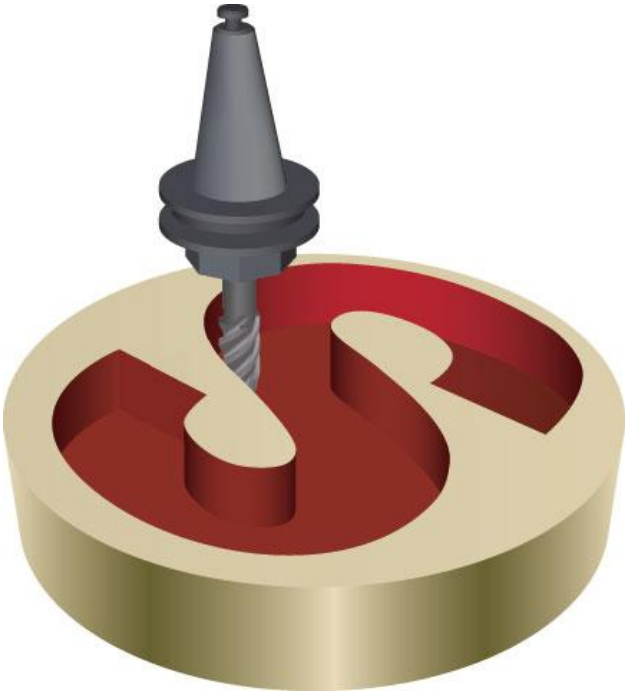
SolidCAM



SolidCAM GPPTool User Guide

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CHAPTER 1

1.1 Introduction

GPPtool is a General Pre- and Post-Processor tool that enables you to accomplish the following:

1. Define the Pre-processor parameters that affect the tool-path generation in **SolidCAM**.

2. Define the Post-processor parameters and the GPPL (General Post-processor language) procedures that define how the **SolidCAM** tool-path commands develop into G-Code for the particular CNC controller.

These capabilities provide you with the following:

1. The ability to change an existing pre- and post-processor for a CNC machine that is already supported by **SolidCAM**. This is done either to make small changes in the G-Code format for example or to customize the G-Code produced by the system in order to fit a certain template that the user is comfortable with.

2. The ability to develop a new pre- and post-processor to support a CNC machine that is not yet supported in **SolidCAM**.

1.2 Types of Post-processors

Three types of Post-processors are provided by GPPtool:

(a) User-defined Post-processor

For each particular CNC-machine controller, two files are needed as input to GPPtool. These files are:

(1) machine.mac
(2) machine.gpp

where [machine] is any name chosen by the user for the particular CNC machine controller.

The file [machine.mac] defines the Pre-processor parameters that affect the tool-path generation in **SolidCAM**.

The file [machine.gpp] defines the Post-processor parameters and the GPPL procedures that define how the **SolidCAM** tool-path commands develop into G-Code for the particular CNC controller.

Both these files can be generated and edited using any text-editor at the disposal of the user.

(b) Internal Fast Post-processor

In the case of an Internal post-processor only the file [machine.mac] is under control of the user; The [machine.gpp] functionality is hard-coded in SolidCAM and cannot be changed by the user. The advantage of the internal post-processor is that it generates G-Code faster than the user-defined post-processor.

(c) User-defined Doc-processor

For each particular CNC-machine controller, two files are needed as input to GPPtool. These files are:

(1) machine.mac
(2) machine.dpp

where [machine] is any name chosen by the user for the particular CNC machine controller.

The file [machine.mac] defines the Doc-processor parameters that affect the Documentation output in **SOLIDCAM**.

The file [machine.dpp] defines the Doc-processor parameters and the GPPL procedures that define the documantation output in **SolidCAM** for the particular CNC controller.

Both these files can be generated and edited using any text-editor at the disposal of the user.

1.3 About this manual

The GPPTOOL manual is organized in seven chapters and three appendices:

Chapter 1 gives an introduction to GPPtool.

Chapter 2 describes the installation and running procedures.

Chapter 3 describes the Pre-processor parameters that affect the tool-path generation in **SolidCAM** and that are included in the [machine.mac] file.

