rotate a CS around any axis by a specified angle or enter the coordinates for three points to define the plane.

   Coordinate systems can also be defined from several combinations of geometry including 3 points, 2 lines, a line and a point, an arc or a planar curve. A normal vector (perpendicular) can also be used to define the orientation of a CS. Normal defining geometry includes: 1 line, 2 points, and a point and an arc (or spline).

3. Check the depth axis polarity. (For details, see " Toggle Depth" on page 33.)

> (i) It is important to correctly orient the depth axis of coordinate systems. The tool always approaches the part along the positive depth axis of the machining coordinate system. Also, when using the solid and surface modeling tools, several functions are performed along the depth axis.

The depth axis of a coordinate system is indicated by the positive or negative sign on the axis markers. If there is a positive sign, the positive direction of the depth axis is projecting out from the screen in the current view. If a negative sign, the negative direction of the depth axis is projecting out from the screen in the current view. The Toggle Depth button in the CS palette is used to invert the polarity (positive/negative) of the depth axis. The Home view always displays the part from a view normal (perpendicular) to the current coordinate system where the positive depth axis is projecting straight out from the screen.

4. Align the horizontal and vertical axes. (For details, see " Align Horizontal (H) Axis" on page 26 and "Align Vertical (V) Axis" on page 27.)

> (i) Holding down the Ctrl or Alt key while using the Align Horizontal Axis or Align Vertical Axis buttons will adjust the axial alignment and adjust the depth orientation of the plane.

There are a few different ways to do this. The Align CS Plane button will rotate the horizontal and vertical axes in 90° increments while the plane geometry is selected on the screen. Another method is to use the Align Vertical Axis or Align Horizontal Axis buttons. These buttons align either the horizontal or vertical axes with a selected line. Normally, the selected line is projected to the current CS and the axis is aligned with the projected line. This will not change the actual orientation of the plane. It only affects the axial alignment. The selected line will become the horizontal or vertical axis of the plane.

5. Change the origin for the new plane. (For details, see " Change CS Origin" on page 25.)

> (i) When creating a new plane, its origin should be the point from which the most dimensions are referenced.

The origin can be changed by entering the coordinates for the new origin in the Change CS Origin dialog or by selecting the point to be the new origin and clicking on the Change CS Origin button in the CS palette. Changing the origin for a plane does not affect the overall part origin, which is set in the Document Control dialog.

Minimum Plane Rotation

When modifying coordinate systems, the system will rotate the current coordinate system the minimum amount required according to the Right Hand Rule to set the correct orientation for the new coordinate system. It is important to understand how the system establishes new coordinate systems from the information provided by the user.

The Right Hand Rule

The system uses the Right Hand Rule to define the coordinate systems. To make your hand appear like the picture to the right, open a part drawn in the XY plane and place your right hand near the monitor with the front of your hand facing you. Extend your thumb in the direction of the positive X axis and point your index finger towards the positive direction of the Y axis. Bend your middle finger so the tip is pointing at you and fold the other fingers down so they are flat against your palm. Your middle finger represents the positive direction of the Z axis.

When working in coordinate systems other than the standard XY plane, the thumb represents the horizontal axis, the index finger represents the vertical axis and the middle finger represents the depth axis. No matter how you rotate your hand around in 3D space, the positive directions of each of the axes are still in the same relative orientation to each other. The positive direction of the depth axis cannot be inverted without breaking your finger or inverting one of the other axes.
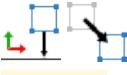
The Right Hand Rule is also used to determine the direction of rotation around an axis. Extend your thumb so it represents the positive direction of an axis. The motion caused by closing the rest of your fingers around this axis represents the counterclockwise rotation direction for that axis. This can be helpful when working with the Rotary Setup options in the Document Control dialog.

Quick Overview

- A quick version of the process for creating and modifying coordinate systems is detailed below. The order of operations is not required. After a new CS is made, the steps detailed below may be followed in any order or skipped if not needed. This is simply a recommended process.

  a. Create a new coordinate system by selecting the New CS command in the CS list or the CS list dropdown in the Command Toolbar. See "CS List Pop-Up Menu" on page 22 and " Coordinate System List" on page 22.

  b. Label the new CS with an identifying name. See " Coordinate System List" on page 22.

c.   Modify the new CS to the proper planar orientation using the Align CS dialog or by selecting the necessary geometry. See " Align CS" on page 29.

d. Check the depth axis polarity. Reverse the positive or negative direction of the depth axis as necessary by clicking on the Toggle Depth button. See " Toggle Depth" on page 33.

e.   Align the horizontal and vertical axes by selecting geometry or by using the Align H Axis or Align V Axis dialogs. See " Align Horizontal (H) Axis" on page 26 and "Align Vertical (V) Axis" on page 27.

f.   Change the origin for the new CS by selecting a point or using the Change CS Origin dialog. See " Change CS Origin" on page 25.

- Use the Home view and the trackball part model (box with a "T") for visualization of how the current CS is oriented in reference to the overall part. See "Menu Items" on page 21.

- The CS Grid and Axis Markers should always be displayed on the screen. The CS Grid is turned on by depressing the Show CS button in the Floating toolbar located at the top of the workspace. See "View Control Palette" on page 18.

- Keep the CS list and the WG list open on the screen during part creation. See " Coordinate System List" on page 22.

- Carefully label all coordinate systems and workgroups with identifying names. See " Coordinate System List" on page 22.

-      Create geometry at D=0 in planes and use the Modify > Force Depth/Radius or Translate, to place geometry at the correct depth location in the coordinate system. See the Common Reference manual for detailed information on these and all items accessed from the menu bar.

Part Setup

Advanced CS parts can be 3-axis, 4-axis, or 5-axis parts on a horizontal or vertical milling machine. As with all GibbsCAM options, the Document Control dialog is used to set up a part.

Document Control Dialog

You should already be familiar with the Document Control dialog and setting part units, material type and stock size. You may also be familiar with selecting the type of machine to use (turning machines, 3-axis or 4-axis mills, etc.) from the Machine pull-down menu. Instead of selecting a 3-axis mill MDD (or a 4-axis mill MDD for simple positioning and rotary milling), you will likely select a 4-axis or 5-axis mill MDD.

When a 4-axis or 5-axis MDD is selected, there is an additional tab in the Document Control dialog. The Machine Setup tab allows you to specify the machine's points of rotation. The Rotary Setup information is very important in order to generate the correct code to cut the part. However, the Rotary Setup information does not affect the actual programming of the part.

Among the 5-axis milling MDDs there are two MDDs that output reversed rotary limits. One is horizontal, and one is vertical. Some users may receive a warning about machine limits when posting a 5-axis mill part. If you experience this warning you may use one of the reversed MDDs which will reverse the limits. Alternatively, you can contact your Reseller or the GibbsCAM Post Department to request a custom MDD with rotary axis limits that match your machine configuration precisely.

Rotary Axis Setup

When a 4-axis or 5-axis machine is selected, the Machine Setup tab appears in the top portion of the Document Control dialog. You define the setup of the rotary axes by entering information in the dialog. The values that you enter are used to calculate rotations and the new origins that result from those rotations.

Four Axis Setup Dialog

The 4 Axis Setup dialog presents controls that indicate how the fourth axis will rotate in reference to where the part is mounted. The checked or unchecked status of the "+" sign indicates the polarity of the axis and is used to determine whether a positioning move will be in a clockwise or counterclockwise direction. In the table diagram, the blue cube represents the stock, the short gray cylinder represents the 4th axis, and the gray cube represents the table on which the 4th axis is mounted. The origin markers show the positive direction of each axis. The clockwise direction for the 4th axis is shown in the picture by a directed red arc relative to the part. The values entered in the text boxes (Y and Z in the following illustration) specify the distance from the origin of CS1 to the centerline of the indexer.
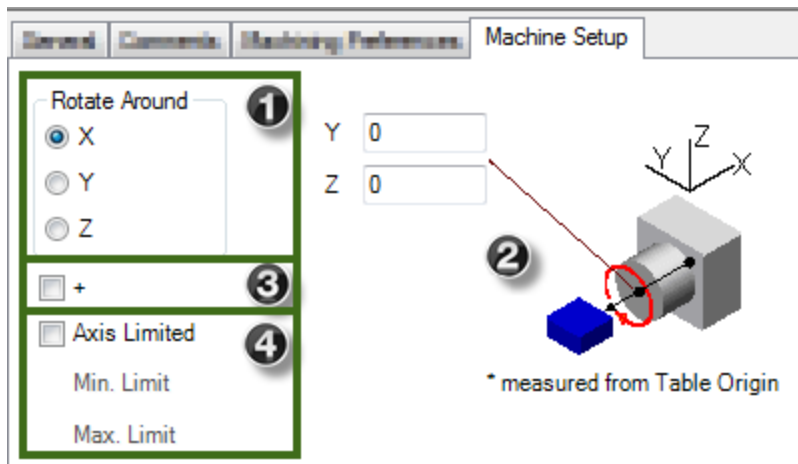
4 Axis Vertical Mill MDD Rotary Setup dialog

1. Rotate Around: { X | Y | Z}
2. Location of Rotary axis
3. Rotation direction ([-] or [+])
4. If axis limited: minimum and maximum

Table Diagram:
In the table diagram, the cube represents the stock. The origin marker shows the positive direction of each axis. The arrows show the clockwise direction of each axis. The short gray cylinder represents the 4th axis, and the gray cube represents the table on which the 4th axis is mounted. The direction arrow in the center of the cylinder shows the positive direction of the axis of revolution.
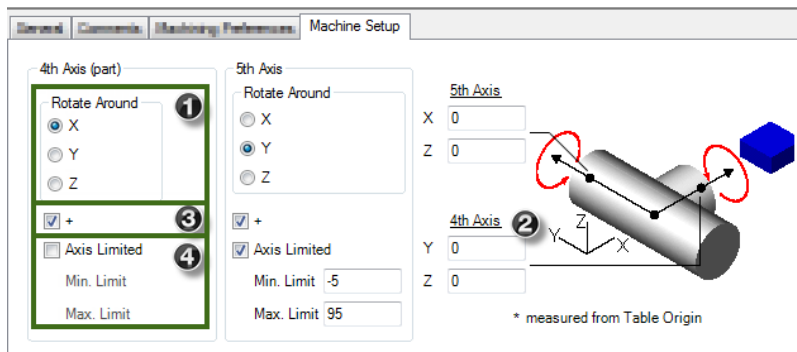
Axis of Rotation:
The selections for X, Y, and Z are option buttons; when one is selected, the others are not. The checkbox determines whether the direction is clockwise or counterclockwise. They determine the orientation of the axes of rotation and should describe the physical orientation of the machine. In most cases, the fourth axis on a horizontal machine is the Y+ axis. On a vertical machine, the fourth axis is the X- axis.

Axis of Rotation Position:
The values specify the distance from the origin of CS1 to the centerline of the indexer. These values will be used to correctly rotate the part into position and to correctly calculate Z- axis distances, which relate mostly to tool length offsets.