Chapter 4 describes the use of internal Fast Post-processor and User documentation.

Chapter 5 describes the GPPL (General Post-Processor language).

Chapter 6 describes the GPPtool system variables.

Chapter 7 describes the GPPtool commands.

Appendix A gives a listing of the [fanuc.mac] and [fanuc.gpp] files for a user-defined Pre and Post processor for a Fanuc controller.

Appendix B gives a listing of the error messages produced by GPPtool.

CHAPTER 2

2. Installation and Running of GPPtool

This chapter describes the installation and running procedures of the GPPtool program.

2.1. GPPtool Installation

GPPtool is installed on the computer during the installation of the **SolidCAM** program.

2.2. Running GPPtool

The GPPtool program can be run in one of two modes:

1. As an integral part of **SolidCAM** program. Whenever the G-Code command is given inside **SolidCAM** the GPPtool program is activated to generate the G-Code.

2. As a separate stand-alone program; It receives as input a Part generated by **SolidCAM** and then generates the G-Code. This program supports list of postprocessors. The user should make sure that the same CNC-machine is used both by **SolidCAM** and **GPPtool**. Run **GPPtool** by Double click on file named GPPToolExe.exe that is located on the following folder:

   \Program Files\SolidCAM2009\SolidCAM

CHAPTER 3

3. MAC (Pre-Processor Parameters)

These are the parameters that are defined by the user and that affect the tool-path generation in **SolidCAM**. They are defined in the file:

machine.mac

where [machine] is any name chosen by the user for the particular CNC machine controller.

The file [machine.mac] can be modified using any text editor at the disposal of the user.

The parameters' types can be one of the following type: integer, numeric, logical and string.

- integer - can hold signed, integer numbers in the range of (-999999999, +999999999).
- numeric - can hold any number in the range of (-1.E300, +1.E300).
- logical - can hold the logical values TRUE (1) or FALSE (0).
- string - can hold any sequence of ASCII characters; the number of characters is unlimited.

3.1. Machine specifications

3.1.1. Internal Parms

3.1.1.1. machine_type type: integer (enumerator)

{MILLING, WIRE_CUT, TURNING, MILL_&_TURN, MILL_&_TURN_FULL}

Defines the type of machining.

3.1.1.2. post_processor type: string { *GPP-filename , GPP-filename}

Tells SolidCAM whether to generate G-Code using the internal fast post processor (postprocessor name proceed with '*'), or whether to generate it using the [machine.GPP] file. Note that it is sufficient to give the name of the machine; the GPP extension is automatically added.

3.1.1.3. doc_processor type: string { DPP-filename}

Define the file name of the DPP file using to customize the Documentation output of **SolidCAM**.
Note that it is sufficient to give the name of the machine; the DPP extension is automatically added.

3.1.1.4. gpp_file_ext type: string

Define the extension of the G_code file name that will be created.

3.1.1.5. mac_holder type: string

Define the name of the upper constant part of the holder. This part of the holder belongs to the machine. When you choose the tool holder option in the Tool menu of the CAM-Part, and the mac_holder name defined in the mac file exists in the holders.tnt table, the holder will join the user holders.

3.1.1.6. tool_table_name type: string

Define the tool table name of the machine to be the part tool table. Note that it is sufficient to give the name of the tool table; the TAB extension is automatically added.

3.1.1.7. max_g_name_length type: integer

Defines the maximum number of characters in the G-Code file name. The name of the file is created from the first Max_g_name_length of the part name.
If there is a split, the name will be built from the first characters of the part and the number of the split.
All the spaces are deleted from the part name.

Example:
Part name: upper plate side 1
Extension: min
Max_g_name_length = 8
Gcode file name: upperpla.min
Split 1: upperpl-1.min
Split 10: upperp-10.min

3.1.1.8. max_tool_numbers type: integer

Defines the maximum number of tools on the machine table.

3.1.1.9. default_lang type: integer

Define the language of the postprocessor from among the following options:
CHINESE, CZECH, DANISH, ENGLISH, FRENCH, GERMAN, HEBREW, ITALIAN, JAPANESE, KOREAN, POLISH, PORTUGUESE, RUSSIAN, SPANISH and TURKISH.
The postprocessor cycle's parameters can be translated to other languages using the MacEdit Utility.