Five Axis Setup Dialog

The 5 Axis Setup dialog presents controls that indicate how the fourth and fifth axes will rotate in reference to where the part is mounted. The option buttons for X, Y, and Z tell the software the polarity of the axes in relation to how the part is mounted on the table, and the + checkbox determines whether a positioning move is clockwise or counterclockwise. The clockwise direction for both rotary axes is shown in the table diagram relative to the part. In this example shown below, the part is mounted to the positive side of both the fourth (X) and fifth (Y) axis. The clockwise direction for both rotary axes is shown in the picture relative to the part.

1. Rotate Around: { X | Y | Z }
2. Location of Rotary axis
3. Rotation direction ([-] or [+])
4. If axis limited: minimum and maximum

(for separate 4th and 5th axis setup)

5 Axis Vertical Mill MDD Rotary Setup dialog

Table Diagram:
In the table diagram, the cube represents the stock. The origin marker shows the positive direction of each axis. The arrows show the clockwise direction of each axis. The intersecting cylinders represent the fourth and fifth axis. The short cylinder is always the fourth axis and the long cylinder is always the fifth axis. The direction arrows in the center of the cylinders indicate the positive direction of the axis of revolution.

Rotate Around:
These selections are option buttons; when one is selected, the others are not. They determine the orientation of the axes of rotation and should describe the physical orientation of the machine. In selecting the appropriate setting for your machine the first determination needs to be which axis is the fourth axis (X, Y or Z). Once that is known, the number of options is reduced and you will not be able to set the 5th axis to the same as the 4th. Next, determine whether the part will be mounted on the positive or negative side of the 4th and 5th axis. It may be helpful to look at the 4 Axis Setup dialog in order to better visualize which is the correct choice. Lastly, if an axis has a limited rotary range, enter the angular values.

Position of Axis:
The values entered in the text boxes (in the illustration, X and Z under 5th Axis and Y and Z under 4th Axis) specify the distance from the origin of CS1 to the centerline of each indexing axis. These values will be used to correctly rotate the part into position and are dependent on the rotation of the fifth axis.

Clearance Planes

There are two types of clearance planes used by the system – the operation clearance planes and the master part clearance plane. The operation clearance planes are entered in the process dialog and are the entry and exit clearance planes for the current operation. The master clearance plane, defined in the Document Control dialog, is used when the tool is coming back from a tool change and during part rotations. The operation clearance planes are relative to the machining coordinate system, but the master clearance plane is not.

Master Clearance Plane   Operation Clearance Planes

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Master Clearance Plane

The Master Z Part Clearance Plane is a fixed Z height specified in CS1 coordinates. It is not relative to the machining coordinate system being used by the current operation. Because of this, the Z value for the master clearance plane output in the posted code will change from one machining coordinate system to another. If this value is not entered correctly, it is very possible that the system will produce unexpected negative Z rapid moves. Therefore, it is very important that the master clearance plane is high enough to clear all possible rotations.

> The system does not render moves to and from the tool change position. It is not always obvious that there is potential interference when the tool retracts to the change position until the posted code is generated. The actual Z values that are output are heavily dependent on the values entered in the rotary setup and are not always obvious when programming the part with the system. To avoid accidents, be sure to review all G-code for potential interference before cutting any material.

For a specific example on part clearance planes, refer to the Advanced CS tutorial.

Interface

This chapter describes interface items that are specific to the system when the Advanced CS option is installed. In order to use the Advanced CS capabilities, the Level 2 interface must be selected. The interface level is specified in the File > Preferences > Interface tab. The Level 2 interface has a comprehensive Commands palette, a Floating Toolbar and other slight interface differences. Some items in the Level 2 interface will be unavailable if the SolidSurfacer or Multi-Task Machining options are not installed.

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- Menu Items on page 21
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The Workspace

- View Control Palette on page 18
- CS Grid and Axis Markers on page 18
- CS Frame Indicator on page 20

View Control Palette

The View Control palette is not unique to the Advanced CS option; however, it can be used to provide enhanced part visualization. The Home view displays the part at a view normal to the current coordinate system. This allows the user to view the part from the orientation that the tool will be approaching and machining the part. Switching to the Home view displays the part with the depth axis coming directly out of the screen, with the "+" at the center of the axis markers.

CS Grid and Axis Markers

The coordinate system (CS) grid and axis markers are very important tools when working with multiple coordinate systems. The CS grid graphically displays the planar orientation of the current coordinate system. There are four options for displaying CS's, the currently selected option is displayed on the floating toolbar. Click the icon in the toolbar to step through the options or click the down arrow and select the required display. When creating multiple coordinate systems, the CS grid should be displayed on the screen at all times.

☐ **Hide CS Grid:**

This option draws the active CS geometry in pale blue, but does not draw a Grid or axis markers. Geometry in the other CSs is displayed in pink.

CS Grid and Plane

When this option is turned on, the CS grid and axis markers and a translucent plane are displayed for the current CS.

CS Plane

This option draws a translucent plane and axis markers for the active CS.

CS Grid

The option draws the CS grid and axis markers.

The CS axis markers will be placed at the origin of the current coordinate system. The axis marker arrows show the positive direction of the horizontal (H) and vertical (V) axes. At the intersection of the axis marker arrows, there is either a plus "+" or minus "-" sign. This indicates the polarity (positive/negative direction) of the depth (D) axis with respect to the current view.

These arrows are labeled with an H and a V indicating the horizontal and vertical axes. If the H or V axis aligns with one of the primary axes (X,Y or Z) the primary axis label will be used instead of an H or V. For example, when working in the XZ plane, the horizontal axis marker will be labeled with an X (rather than H) and the vertical axis marker will be labeled with a Z (rather than V).

The grid is drawn in dark gray and shows the plane of the current coordinate system. Additional light gray lines will be drawn showing where the coordinate system intersects with the stock size,
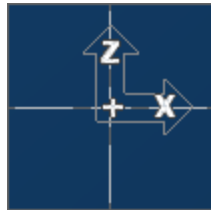
XY Plane CS   XZ Plane CS   YZ Plane CS

Axis markers for the three standard planes (XY, XZ and YZ).

Graphics Preference

The Display Preferences (File> Preferences Display tab) page contains an item called Grid

Grid Brightness

Brightness. This affects the contrast and brightness of the CS grid drawn on the screen. The brightness can be adjusted by moving the slider. Closing the dialog will apply the changes.

CS Frame Indicator

The system can also display a CS frame indicator that shows the origin of other coordinate systems. CS frame indicators are composed of three lines that indicate the orientation of the axes. The CS frame indicator is not labeled; it is simply three intersecting lines that are displayed in red on the screen. The current CS will still be designated with labeled axis markers and the CS grid.

The CS frame indicator is displayed by opening the eyeball icon in the CS list (detailed in " Coordinate System List" on page 22). Double-clicking on a CS eyeball icon in the CS list will bring up the CS frame indicator for that coordinate system. Multiple eyeballs can be opened at one time by double-clicking on more than one eyeball icon so that the CS Frame Indicator will be displayed for several coordinate systems.

> The CS Frame Indicators can be used to change coordinate systems. The current CS can be changed by clicking on a CS Frame Indicator. The coordinate system represented by the CS frame indicator selected will become the current CS and the CS grid and axis markers will reflect this change.
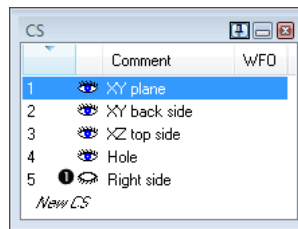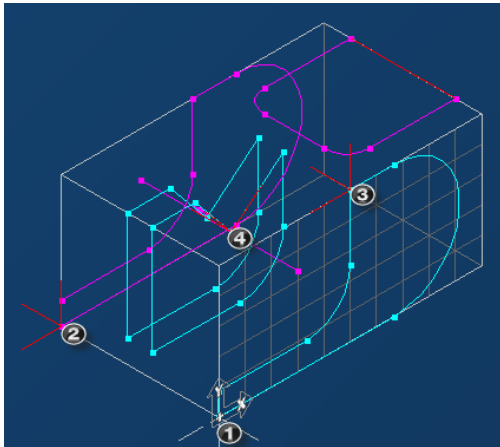
1. Hidden Indicator
2. Indicator for CS2
3. Indicator for CS3
4. Indicator for CS4

Menu Items

On the **Modify** menu, menu items Change CS (XYZ) and Change CS (HVD) are available only if geometry is selected. Either item will reassign geometry to the current CS. These items are also described in the *Common Reference* guide, but the material is duplicated here because these menu items are essential to the topics discussed in this guide.

XYZ Change CS (XYZ)

When Change CS (XYZ) is used, all selected geometry will be assigned to the current coordinate system. The geometry will stay in its same location in 3D space. It will change color to reflect the fact that it is now in the current coordinate system.

All selected arcs will be segmented (changed into line segments), if the coordinate system they are being changed into uses a different plane than their original coordinate system.

HVD Change CS (HVD)

When Change CS (HVD) is used, all selected geometry will be assigned to the current coordinate system, and the HVD values of the geometry will be preserved. This means that the geometry will be modified to be planar to the new CS location preserving the relative position.
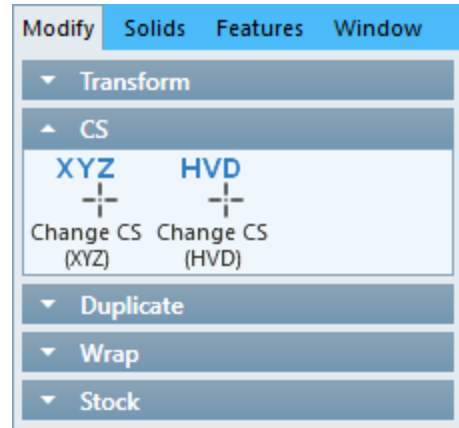
Command Toolbar

The Command Toolbar contains two buttons that are used specifically for working with multiple coordinate systems.
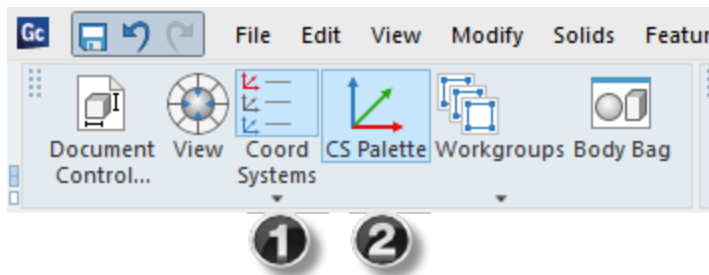
1. CS list button
2. CS palette button

Depressing the CS list button accesses the CS list which displays a list of all coordinate systems contained in a file. This dialog is also used to create new coordinate systems. The CS list button can also be held down (as opposed to a single click) to bring up a pop-up list of all the coordinate systems. This pop-up list can be used to change the current coordinate system. The CS palette button accesses the CS palette which is used to modify coordinate systems.

CS List Pop-Up Menu

Clicking the down arrow under the CS list button will bring up a dropdown menu showing all of the current coordinate systems. Click the required Coordinate System to select. Once a CS is selected the list will disappear. Click New Coordinate System to create a new coordinate system.
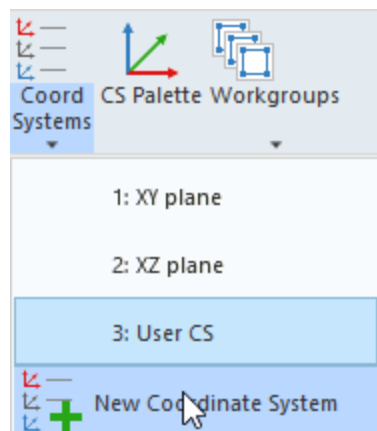
Coordinate System List

Clicking on the Coordinate Systems button opens the CS list. This dialog displays a list of all existing coordinate systems, highlighting the current coordinate system. Similar to the Workgroup list, the CS list is used to create, show, and hide coordinate systems. The CS list also has additional commands available through a context menu. It is strongly recommended that the CS list remain open at all times when working with multiple coordinate systems.

Number:

All coordinate systems have a number for ease of reference. The number is not successive, meaning that if you have coordinate systems numbered 1 through 4, and CS2 is deleted, the next CS you create will be labeled as #2.

Eyeball Icon:

The CS list contains eyeball icons next to each of the coordinate systems. Double-clicking a closed eyeball opens it and vice-versa. When open, the CS frame indicator for that coordinate system will be displayed on the screen. This actions does not affect the current CS, which will remain highlighted in the CS list. The CS grid and axis markers will be based on the current CS.

> (i) Multiple frame indicators may be shown or hidden at the same time. Holding down the Shift key when selecting eyeball icons will allow you to select a range of coordinate systems. Clicking on an eyeball icon with the Ctrl key held down will allow you to select and deselect individual planes. Once you have the planes selected that you wish to show or hide, double-clicking will show or hide all selected planes at the same time.

Comment:
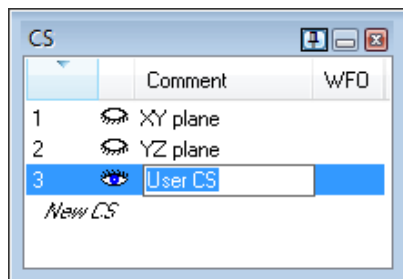
The Comment column shows the name of a CS. Double-clicking on the name of a selected coordinate system in the CS list allows you to edit the CS name. The name of the CS also appears as the title for the CS palette. Because the system names all new coordinate systems "User CS", it is an excellent idea to enter a comment in order to differentiate one CS from another.

NOTE: The comment is only a reference name and does not affect posted G-code executable command values.

WFO:

This item is the Work Fixture Offset number of the CS. By default the entry is blank and WFOs are not used. Clicking in the WFO area of a CS allows you to assign a WFO number to the CS. The number can be any positive integer (1, 2, 15, etc.). This number is a Gibbs WFO number and correlates to machine WFOs.

The Post Processor handles the conversion of Gibbs WFO #s to Machine WFO #s (i.e. G54 - G59 (and G54.1-G54.999) on Fanucs and E1-999 on Fadals).

The numbers can be in any order. If a CS does not have a WFO number and it is not used in any machining operations, then it is ignored. If a CS without a WFO number is used, then the system will automatically assign a WFO number based on CS's position in the CS list. In the above image, CS2: YZ plane does not have a WFO number. If the CS is used for machining, the operations associated with the CS will be assigned to WFO2. Note that CS4 is designated as WFO2 – this is perfectly fine. Multiple CSs can be assigned to the same WFO, allowing multiple setups.

New CS:
Click New CS to create a new coordinate system which will be a duplicate of the current coordinate system. The new coordinate system will be labeled User CS in the CS list.

Coordinate System List Context Menu
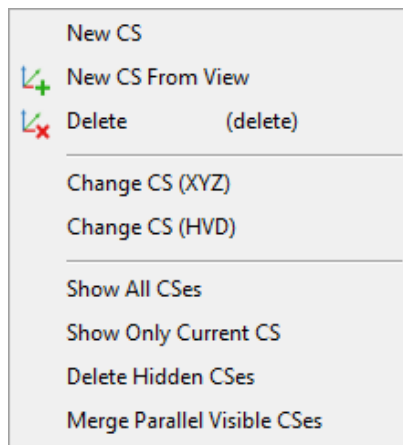
The CS list has a context menu which is accessed by a right-clicking the title bar of the CS list. The items contained in the context menu relate to the creation and modification of coordinate systems.

 New CS
Selecting New CS will create a new coordinate system.

New CS from View

Selecting this item will create a new coordinate system from the current view. This is an excellent way to save nonstandard part views.

Delete

Selecting this item will delete the current coordinate system, which is highlighted in the CS list. This is also accomplished by pressing the `Delete` key.

Change CS (XYZ)

This item is also found in the Modify menu and its functionality is the same (see " Change CS (XYZ)" on page 21). When this item is selected, all selected geometry will be assigned to the current coordinate system, and will stay in the same location in 3D space.

Change CS (HVD)

This item is also found in the Modify menu with its functionality remaining the same (see " Change CS (HVD)" on page 21). When this item is selected, all selected geometry will be assigned to the current coordinate system, and the HVD values of the geometry will be preserved. This means that the geometry will move in 3D space to reflect the change to a different coordinate system.

Show All CSs

Switches all the eye icons to open (👁) to display all geometry.

Show Only Current CS

Changes all the eye icons except the currently selected CS to shut (👁). Only geometry in that CS will be displayed.

Delete Hidden CSs

This command will delete all CSs where the "eye" icon is shut (👁). For each CS, a confirmation dialog appears. Choose to either move or delete the geometry. Click the checkbox to move/delete all subsequent CSs without further prompting.
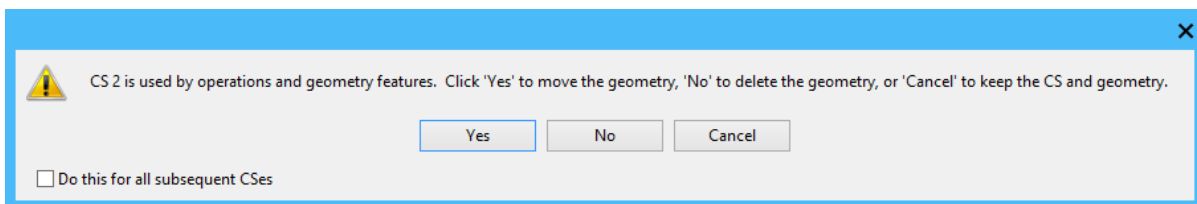
Merge Visible CS's

If multiple CS's are on the same plane, but with rotated axes, these can be merged. They will be merged into the lowest numbered CS. Open the eye on the CS's that are to be merged. (👁). A confirmation message will be displayed as above. You can choose to either move or delete the geometry. Click the checkbox to merge all subsequent CSs without further prompting.

⊿ Coordinate System Palette

The CS palette tools allow you to modify the attributes of any CS, except CS1 which is not modifiable. The name in the title bar of the palette is the name of the current coordinate system. The buttons in the palette will be grayed out if the current coordinate system is CS1, because that coordinate system cannot be modified. The CS palette is accessed by clicking on the CS button in the Commands palette. A CS has an origin (H0, V0, D0), axis alignment plane (H and V) and a planar alignment.

1. Change CS Origin
2. Align Horizontal Axis
3. Align Vertical Axis
4. Align CS Plane

5. XY Plane
6. XZ Plane
7. YZ Plane
8. Toggle Depth Direction

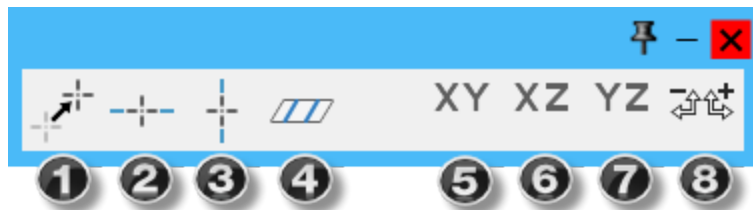The Coordinate System Palette

⊿ Change CS Origin

This button is used to modify the current coordinate system by designating a new origin. This action will only affect the current coordinate system. The origin for the part will not be changed. The part origin, which is in CS1, is set by the information entered in the Document Control dialog.

- If a point is selected when this button is clicked, the current CS origin will be moved to the location of the selected point.

-
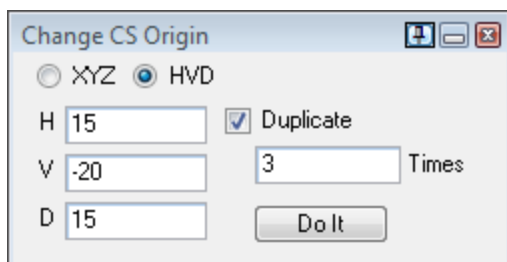
If no point is selected when the Change CS Origin button is depressed, the Change CS Origin dialog will appear on the screen. This dialog allows the user to enter coordinates for the new origin.

The coordinates can be entered as XYZ coordinates or HVD coordinates, depending on the radio button depressed. The XYZ coordinates specify an absolute position based on CS1, the

standard XY plane. The HVD coordinates specify an incremental translation from the existing origin of the current CS.

Duplicate

The Duplicate item can be checked to create additional coordinate systems based on the coordinates entered in this dialog. The Duplicate function is only useful when the HVD selection is made for the origin coordinates. This is because if XYZ coordinates are being used the duplicate coordinate systems would all be identical. With the Duplicate item checked, the system will not modify the current CS, but will create duplicate coordinate systems based on the number entered in the Times field. The origin for each new CS will be offset by the amount entered in the H, V and D fields.

Align Horizontal (H) Axis

This button is used to change the alignment of the horizontal axis of the current coordinate system. It can be used with a line selected or no geometry selected at all.

Geometry Selected

Clicking on this button with a line selected will project the selected line to the current CS and align the horizontal axis with the projected line. This action will not change the origin of the plane. It will only affect the axial alignment in plane.

- Holding down the `Alt` key while clicking on this button will change the origin of the plane, as well as the axial alignment, so that the selected line becomes the horizontal axis at V0. A second click will reverse the polarity of the H axis (flip axis).

- Holding down the `Ctrl` key while clicking on this button will create a new coordinate system which will have the H axis aligned with the selected line.

- Holding down the `Alt` + `Ctrl` keys simultaneously will create a new coordinate system, align the H axis and change the origin of the plane so that the selected line is the horizontal axis.

Align H Axis Context Menu:

-∙∣- Align H Axis
⤢ Align H Axis & Move (Alt)
-∙∣- Create CS & Align H Axis (Ctrl)
⊥ Flip Axis
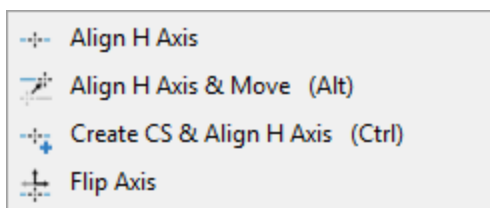
The Align H Axis function has a context menu associated with it which is accessed by right-clicking the button. All of the functions contained in the context menu can be performed in the ways described above or by selecting the item from the context menu.