3.1.1.10. dir_gcode **type: string**

SolidCAM saves the generated GCode files in the specified GCode folder location. When the GCode generation is started, **SolidCAM** creates a new folder with the CAM-Part name in the specified GCode directory and saves the GCode files there. If this folder already exists, **SolidCAM** uses it for the GCode output.

3.1.1.11. split_gcode_folders type : logical {Y/N}

If TRUE, **SolidCAM** creates a separate folder for each GCode segment file and saves the GCode segments files there. The folder is created in the GCode folder of the CAM-Part in the specified GCode folder location. The name of the folder is the same as the GCode segment file name.

3.1.1.12. gcode_part_subfolder type : logical {Y/N}

If TRUE, **SolidCAM** creates a folder for each CAM-Part and saves the GCode file there. Otherwise, the GCode files for all CAM-Parts are generated into the GCode directory.

3.1.1.13. Fast Gcode Generation

3.1.1.13.1. internal_line

type: logical {Y/N}

This parameter enables you to turn on the fast G-Code generation option for line P-Code commands. To turn on the option set internal_line = Y. In this case, **SolidCAM** does not check the @line subroutine, but generates the G-Code according to internal rules.

3.1.1.13.2. internal_line4x

type: logical {Y/N}

This parameter enables you to turn on the fast G-Code generation option for line_4x commands. To turn on the option set internal_line4x = Y. In this case **SolidCAM** does not check the@line_4x subroutine, but generates the G-Code according to internal rules.

3.1.1.13.3. internal_line5x

type: logical {Y/N}

This parameter enables you to turn on the fast G-Code generation option for **line_5x** commands. To turn on the option set *internal_line5x = Y*. In this case **SolidCAM** does not check the**@line_5x** subroutine, but generates the G-Code according to internal rules.

3.1.1.13.4. internal_arc

type: logical {Y/N}

This parameter enables you to turn on the fast G-Code generation option for arc P-Code commands. To turn on the option set internal_arc = Y. In this case, **SolidCAM** does not check the @arc subroutine, but generates the G-Code according to internal rules.

3.1.1.13.5. gcode_line

type: string

This parameter enables you to define the format of G command for line output.

3.1.1.13.6. gcode_arc_CW

type: string

This parameter enables you to define the format of G command for clockwise arc output.

3.1.1.13.7. gcode_arc_CCW

type: string

This parameter enables you to define the format of G command for counter clockwise arc output.

3.1.1.13.8. gcode_modal

type: logical {Y/N}

If this parameter is set to N, **SolidCAM** preforms the output of the actual G-code command in every block of the G-code.

If this parameter is set to Y, **SolidCAM** preforms the output of the actual G-code command in the G-code block only in case when the G-code command is changed from the previous G-code block.

3.1.1.13.9. space_in_line

type: logical {Y/N}

With this parameter, **SolidCAM** enables you to generate spaces before coordinate addresses **X**, **Y**, **Z**, **I**, **J**, **K**, **R**, **F**, **M**.

3.1.1.13.10. point_in_coordinate

type: logical {Y/N}

This parameter defines if there is a point after the coordinate value (X, Y, Z, I, J, K) in case of absence of fraction part of the value.

3.1.1.13.11. point_in_feed

type: logical {Y/N}

This parameter defines if there is a point after the feed value in case of absence of fraction part of the value.

3.1.1.13.12. point_in_radius

type: logical {Y/N}

This parameter defines if there is a point after the radius value in case of absence of fraction part of the value.

3.1.1.13.13. zero_in_coordinate

type: logical {Y/N}

With this parameter, **SolidCAM** enables you to print zeroes at the end of fraction part of the coordinate value (**X, Y, Z, I, J, K**).

3.1.1.13.14. zero_in_feed

type: logical {Y/N}

With this parameter, **SolidCAM** enables you to print zeroes at the end of fraction part of the feed value.