Align H Axis

With geometry selected, this item will perform the standard align function where the H axis will align with a projection of the selected line.

Align H Axis & Move:

With geometry selected, this item will adjust the axial alignment as well as the depth orientation of the plane to the line selected for the horizontal axis. The selected line will

become the actual horizontal axis of the plane. This can also be accomplished by holding the `Alt` key down and selecting this item.
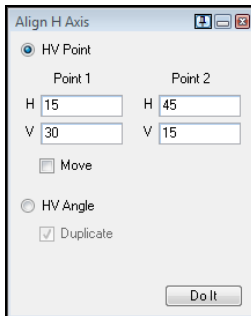
Create CS & Align H Axis

With geometry selected, this item will create a new coordinate system which will have the H axis aligned with the selected line. The current coordinate system will not be modified; the system will create a new CS and modify that CS. This can also be accomplished by holding the `Ctrl` key down and selecting this item.

Flip Axis

Selecting these items will reverse the direction of the H or V axes, rotating it 180°.

No Geometry Selected

If no geometry is selected when the Align Horizontal Axis button is clicked, the Align H Axis dialog will appear on the screen. This dialog allows the user to enter either two coordinates or an angle value to designate the line that will be used to align the H axis. The H axis for the current coordinate system will be aligned along the specified line.

HV Point:

The H and V coordinates entered are measured from the origin of the current coordinate system. If the Move item is checked, the H axis will be aligned with the specified line and the origin will be changed so that it lies on the selected line. The new origin will be a projection of the old origin onto the line.

HV Angle

The HV Angle entered specifies an incremental rotation in a counterclockwise direction in the CS Plane. If the Duplicate item is checked, the system will create duplicate coordinate systems based on the number entered in the Times field. Each of the new coordinate systems will have the H axis rotated by the specified angle. For example, a value of 15° is entered for the angle, the Duplicate item is checked and 3 is entered in the times text box. The current CS would not be modified. Three additional coordinate systems would be created. The first CS would align the H axis with a line at a 15° angle from the original H axis, the second at 30° and the third at 45°.

Align Vertical (V) Axis

This button is used to change the alignment of the vertical axis of the current coordinate system. It can be used with a line selected or no geometry selected at all.

Geometry Selected

Clicking on this button with a line selected will project the selected line to the current CS and align the vertical axis with the projected line. This action will not change the origin of the plane. It will only affect the axial alignment in plane.

- Holding down the `Alt` key while clicking on this button will change the origin of the plane, as well as the axial alignment, so that the selected line becomes the vertical axis at H0. A second click will reverse the polarity of the V axis.

- Holding down the `Ctrl` key while clicking on this button will create a new coordinate system which will have the V axis aligned with the selected line.

- Holding down the `Alt` + `Ctrl` keys simultaneously will create a new coordinate system, align the V axis and change the origin of the plane so that the selected line becomes the vertical axis.

Align V Axis Context Menu

The Align V Axis function has a context menu associated with it which is accessed by right-clicking the button. All of the functions contained in the context menu can be performed in the ways described below or by using the context menu.

	Align V Axis
	Align V Axis & Move (Alt)
	Create CS & Align V Axis (Ctrl)
	Flip Axis

Align V Axis

With geometry selected, this will perform the standard align function where the V axis will align with a projection of the selected line.

Align V Axis & Move

With geometry selected, this item will adjust the axial alignment as well as the depth orientation of the plane to the line selected for the vertical axis. The selected line will become the actual vertical axis of the plane. This can also be accomplished by holding the `Alt` key down and selecting this item.

Create CS & Align V Axis

With geometry selected, this item will create a new coordinate system which will have the V axis aligned with the selected line. The current coordinate system will not be modified; the system will create a new CS and modify that CS. This can also be accomplished by holding the `Ctrl` key down and selecting this item.

Flip Axis

Selecting this item will reverse the direction of the V axis, rotating it 180°.
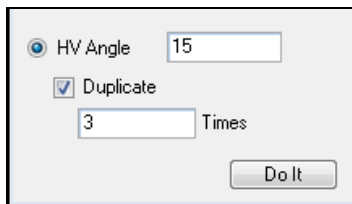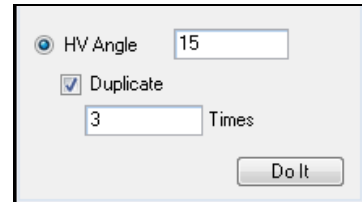
No Geometry Selected
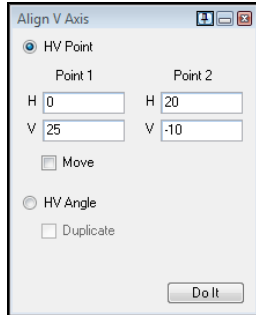
If there is no geometry selected when the button is clicked, the Align V Axis dialog will appear on the screen. This dialog allows the user to either enter two coordinates or an angle value to designate the line that will be used to align the V axis. The V axis for the current coordinate system will be aligned with the specified line.

HV Point

The H and V coordinates entered are measured from the origin of the current coordinate system. If the Move item is checked, the V axis will be aligned with the specified line and the origin will be changed so that it lies on the selected line. The new origin will be a projection of the old origin onto the line.

HV Angle

The HV Angle entered specifies an incremental rotation in a counterclockwise direction in the CS plane. If the Duplicate item is checked, the system will create duplicate coordinate systems based on the number entered in the Times field. Each of the new coordinate systems will have the V axis rotated by the specified HV angle. For example, a value of 15° is entered for the angle, the Duplicate item is checked and 3 is entered in the times text box. The current CS would not be modified. Three additional coordinate systems would be created. The first CS would align the V axis with a line at a 15° angle from the original V axis, the second at 30° and the third at 45°.

Align CS

This button is used to change the planar orientation of the current coordinate system. It can be used with geometry selected or no geometry selected.

Geometry Selected

The Align CS button will produce different results depending on what geometry is selected. Some groups of geometry will be used to define a plane, others will be used to define a normal vector for a plane. Defining a normal vector is equivalent to defining the depth axis. The groups of geometry necessary to define planes and normal vectors are listed below.

Plane Through Geometry Groups

- Three Points

- Two Intersecting or Parallel Lines

- One Point (not on the line) and One Line

Plane Normal Geometry Groups

- Two Points

- One Line

- Line and Point

Plane Through Geometry Groups

- One Arc

- Planar Spline

- Planar Edge (Solids)

- Planar Face (Solids)

Geometry Groups for Aligning Planes

Plane Normal Geometry Groups

- Spline and Point (normal to tangent vector of spline at the point)

- Circle and Point (normal to tangent vector of circle at the point)

- Edge and Point

- Face (planar or non-planar) and Point

The plane can either be oriented so that it aligns "through" the selected geometry or "normal" to the selected geometry. When using the Align CS button, the system will first attempt to align the CS through the selected geometry, which means that the plane will be constructed so that all selected geometry lies in it and the CS will be rotated parallel. If the geometry selection does not adequately define a plane, the system will attempt to align the plane normal to the selected geometry. If the geometry selected fails to adequately define a normal vector, the Align CS dialog will come up. The Align CS dialog is described in the following section.
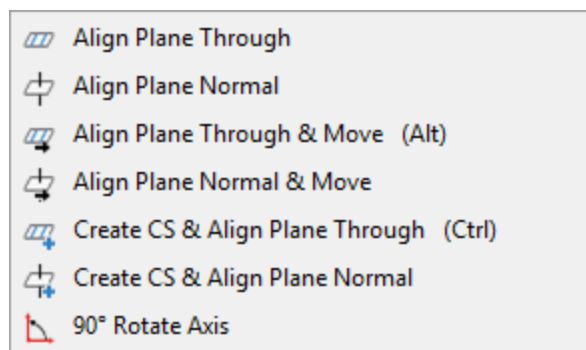
- By itself, this button will not affect the origin of the coordinate system. Holding down the `Alt` button when this button is clicked, the origin of the plane will also be moved to the depth of the selected geometry.

- Holding down the `Ctrl` key while clicking on the Align CS button will create a new coordinate system and orient it according to the geometry selected or the information entered in the Align CS dialog. The current coordinate system will not be modified; the system will create a new CS and modify that CS.

- Holding down the `Alt` + `Ctrl` keys simultaneously will create a new coordinate system, align the plane through the selected planar group geometry and modify the origin so that the selected geometry actually lies in the modified plane.

- Additional clicks on the Align CS button with geometry selected, will rotate the horizontal and vertical axes around the depth axis in 90° increments.

Align CS Context Menu

The Align CS button has a context menu associated with it which is accessed by right-clicking the button.

Align Plane Thru

When this item is selected, the system attempts to match the selected geometry with one of the Plane Through Geometry Groups. If the necessary geometry is selected, the system will align the plane


```
▱  Align Plane Through
⊹  Align Plane Normal
▱  Align Plane Through & Move   (Alt)
⊹  Align Plane Normal & Move
▱  Create CS & Align Plane Through   (Ctrl)
⊹  Create CS & Align Plane Normal
◣  90° Rotate Axis
```

through the selected geometry. The origin will not be adjusted. If the geometry selection fails to define a CS, the Align CS dialog will appear.

Align Plane Normal

When this item is selected, the system attempts to match the selected geometry with one of the Plane Normal Geometry Groups. If the necessary geometry is selected, the system will align the plane normal to the selected geometry. The origin will not be adjusted. If the geometry selection fails at defining a normal vector, the Align CS dialog will appear.

> ⓘ Several Align Normal capabilities cannot be accomplished using the Align CS button and must be done using this menu item. In the cases where the Plane Normal Geometry Group contains a selected point (spline and point, circle and point, line and point, edge and point, planar face and point), the system will align the plane normal to the selected feature and through the selected point, providing the point does not lie on the feature. If these selections were made and the Align CS button was clicked, the system would align the plane through the selected geometry rather than normal.

Align Plane Thru & Move

Selecting this item will align the plane through the selected planar group geometry. The origin will be modified so that the selected geometry actually lies in the modified plane. The function moves the origin by projecting it onto the new plane. This can also be accomplished by holding the `Alt` key down and clicking the button.

Align Plane Normal & Move:

Selecting this item will align the plane normal to the selected normal vector geometry. The origin will be modified to a point on the selected normal vector. The Align Plane Normal item also allows the user to select a point in addition to the normal vector geometry and the system will align the plane normal to the selected geometry and through the selected point.

Create CS & Align Plane Thru

Selecting this item will create a new CS, rather than modify the current CS, and align it through the selected plane geometry. The origin will not be modified so the selected geometry will not necessarily lie in the new CS. This can also be accomplished by holding the `Ctrl` key down and clicking the button or clicking Do It.