3.1.1.13.15. zero_in_radius type: logical {Y/N}

With this parameter, **SolidCAM** enables you to print zeroes at the end of fraction part of the radius value.

3.1.1.13.16. plus_in_coordinate type: logical {Y/N}

With this parameter, **SolidCAM** enables you to print the plus sign before the positive coordinate (**X, Y, Z, I, J, K**) value.

3.1.1.13.17. plus_in_center type: logical {Y/N}

With this parameter, **SolidCAM** enables you to print the plus sign before the center value (CC) value when the value is positive.

3.1.1.13.18. max_d_before_p_in_c type: integer

With this parameter, **SolidCAM** enables you to define the number of digits before the decimal point for coordinate value (**X, Y, Z, I, J, K**).

3.1.1.13.19. max_d_before_p_in_f type: integer

With this parameter, **SolidCAM** enables you to define the number of digits before the decimal point for feed value.

3.1.1.13.20. max_d_before_p_in_r type: integer

With this parameter, **SolidCAM** enables you to define the number of digits before the decimal point for radius value.

3.1.1.13.21. x_string type: string

This parameter that defines the format of the **X** address output.

3.1.1.13.22. y_string type: string

This parameter that defines the format of the **Y** address output.

3.1.1.13.23. z_string type: string

This parameter that defines the format of the **Z** address output.

3.1.1.13.24. a_string type: string

This parameter that defines the format of the **A** address output (first rotation coordinate).

3.1.1.13.25. b_string type: string

This parameter that defines the format of the **B** address output (second rotation coordinate).

3.1.1.13.26. f_string type: string

This parameter that defines the format of the **F** address output.

3.1.1.13.27. i_string type: string

This parameter that defines the format of the **I** address output (X coordinate of an arc/circle center).

3.1.1.13.28. j_string type: string

This parameter that defines the format of the **J** address output (Y coordinate of an arc/circle center).

3.1.1.13.29. k_string type: string

This parameter that defines the format of the **K** address output (Z coordinate of an arc/circle center).

3.1.1.13.30. r_string type: string

This parameter that defines the format of the **R** address output (radius).

3.1.1.13.31. x_rel_string type: string

This parameter that defines the format of the **X** address output in relative mode.

3.1.1.13.32. y_rel_string type: string

This parameter that defines the format of the **Y** address output in relative mode.

3.1.1.13.33. z_rel_string type: string

This parameter that defines the format of the **Z** address output in relative mode.

3.1.1.13.34. a_rel_string type: string

This parameter that defines the format of the A address output (first rotation coordinate) in relative mode.

3.1.1.13.35. b_rel_string type: string

This parameter that defines the format of the **B** address output (second rotation coordinate) in relative mode.

3.1.1.13.36. comp_L_string type: string

This parameter enables you to define the format of the address starting the left side compensation mode.

3.1.1.13.37. comp_R_string type: string

This parameter enables you to define the format of the address starting the right side compensation mode.

3.1.1.13.38. comp_M_string type: string

This parameter enables you to define the format of the address stopping the side compensation mode.

3.1.1.13.39. comp_N_string type: string

This parameter enables you to define the format of the address used in the block that uses side compensation mode.

3.1.1.13.40. end_F_string type: string

This parameter enables you to define the format of the feed address used at the end of the block in case when the feed value is not changed from the previous block.

3.1.1.13.41. end_string type: string

This parameter enables you to define the format of the end block address.

3.1.1.13.42. arc_dir_CW_string type: string

This parameter enables you to define the format of the address describing **CW** direction of the arc.

3.1.1.13.43. arc_dir_CCW_string type: string

This parameter enables you to define the format of the address describing **CCW** direction of the arc.

3.1.1.13.44. gcode_arc_1_block type: string

This parameter enables you to define the format of the G-code used for the first block of the arc description.

3.1.1.13.45. r_less_360 type: logical {Y/N}

This parameter enables you to define the output format for arcs with the sweep angle less than 360°.

When r_less_360 = Y, **SolidCAM** performs the output using the Radius address and value.

3.1.1.13.46. rel_center type: logical {Y/N}

This parameter enables you to define if the arc center coordinates are relative or not.