Create CS & Align Plane Normal

Selecting this item will create a new CS, rather than modify the current CS, and align the plane so that it is normal (perpendicular) to the selected normal vector geometry. The origin will not be modified.

90° Rotate Axis

Selecting this item will rotate the horizontal and vertical axes in 90° increments about the depth axis.

No Geometry Selected

If there is no geometry selected or if the selected geometry is inadequate to define a plane, the CS Align dialog will come up on the screen. This dialog allows the user to change the orientation of the plane without creating CS construction geometry. There are two ways to define the plane using this dialog.
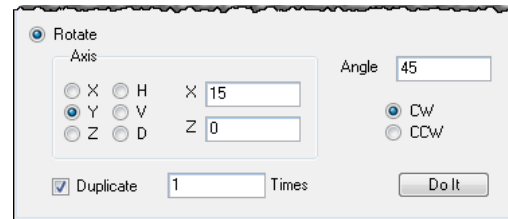
3D Points

This method requires coordinates for three points that will be used to define the plane. The coordinates can be entered as XYZ coordinates or HVD coordinates depending on which radio button is depressed. The XYZ coordinates specify an absolute position based on CS1, the standard XY plane. The HVD coordinates specify an incremental translation from the existing origin of the current CS. It should be noted that these points are not actually created as geometry, but are only used to align the CS.
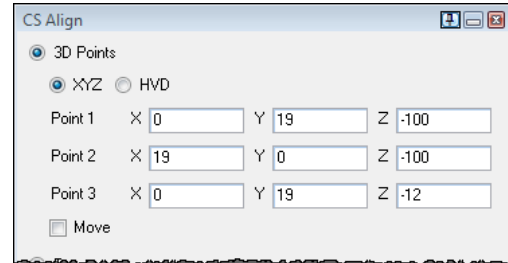
Rotate

This method defines the orientation of the CS by rotating it about an axis. The axis of rotation is determined by the radio buttons in the Axis section of the dialog. The standard X, Y and Z axes can be selected for the axis of rotation. There are also H, V and D selections which designate that the axis of rotation be based on the current coordinate system. The two text boxes in the Axis section of the dialog are used to designate the position of the axis of rotation. The Angle value entered determines the number of degrees the CS will be rotated about the selected axis of rotation. The CW and CCW radio buttons determine whether the CS will be rotated in a clockwise or counterclockwise direction. The CW and CCW directions are referenced by looking down the axis of rotation in the negative direction. If the Duplicate item is checked, the system will create duplicate coordinate systems based on the number entered in the Times field. Each of the new coordinate systems will be incrementally rotated by the angle value.

Standard Plane Orientation

The buttons on the Coordinate System palette all have three levels of use:

First click

The first `click` will align the current CS to the orientation of the plane specified using the same origin.

Additional click

Once the plane is aligned `click` to rotate the plane about the depth axis in 90° increments.

Ctrl-click

The `Ctrl` key indicates that the a results should be a new CS based on the same origin of the current CS.

Right-click

This opens a context menu which provides a simplified method of producing the same results. For the Create CS options the Ctrl key does not need to be pressed.

XY XY Plane

Align to the standard XY orientation. The plane will rotate about the Z axis 90°.

XZ XZ Plane

Align to the standard XZ orientation. The The plane will rotate about the Y axis 90°.

YZ YZ Plane

Align to the standard YZ plane or rotate about the X axis 90°.

Toggle Depth

Rotate 180° about the V axis to invert the positive direction of the H and D axis. The right hand rule of 3-axis space applies.

Machining

Tools

Tool setup and creation for Advanced CS is identical to the standard Mill package. Please see the Mill Module manual for tool definition and use.

Processes

Rotate Tab

The Rotate tab is available when a 4-axis or 5-axis MDD is selected. The information found in this section is used to set the Machining Coordinate System.
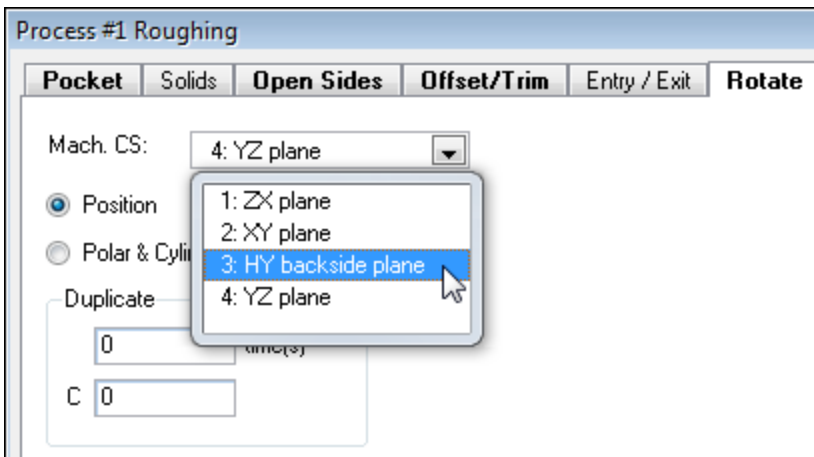
Machining Coordinate System (Mach. CS)
Coordinate systems are not just for creating geometry, they are used for setting the part orientation. The Machining CS (Machining Coordinate System) pull-down list contains all of the coordinate systems in the current part. The part will be rotated so that the tool will approach the part from the positive depth axis of this coordinate system. The geometry to be machined does not have to lie in this plane. An example of this is geometry created in the XZ or YZ plane that is machined from the

XY plane. Because of this, be sure to review the toolpath to verify whether you have the results you were expecting.

Position / Polar & Cylindrical Milling
This set of option buttons allows you to set whether the operation is a standard positioning operation (possibly including duplicating the toolpath at an angle) or a rotary toolpath operation. This item is fully detailed in the _Mill_ guide.

Operations

Advanced CS operations are basically the same as standard 2D Mill toolpath (2D toolpath with a part-centric view where the tool moves around the part) except that the toolpath can be in a plane the Mill Module would never be able to reach.

Toolpath and Rendering

The Advanced CS module displays all toolpath that is around the part, including retracts to clearances for positioning and rotations. This includes cut part rendering. Advanced CS parts, however, do not show tools retracting to the tool change position. You should carefully check the posted output to ensure there is no interference when the tool retracts.

Rotary Tables

This chapter contains information for using the Advanced CS option to produce fourth and fifth axis positioning moves for rotary tables. The system allows the user to designate a Machining CS for operations. The Machining CS is set in the Rotate tab of the process dialog when defining the operation parameters. Only one Machining CS can be used per process group. If the Machining CS is changed in one process in a specific process group, all of the other processes in that group will use the new Machining CS.
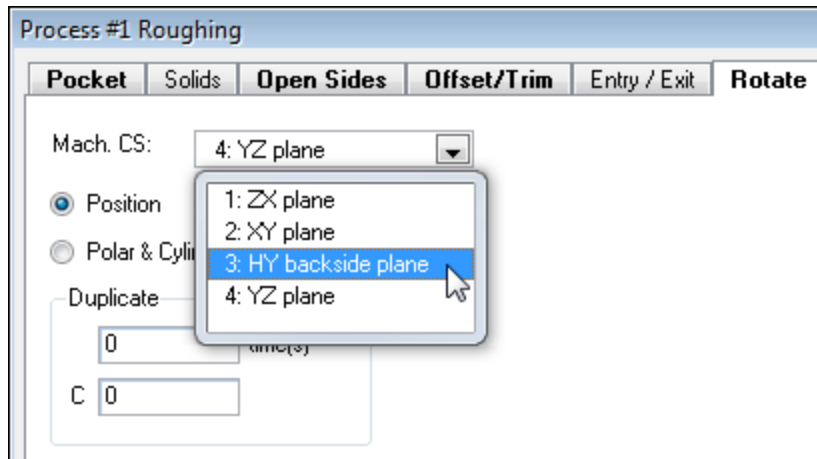
- "Rotary Axis Setup" on page 36
- "Work Fixture Offsets" on page 37
- "Limitations" on page 38
- "General Rotary Setup Example" on page 38

Rotary Axis Setup

The Rotary Axis Setup information (described in detail in "Rotary Axis Setup" on page 14) is very important in order to generate the correct code to cut the part. However, the Rotary Axis Setup information does not affect the actual programming of the part with the system.
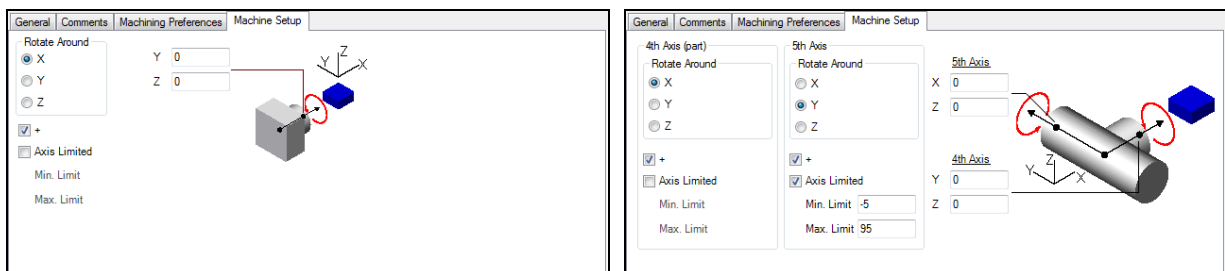
Work Fixture Offsets

Work fixture offsets are defined by coordinate systems. The CS list has an entry for designating a coordinate system as having a WFO setting. By default WFOs are not specified. In order to activate their use, a coordinate system is given a WFO number. Clicking in the WFO column of a coordinate system in the CS list allows you to assign a WFO number to the CS.

The WFO number is not the machine-specific G-code number (G54, G54.1, E1, etc.) but a Gibbs WFO number. The Gibbs WFO number is the 1st or 2nd or 3rd or 50th work fixture offset. The number may be any positive integer (1, 2, 50, etc.). When post processing the part the system will convert the Gibbs WFO number to the machine-specific WFO numbers (i.e. G54 -G59 (and G54.1-G54.999) on Fanucs and E1-999 on Fadals). The Gibbs WFO numbers in the CS list do not have to be in any order. If a WFO number is not specified, the system will use the CS number as the Gibbs WFO number.

In the dialog above, CS1 does not have a WFO number so it will be automatically assigned to WFO1. CS4 also does not have a WFO number so it will be assigned to WFO4. CS2 and CS3 have been given specific WFO numbers. CS5 has been assigned to WFO1. That means that any operations performed in this plane will be done from WFO1. Results of the output once posted would be as shown below.
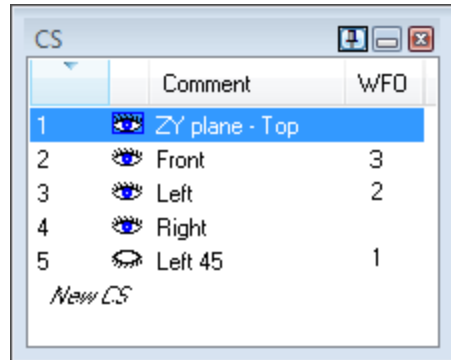
Gibbs WFO	Fanuc	Fanuc	Fadal	Haas
1	G54	G54.1	E1	G54
2	G55	G54.2	E2	G55
3	G56	G54.3	E3	G56
4	G57	G54.4	E4	G57
...999	...G59	...G54.999	...E999	...G59, G110-G199

3-Axis Posting of Advanced CS Parts

The system has the capability to make local CS output from Advanced CS parts using 3-axis MDDs. This functionality uses the Work Fixture Offset capability of your control. This capability allows axial alignment in 3-axis MDDs. To accomplish this, an Advanced CS B-Style or C-Style post should be used. The numbers generated in the output are exactly as they are programmed in GibbsCAM. This is axial alignment. Any moves to the Master Clearance Plane are output with the value entered for the part. This function is useful to those who do not have rotary tables, and to those who use multiple setups for different sides of a part or who manually flip parts.

Limitations

Axial Alignment

The system uses the plane of a CS to determine the rotations needed to machine geometry that lies in that plane. When this is done, the system calculates a rotation to create a plane parallel to the machining coordinate system through the origin of the coordinate system. It does not line up the H and V axis to match the coordinate system. This means that after several rotations the part may end up being rotated so all of the X and Y values are switched and one of them is negated. This can be especially confusing when the same coordinate system is re-used after doing machining in other coordinate systems. The first rotations will often match the axis defined in the coordinate system, but its possible that upon returning to the coordinate system the axes will appear rotated 90° or 180°.

Rotary Tables vs. Rotary Heads

GibbsCAM supports rotary head positioning and 4th axis rotary milling, on any machine/control with a Work Plane capability (toolpath output as 2D toolpath, with HV in the rotated plane). GibbsCAM does not generally support rotary heads for positioning or simultaneous machining on machines that require primary XYZ orientation of output toolpath.

General Rotary Setup Example

In this example, the machine type selected is a 4-Axis Horizontal Mill. In the MDD, the Clearance Plane Z is 100. In the 4 Axis Setup dialog, choose fourth Y+ for the axis of rotation. For the position of the axis of rotation, enter 150 in the X text box and -300 in the Z text box.
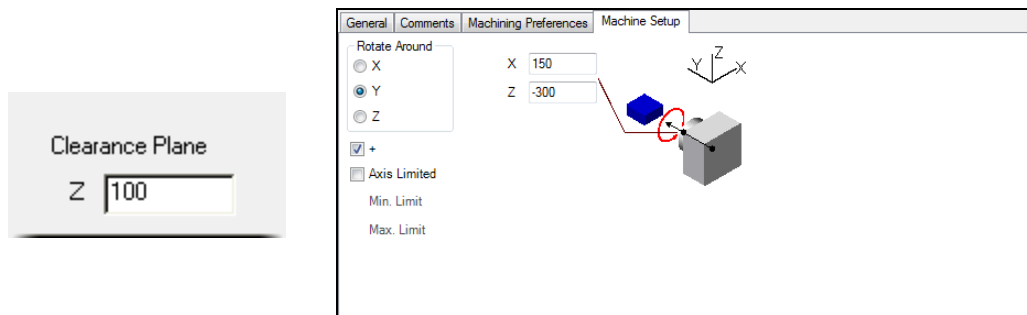
In our example, the part will be rotated to machine on the left side. This will cause the part to be rotated 90° in the counterclockwise direction. The rotated part origin will be at X450, Y0, Z-150. The value for the Clearance Plane output in the posted code will be Z250.

The following diagram illustrates how the rotated part origin is calculated based on the information that has been given in the Rotary Setup dialog. The diagram shows the table and part being viewed from the top as if you were looking straight down along the axis of rotation.

1. Axis of Rotation (CW)
2. Master Part Origin
3. Master Part Clearance Plane
4. Rotated Part Origin
5. Part in Initial Position
6. Part After Being Rotated
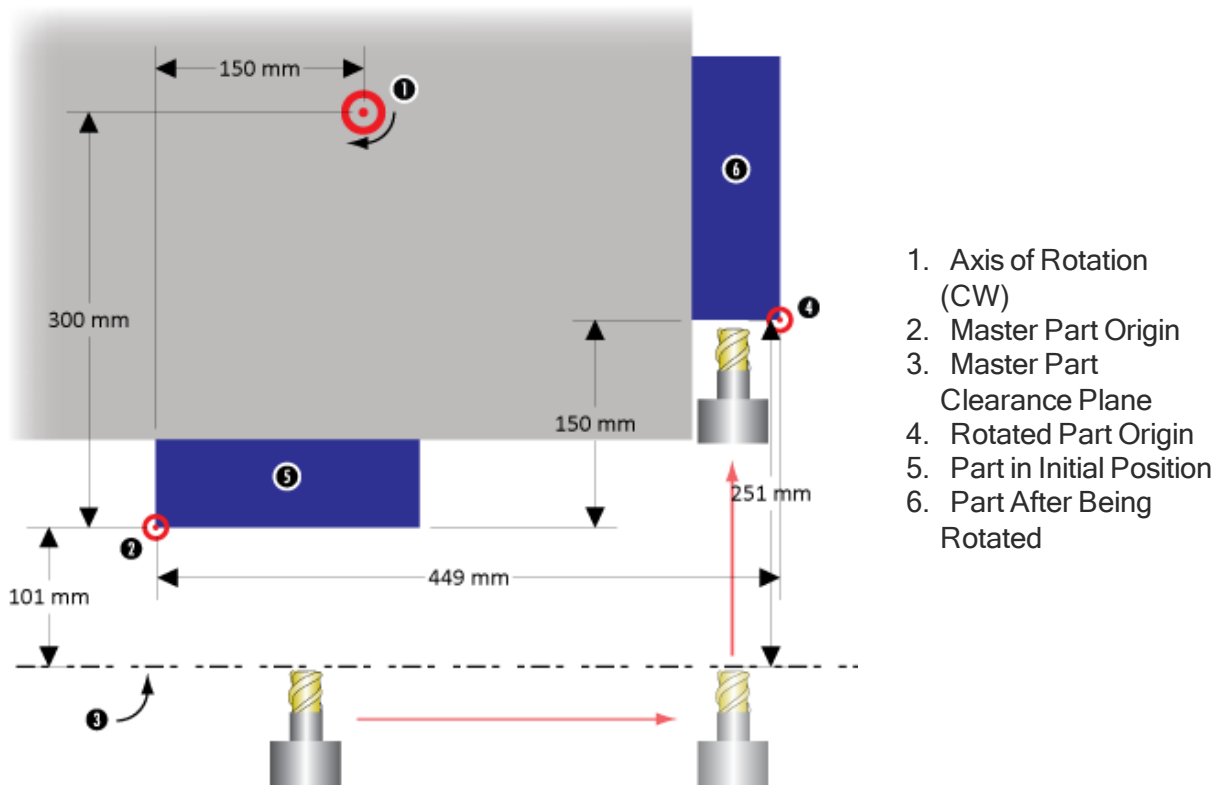
Part Rotation Calculations

Below are sample G-code formats from each of the three styles of GibbsCAM's Advanced CS Post Processors. The values in parentheses are output as comments in the posted code.

B-Style Post Processor	C-Style Post Processor	D-Style Post Processor
Master Part Origin:	Master Part Origin:	All origins are:
G54 (X0 Y0 Z0 B0)	G54 (X0 Y0 Z0)	G54 (X0, Y0, Z0).
Rotated Part Origin:	Rotated Part Origin:	Operations that use the rotated origin would have X450 and Z-150 added to each move.
G55 (X450 Y0 Z-150 B90)	G55 (X450 Y0 Z-150)	
Master Clearance Plane:	Master Clearance Plane:	Master Clearance Plane:
Output as Z250	Output as Z250	Output as Z100
Rotation is part of WFO.	Rotation is called in the code before positioning the tool above the start point of the operation.	Rotation is called in the code before positioning the tool above the start point of the operation.

Post Processing

Post Processors

There are three types of post processors available for the Advanced CS option. The differences in how the three post processors output code are based on how work fixture offsets are handled. Machine limitations and customer preference are the primary factors that affect which type of Advanced CS post processor should be selected.

Advanced CS post processors are labeled with the prefixes B, C, and D which correspond to the way each processor handles work fixture offsets (WFO). The B-style is designated as Full WFO; the C-style is Partial WFO; and the D-style is No WFO.

If it is not specified in the WFO column of the CS list, the work fixtures that the Advanced CS processor will use is determined by the machining coordinate systems (CS). The number of the WFO is directly related to the number of the machining coordinate system. For example, CS1=G54 and CS5=G58 on Fanuc controls. The first coordinate system will always be in the XY plane which is G54. If no cuts are made in the XY plane or in any other CS that is designated as using the first WFO, the posted output will not use G54.

B-Style (Full WFO) Posts

All Advanced CS post processors assume the starting rotary position of the machine is A0B0. With a B-Style (Full WFO) processor, the posted output contains a comment for each WFO which lists the X,Y,Z,A and B settings that the work fixture must be set to. B-Style posts use a Work Fixture Offset (WFO) to handle both the CS origin offset and any A or B axis rotations, if necessary. Only the WFO will be called in the code, e.g. G55, G56. The B-style post will always output an A0 and B0 move for every CS shift. Each of the WFO settings must be input at the control by the operator. This type of processor is useful because changes can be made to the WFO at the machine without having to change the part program itself. In order to use a Full WFO processor, the CNC machine must support A and B WFO settings and have multiple WFO capability.

The Master Clearance Plane, entered in the Document Control dialog, is calculated in the code based on the rotations being made and the information entered in the Axis Setup dialog. It should be noted that the Master Clearance Plane calculated in the code changes depending on the Machining CS. The Entry Clearance Plane is relative to the machining CS so the Entry Clearance Plane will stay the same value that was entered in the process dialog. This treatment of the Clearance Planes is true for B-style and C-style post processors.

The Full WFO post processors verify that the CNC machine can handle the number of WFOs being used. If the number of programmed WFOs exceeds the number that the machine can handle, the processor adjusts and functions like a No WFO processor, as described below.

C-Style (Partial WFO) Posts

All Advanced CS post processors assume the starting rotary position of the machine is A0B0. The Partial WFO processor requires that X, Y and Z values be entered at the control by the operator for each WFO but output the A and B rotation moves in the posted code. The WFO will be called in the code; e.g., G55, G56 and the A and B rotation moves will also be called in the code. These values are output on a comment line exactly like the Full WFO processor. All Advanced CS post processors assume the starting rotary position of the machine is A0B0. The A and B positioning moves will be output in the program each time a rotation occurs. If changes need to be made to the angular rotation, they can be manually edited in the program, or the GibbsCAM file (a .vnc file) can be modified and the program reprocessed.

The Partial WFO post processors verify that the CNC machine can handle the number of WFOs being used. If the number of programmed WFOs exceeds the number that the machine can handle, the processor adjusts and functions like a No WFO processor, as described below.