3.1.1.13.47. arc_in_2_blocks type: logical {Y/N}

When this parameter is set to Y, the arc is described by two blocks; when the parameter is set to N, the arc is described by one block.

3.1.1.13.48. rel_adress_format type: logical {Y/N}

This parameter defines if to use the relative format mode.

When rel_address_format = Y, the coordinate addresses defined by the x_rel_string,y_rel_string and z_rel_string parameters are used in the relative mode.

When rel_address_format = N, the coordinate addresses defined by the x_string,y_string and z_string parameters are used in the relative mode.

3.1.1.13.49. comp_in_block type: logical {Y/N}

This parameter enables you to control the compensation use in the G-code blocks. When the comp_in_block = Y, SolidCAM uses the compensation parameters (comp_L_string,comp_R_string, comp_M_string, comp_N_string) for the compensation definition.

3.1.2. Machine Initialize

3.1.2.1. machine_plane type: integer (enumerated) {XY, YZ, ZX}

Defines the default machine-plane for home definition. It can be changed in the home definition dialog for current home.

3.1.2.2. mac_axes type: integer (enumerated) {XYZ, XZC, XYZC, XYZCB}

This parameter defines the axes in which the machine can work. If 'num_axes' is 4, *'mac_axes' is considered as XYZC. The G-Code for simultaneous 4th axis can be generated* only for XYZC or XZC machines. This parameter is not relevant for turning machines without milling capabilities. This parameter is relevant for `MILL_&_TURN` machines only.

3.1.2.3. back_mac_axes type: integer (enumerated) {XYZ, XZC, XYZC, XYZCB}

This parameter defines the back spindle axes in which the machine can work. If 'num_axes' is 4, 'mac_axes' is considered as XYZC. The G-Code for simultaneous 4th axis can be generated only for XYZC or XZC machines. This parameter is relevant for `MILL_&_TURN` machines only.

3.1.2.4. num_axes type: integer

This parameter defines the number of machine axes. Max value is 5.

3.1.2.5. num_simult_axes type: integer

This parameter defines the number of allowed simultaneous machine axes movement.

3.1.2.6. abs_coord type: logical {Y/N}

Defines the default starting mode for the CNC machine;

- If Yes, then the default starting condition of the CNC machine is absolute coordinates;
- If No, then the default starting condition of the CNC machine is relative coordinates.

Note:

All the tool-path commands generated by **SolidCAM** are in absolute coordinates. So if the starting condition of the CNC machine is relative coordinates, then **SolidCAM** generates the G-command (G90) that activates the absolute coordinates.

3.1.2.7. relative_gcode type: logical {Y/N}

This parameter enable to generate G_Code in relative mode.

3.1.2.8. rotate type: logical {Y/N}

This defines the CNC machine has a G-code command for rotation.

- If Yes a G-code procedure can be rotated using controller rotate G-code or parametric G-code.
- If No, the G-code procedure has to be regenerated with the new rotated coordinates. This option is disabled in the Transform menu.

3.1.2.9. mirror type: logical {Y/N}

This parameter defines the CNC machine has a G-code command for mirroring.

- If Yes, a G-code procedure can be mirrored using controller mirror G-code or parametric G-code.
- If No, the G-code procedure has to be regenerated with the new mirrored coordinates. This option is disabled in the Transform menu.

3.1.2.10. _4th_axes_around type: integer {X, Y, Z}

When the parameter num_axes has a value of 4 (4-axis CNC machine), the new parameter _4th_axes_around defines the constant axes for the machine. There are 2 possibilities:

Possibility #1
If
num_axes = 4
and
_4th_axes_around = X

This means that the fourth axis is along the X-axis of the machine (vertical machine) and the modul will be rotated around the X-axis of the screen.

Possibility #2
If
num_axes = 4
and
_4th_axes_around = Y

This means that the fourth axis is along the Y-axis of the machine (horizontal machine) and the modul will be rotated around the Y-axis of the screen.

Note:
It is not possible to change the part generated with post include_4th_axes_around = Y to 4th_axes_around = X. The reason is that the homes are saved relatively to no of axis definition.