D-Style (No WFO) Posts

These posts are used on machines that do not have any WFO. With the No WFO processor, the system outputs all X,Y, Z and A and B values integrated into the output. It should be noted that all machining is done in G54. D-style posts will calculate machining coordinate values from CS1 coordinates into coordinates for the operation's machining CS. No WFO settings are input at the control, so any edits needed must be done by hand or changed using the systems file and then reprocessed. This option is necessary for machines that do not have the ability or have limited ability when dealing with WFOs.

The Master Clearance Plane, entered in the Document Control dialog, is relative to the machining CS so it will stay the same value that was entered in the Document Control dialog. The Entry Clearance Plane will be calculated in the code based on the rotations being made. Notice that it changes depending on the machining CS.

> ⓘ In order to use multiple parts on different sides of a tombstone with an Advanced CS post processor, the control must support A and/or B values in work fixtures. The index from one part to another must be placed in each work fixture.

Using 3-Axis Milling Posts

The system has the ability to get local CS output from Advanced CS parts for 3-axis posts. This functionality uses the Work Fixture Offset capability of your controller. This allows axial alignment in 3 xis MDDs or allows a post to specify 3-axis output from a custom 4-axis or 5-axis post. Basically this means that you can use a 3-axis post with Advanced CS parts when doing Work Fixture Offsets. The system will automatically unfold the part (as detailed in "Unfolding a Part" in the Advanced CS tutorial) and set the WFOs.

Advanced CS Post Processor Definitions

An Advanced CS post is needed when coordinate systems are defined in any part. An Advanced CS post has the same capability as a 3-axis post. A 3-axis post is no longer needed if an Advanced CS post is available.

Label Definitions

There are three different letter designations for Advanced CS Posts. Most customers use either a "B" or "C" style post. Both the "B" and "C" style posts fall back to "D" style output if they exceed the maximum number of work fixture offsets available for a particular CNC machine.

This post style is useful for multiple setups of the same part, tombstone work and machines without automatic rotation capability.

B The "B" style post uses a Work Fixture Offset for any machining coordinate system. All of the X, Y, Z, A and B axis offsets must be stored in the control's Work Fixture Offsets. The output of the rotary axes will always be zero (A0 and/or B0). The X, Y, Z, A and B-axis offsets are output in the operation comments. Example:

`Fanuc 6M [FW] B001.16.pst`

This post style is useful if you have a 4th and/or 5th axis rotary table.

C The "C" style post also uses Work Fixture Offsets for any machining coordinate system. Only the X, Y and Z axis offsets must be stored in the control's Work Fixture Offsets. The A and B axis rotations are output in the G-code. The X, Y and Z-axis offsets are output in the operation comments. Example:

`Fanuc 6M [PW] C001.16.pst`

This post style is useful for 4th and/or 5th axis parts and you do not want to use Work Fixture Offsets. It is also useful if you do not like having to input data into the control's Work Fixture Offsets.

D The "D" Style post uses one Work Fixture Offset for the entire part. This means that the X, Y and Z axis values in the G-code are offset based on the machining coordinate system. The A and B axis rotations are output in the G-code. Example:

`Fanuc 6M [NW] D001.16.pst`

Any Advanced CS post can be modified into a Long Hand post. Examples:

N
`Fanuc 6M [FW] NB299.16.pst`

`Fanuc 6M [PW] NC299.16.pst`

`Fanuc 6M [NW] ND299.16.pst`

Code Issues

- Advanced CS vs. Simple Positioning and/or Polar & Cylindrical Milling

    - An Advanced CS post is incompatible with a Simple Positioning post or a post for Polar & Cylindrical Milling. If you use coordinate systems to specify rotations, you need to use an Advanced CS post.

- Master Clearance Plane

    The value entered into the Z clearance plane in the Document Control dialog is a fixed point in space. This position or location is *not* relative to the current coordinate system. In other words, this value is *always local* to the home coordinate system.

    - This value is output at the beginning of each new tool operation and at the beginning of a same tool operation if there is a new coordinate system specified.

    - If this value is not entered correctly, it is very possible that the system will produce unexpected *negative* Z rapid moves. Therefore, it is essential to make sure this value is *clear* of all machining coordinate system rotations.

- Rotate to Shortest Distance

    - The system calculates the shortest distance to rotate from one coordinate system to another. For example, the system will output a positive move in the clockwise direction to get from 270° to 0° degrees. The system will output a negative move in the counterclockwise direction to get from 90° to 0°. The system will output either a clockwise or a counterclockwise move to get from 180° to 0°.

Post Output Samples

This section shows the G-code output of the part shown to the right. The code is output without comments and is aligned in a table so that you can compare the output. The part is a simple 5-axis part with three coordinate systems. The pockets (circles with a 30mm diameter) are cut with a 20mm endmill to a depth of 20mm. You may note that the CS list entries are assigned WFO numbers.
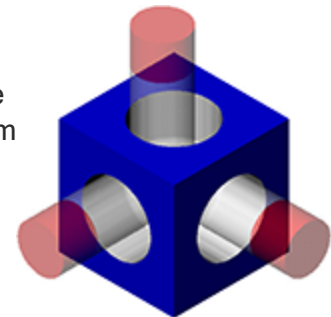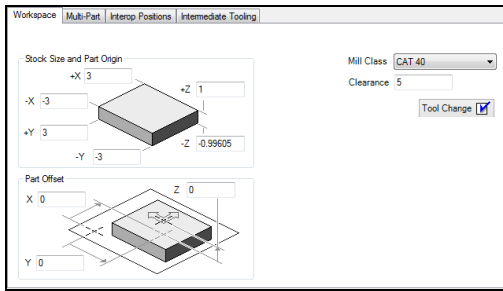
While this feature is very useful, it is not always needed as the system automatically uses CS1 as WFO1, CS2 as WFO2, etc. In this case we simply wanted to reinforce the use of the WFO numbers.

B and C Style Output

The Master Clearance Plane, 75mm in this example, is calculated in the code based on the rotations being made and the information entered in the Axis Setup dialog. This changes depending on the machining CS. The Entry Clearance Plane is relative to the machining CS so it will stay the same value that was entered in the process dialog. (The processes were set up using a clearance plane of 5.0mm.) This treatment of the Clearance Planes is true for B style and C style post processors.

D Style Output

The Master Clearance Plane is relative to the Machining CS, so it will stay the same value that was entered in the Document Control dialog. The Entry Clearance Plane will be calculated in the code based on the rotations being made. This changes depending on the machining CS.

Output Comparison Tables

The following two tables show the G-code generated by this part, in all three styles. The first table is code only, to maximize ease of comparison. The second table, including comments, will show even more differences between the formats.

Table 1: Comparison of B, C and D Style Output

B Style Post	C Style Post	D Style Post	What it is
%	%	%	
O1	O1	O1	
N1G17G40G80	N1G17G40G80	N1G17G40G80	
N2T1	N2T1	N2T1	
N3M6	N3M6	N3M6	
N4<u>G54</u>	N4<u>G54</u>	N4<u>G54</u>	*Operation #1*, G54
N5S218M3	N5S218M3	N5S218M3	

B Style Post	C Style Post	D Style Post	What it is
N6G90G0X0.Y5.A0.B0.	N6G90G0X0.Y5.A0.B0.	N6G90G0X0.Y5.A0.B0.	
N7G43Z75.H1	N7G43Z75.H1	N7G43Z75.H1	
N8M8	N8M8	N8M8	
N9Z5.	N9Z5.	N9Z5.	
N10G1Z-10.F22.	N10G1Z-10.F22.	N10G1Z-10.F22.	Z Step 1
N11M98P2	N11M98P2	N11M98P2	
N12G0Z5.	N12G0Z5.	N12G0Z5.	
N13G1Z-20.F22.	N13G1Z-20.F22.	N13G1Z-20.F22.	Z Step 2
N14M98P2	N14M98P2	N14M98P2	
N15G91G28Z0.	N15G91G28Z0.	N15G91G28Z0.	
N16G55	N16G55		*Op #2*, No WFO in D
N17G90G0X0.Y5.A0.B0.	N17G90G0X0.Y5.A-90.B0.	N16G90G0X0.Y55.A-90.B0.	Rotations
N18G43Z125.H1	N18G43Z125.H1	N17G43Z75.H1	Master Clearance Plane
N19Z5.	N19Z5.	N18Z-45.	Entry Clearance Plane
N20G1Z-10.F22.	N20G1Z-10.F22.	N19G1Z-60.F22.	Z Step 1
N21M98P3	N21M98P3	N20M98P3	
N22G0Z5.	N22G0Z5.	N21G0Z-45.	
N23G1Z-20.F22.	N23G1Z-20.F22.	N22G1Z-70.F22.	Z Step 2
N24M98P3	N24M98P3	N23M98P3	
N25G91G28Z0.	N25G91G28Z0.	N24G91G28Z0.	
N26G56	N26G56		*Op #3*, No WFO in D
N27G90G0X0.Y5.A0.B0.	N27G90G0X0.Y5.A-90.B-90.	N25G90G0X225.Y55.A-90.B-90.	Rotations
N28G43Z50.H1	N28G43Z50.H1	N26G43Z75.H1	Master Clearance Plane
N29Z5.	N29Z5.	N27Z30.	Entry Clearance Plane

B Style Post	C Style Post	D Style Post	What it is
N30G1Z-10.F22.	N30G1Z-10.F22.	N28G1Z15.F22.	Z Step 1
N31M98P4	N31M98P4	N29M98P4	
N32G0Z5.	N32G0Z5.	N30G0Z30.	
N33G1Z-20.F22.	N33G1Z-20.F22.	N31G1Z5.F22.	Z Step 2
N34M98P4	N34M98P4	N32M98P4	
N35M9	N35M9	N33M9	
N36G91G28Z0.	N36G91G28Z0.	N34G91G28Z0.	
N37M5	N37M5	N35M5	
N38M30	N38M30	N36M30	
O2	O2	O2	*Sub-Routine*
N1G3J-5.	N1G3J-5.	N1G3J-5.	
N2G0Z5.	N2G0Z5.	N2G0Z5.	
N3M99	N3M99	N3M99	
O3	O3	O3	*Sub-Routine*
N1G3J-5.	N1G3J-5.	N1G3J-5.	
N2G0Z5.	N2G0Z5.	N2G0Z-45.	
N3M99	N3M99	N3M99	
O4	O4	O4	*Sub-Routine*
N1G3J-5.	N1G3J-5.	N1G3J-5.	
N2G0Z5.	N2G0Z5.	N2G0Z30.	Exit Clearance Plane
N3M99	N3M99	N3M99	
%	%	%	

Table 2: Post Output With Comments

B Style Post	C Style Post	D Style Post
%	%	%
O1(PROGRAM: POST SAMPLE B.NCF)	O1(PROGRAM: POST SAMPLE C.NCF)	O1(PROGRAM: POST SAMPLE D.NCF)
(FORMAT: FANUC 6M [FW] B001.16M.PST)	(FORMAT: FANUC 6M [PW] C001.16M.PST)	(FORMAT: FANUC 6M [NW] D001.16M.PST)
(6/26/03 AT 11:03 AM)	(6/26/03 AT 11:03 AM)	(6/26/03 AT 11:02 AM)

B Style Post	C Style Post	D Style Post
(OUTPUT IN ABSOLUTE MILLIMETERS)	(OUTPUT IN ABSOLUTE MILLIMETERS)	(OUTPUT IN ABSOLUTE MILLIMETERS)
(PARTS PROGRAMMED: 1)	(PARTS PROGRAMMED: 1)	(PARTS PROGRAMMED: 1)
(FIRST TOOL NOT IN SPINDLE)	(FIRST TOOL NOT IN SPINDLE)	(FIRST TOOL NOT IN SPINDLE)
N1G17G40G80	N1G17G40G80	N1G17G40G80
N2T1	N2T1	N2T1
N3M6	N3M6	N3M6
(OPERATION 1: CONTOUR)	(OPERATION 1: CONTOUR)	(OPERATION 1: CONTOUR)
(WORKGROUP001)	(WORKGROUP001)	(WORKGROUP001)
(TOOL 1: 20. ROUGH ENDMILL)	(TOOL 1: 20. ROUGH ENDMILL)	(TOOL 1: 20. ROUGH ENDMILL)
(CS#1 - XY PLANE)	(CS#1 - XY PLANE)	(CS#1 - XY PLANE)
(G54 = X0. Y0. Z0. A0. B0.)	(G54 = X0. Y0. Z0.)	
N4G54	N4G54	N4G54
N5S218M3	N5S218M3	N5S218M3
N6G90G0X0.Y5.A0.B0.	N6G90G0X0.Y5.A0.B0.	N6G90G0X0.Y5.A0.B0.
N7G43Z75.H1	N7G43Z75.H1	N7G43Z75.H1
N8M8	N8M8	N8M8
N9Z5.	N9Z5.	N9Z5.
N10G1Z-10.F22.	N10G1Z-10.F22.	N10G1Z-10.F22.
N11M98P2	N11M98P2	N11M98P2
N12G0Z5.	N12G0Z5.	N12G0Z5.
N13G1Z-20.F22.	N13G1Z-20.F22.	N13G1Z-20.F22.
N14M98P2	N14M98P2	N14M98P2
N15G91G28Z0.	N15G91G28Z0.	N15G91G28Z0.
(OPERATION 2: CONTOUR)	(OPERATION 2: CONTOUR)	(OPERATION 2: CONTOUR)
(WORKGROUP001)	(WORKGROUP001)	(WORKGROUP001)
(TOOL 1: 20. ROUGH ENDMILL)	(TOOL 1: 20. ROUGH ENDMILL)	(TOOL 1: 20. ROUGH ENDMILL)
(CS#2 - XZ PLANE)	(CS#2 - XZ PLANE)	(CS#2 - XZ PLANE)
(G55 = X0. Y50. Z-50. A-90. B0.)	(G55 = X0. Y50. Z-50.)	
N16G55	N16G55	

B Style Post	C Style Post	D Style Post
N17G90G0X0.Y5.A0.B0.	N17G90G0X0.Y5.A-90.B0.	N16G90G0X0.Y55.A-90.B0.
N18G43Z125.H1	N18G43Z125.H1	N17G43Z75.H1
N19Z5.	N19Z5.	N18Z-45.
N20G1Z-10.F22.	N20G1Z-10.F22.	N19G1Z-60.F22.
N21M98P3	N21M98P3	N20M98P3
N22G0Z5.	N22G0Z5.	N21G0Z-45.
N23G1Z-20.F22.	N23G1Z-20.F22.	N22G1Z-70.F22.
N24M98P3	N24M98P3	N23M98P3
N25G91G28Z0.	N25G91G28Z0.	N24G91G28Z0.
(OPERATION 3: CONTOUR)	(OPERATION 3: CONTOUR)	(OPERATION 3: CONTOUR)
(WORKGROUP001)	(WORKGROUP001)	(WORKGROUP001)
(TOOL 1: 20. ROUGH ENDMILL)	(TOOL 1: 20. ROUGH ENDMILL)	(TOOL 1: 20. ROUGH ENDMILL)
(CS#3 - -YZ PLANE)	(CS#3 - -YZ PLANE)	(CS#3 - -YZ PLANE)
(G56 = X225. Y50. Z25. A-90. B-90.)	(G56 = X225. Y50. Z25.)	
N26G56	N26G56	
N27G90G0X0.Y5.A0.B0.	N27G90G0X0.Y5.A-90.B-90.	N25G90G0X225.Y55.A-90.B-90.
N28G43Z50.H1	N28G43Z50.H1	N26G43Z75.H1
N29Z5.	N29Z5.	N27Z30.
N30G1Z-10.F22.	N30G1Z-10.F22.	N28G1Z15.F22.
N31M98P4	N31M98P4	N29M98P4
N32G0Z5.	N32G0Z5.	N30G0Z30.
N33G1Z-20.F22.	N33G1Z-20.F22.	N31G1Z5.F22.
N34M98P4	N34M98P4	N32M98P4
N35M9	N35M9	N33M9
N36G91G28Z0.	N36G91G28Z0.	N34G91G28Z0.
N37M5	N37M5	N35M5
N38M30	N38M30	N36M30
O2	O2	O2
(SUB NUMBER: 2)	(SUB NUMBER: 2)	(SUB NUMBER: 2)
N1G3J-5.	N1G3J-5.	N1G3J-5.

B Style Post	C Style Post	D Style Post
N2G0Z5.	N2G0Z5.	N2G0Z5.
N3M99	N3M99	N3M99
O3	O3	O3
(SUB NUMBER: 3)	(SUB NUMBER: 3)	(SUB NUMBER: 3)
N1G3J-5.	N1G3J-5.	N1G3J-5.
N2G0Z5.	N2G0Z5.	N2G0Z-45.
N3M99	N3M99	N3M99
O4	O4	O4
(SUB NUMBER: 4)	(SUB NUMBER: 4)	(SUB NUMBER: 4)
N1G3J-5.	N1G3J-5.	N1G3J-5.
N2G0Z5.	N2G0Z5.	N2G0Z30.
N3M99	N3M99	N3M99
%	%	%
(FILE LENGTH: 1183 CHARACTERS)	(FILE LENGTH: 1159 CHARACTERS)	(FILE LENGTH: 1076 CHARACTERS)
(FILE LENGTH: 10.14 FEET)	(FILE LENGTH: 9.94 FEET)	(FILE LENGTH: 9.25 FEET)
(FILE LENGTH: 3.16 METERS)	(FILE LENGTH: 3.10 METERS)	(FILE LENGTH: 2.89 METERS)

Glossary

Axes	Fixed, intersecting, perpendicular lines that lie in the same plane. The three axes are the horizontal (H), vertical (V) and depth (D) axes. In the standard XY Plane, the X axis is the horizontal axis, the Y axis is the vertical axis and the Z axis is the depth axis.
Axial	Term used to describe the state of being around, on or along an axis.
Axial Alignment	Axial Alignment refers to the alignment or position of an axis.
Cartesian Coordinates	A pair of numbers that locate a point in a plane by its distances from two or more axes.
Coordinate System	A plane in space with an origin and three axes.
CS	Short for Coordinate System.
Normal	Geometry or planes are normal when they are perpendicular or at right angles. Also the point of tangency between a line and a curve.
Origin	The origin is the point at which the axes of a coordinate system intersect and serves as a zero reference point.
Parallel	Lines and planes are parallel when the lines or planes extend in the same direction and are the same distance apart at every point.
Perpendicular	A line or plane is perpendicular when it is at right angles to a given plane or line.
Planar	A term used to describe two or more items when they lie in the same plane.
Plane	A flat, even surface that wholly contains every straight line joining any two points lying in it.
Primary Plane	There are three primary planes for milling parts, the XY, XZ and YZ planes.
Right Hand Rule	The Right Hand Rule is used to help you visualize the Horizontal, Vertical and Depth axes of a coordinate system. See "The Right Hand Rule" on page 12.
Tangent	Geometry or a plane is at a tangent (or tangential) when it is touching and not intersecting a line, curve or curved surface at only one point.
WFO, Gibbs	Work Fixture Offset as seen by the GibbsCAM system.
WFO, Machine	Work Fixture Offset set on your control.

Conventions

GibbsCAM documentation uses two special fonts to represent screen text and `keystrokes or mouse actions`. Other conventions in text and graphics are used to allow quick skimming, to suppress irrelevancy, or to indicate links.

Text

Screen text. Text with this appearance indicates text that appears in GibbsCAM or on your monitor. Typically this is a button or text for a dialog.

`Keystroke/Mouse`. Text with `this appearance` indicates a keystroke or mouse action, such as `Ctrl+C` or `right-click`.

`Code`. Text with `this appearance` indicates computer code, such as lines in a macro or a block of G-code.

Graphics

Some graphics are altered so as to de-emphasize irrelevant information. A "torn" edge signifies an intentional omission. Portions of a graphic might be blurred or dimmed to highlight the item being discussed. For example:

Annotations on a graphic are usually numbered callouts (as seen above), and sometimes include green circles, arrows, or tie-lines to focus attention on a particular portion of the graphic.

Faint green borders that outline areas within a graphic usually signify an image map. In online help or a PDF viewer, you can click a green-bordered area to follow the link.

Links to Online Resources

Link	URL	Action / Description
Go	http://www.GibbsCAM.com	Opens the main website for GibbsCAM.
Go	https://online.gibbscam.com	Opens a restricted website containing materials available for download. Requires a GibbsCAM Online Services account; to set up an account, contact GibbsCAM Support.
Go	https://store.GibbsCAM.com	Opens the website for the GibbsCAM Student Store.
Go	https://macros.gibbscam.com	Opens a wiki containing documentation and examples of GibbsCAM macros. Requires a GibbsCAM account.
Go	http://kb01.GibbsCAM.com	Opens a Knowledge Base article, **Contour Operations Using Thread Mill Tools**, that explains in detail the correct way to program Contour processes using Thread Mill tools.
Go	mailto:Support@gibbscam.com	Runs your email client to create a new message addressed to the CAMBRIO Technical Support department for GibbsCAM.
Go	mailto:Registration@gibbscam.com	Runs your email client to create a new message addressed to the CAMBRIO Registration department for GibbsCAM.
Go	mailto:Sales@gibbscam.com	Runs your email client to create a new message addressed to the CAMBRIO Sales department for GibbsCAM.
Go	http://www.autodesk.com/inventor	Opens an external website that provides more information on Autodesk Inventor products.
Go	http://www.celeritive.com	Opens an external website that provides more information on VoluMill Ultra High-Performance Toolpath (UHPT) from Celeritive Technologies.
Go	http://www.predator-software.com	Opens an external website that provides more information on a CNC editor and a virtual CNC viewer from Predator Software, Inc.

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