3.1.2.11. first_rotation_angle

This parameter defines the first rotation axis used for calculation of the home's angles.
First_rotation_angle for XY & XZ have to be set X. Others - Z.

3.1.2.12. _5th_axes_around type: integer {X, Y, Z}

When the parameter num_axes has a value of 5 (5-axis CNC machine), the new parameter _5th_axes_around defines the rotate axes for the machine. There are 3 possibilities:

Possibility #1
If
num_axes = 5
and
_5th_axes_around = X

The modul will be rotated around the X-axis of the screen.

Possibility #2
If
num_axes = 5
and
_5th_axes_around = Y

The modul will be rotated around the Y-axis of the screen.

Possibility #3
If
num_axes = 5
and
_5th_axes_around = Z

The modul will be rotated around the Z-axis of the screen.

3.1.2.13. _5x_rotary_axes type: integer {ZYX, ZY , ZX , YX}

Set the _5x_rotary_axes parameter to define the linear axes which have a rotary axis that rotates about them. (default setting is ZYX) supports several machine configurations where axis rotate around YX, ZY, ZX, XY, XZ Once defined this parameter will rotate (manually or automatically) defined coordinate system, resulting in constant dev_angle = 0 value. (dev_angle `represents the angle in the work plane by which the program must be rotated`).
When the parameter num_axes has a value of 5 (5-axis CNC machine), the parameter _5x_rotary_axes defines which axis can be rotated. The default axis is ZYX.

3.1.2.14. direction_4x type: integer (enumerated) **{CCW/CW)**

This parameter defines the direction of 4_axis rotation.

3.1.2.15. tilt_axis_dir type: integer (enumerated) **{CCW/CW)**

The tilt_axis_dir parameter defines the direction in which the 5th Axis tilts the work piece (in towards the machine or out towards the machine operator) when we wish to position the work piece in five axis, indexed positioning application. CCW is a default value.

When the parameter num_axes has a value of 5 (5-axis CNC machine) and the parameter _5x_rotary_axes is ZX or YX tilt_axis_dir defines the direction of axis X.

When the parameter num_axes has a value of 5 (5-axis CNC machine) and the parameter _5x_rotary_axes is ZY tilt_axis_dir defines the direction of axis Y.

3.1.2.16. 5 Axis Orientation Calculation

Requirement:

Up until now SolidCAM supported a universal part calculation of rotational displacements about the three linear axes of a given coordinate system for the purpose of orienting a CAM Part. In this fashion we emulate a six axis, generic machine that enables SolidCAM to derive an output compatible with all machines regardless of machine kinematics. This model renders a resultant "dev_angle" value which represents the angle in the workplane by which the program must be rotated. (e.g. G68 X0. Y0. R[dev_angle] in ISO programming). There are CNC controllers that are capable of receiving three angular displacement values as input values and converting them into a two angle rotational displacement compatible with the machine kinematics. (e.g. MillPlus, Heidenhein, Sinumerik). In addition they automatically rotate the program in the workplane so there is no need to incorporate the program rotation angle (dev_angle) in a program rotation command in the post processor. (e.g. G68 X0. Y0. R[dev_angle] in ISO programming).

The following option was developed in order to cancel the need to rotate the program in the workplane utilizing the "dev_angle" output. The tradeoff is that this option serves a machine or group of machines with identical kinematics. You can still select a machine with different kinematics and utilize the "dev_angle" as in the generic model.

Purpose:

1. To make the Solid Verify Simulation (the Coordinate System dialog) visually compatible with the machine kinematics.
2. To obtain the proper positioning displacements of the rotational axes when orienting the workpiece from one coordinate system to another.
3. To obtain a G-code that doesn't have to be rotated in the workplane using the machine controller's macro functions (G68, G69).

Method:

1. Define parameters in the *.mac file that identify which the linear axis that does **not** have a corresponding rotary axis that can rotate about it and other parameters that affect the coordinate system definitions and derived angles output.
2. Num_axis defines axes capabilities of the machine (Num_axis = 5)
3. _*5x*_rotary_axes, tilt_axis_dir, tilt_axis_dir_cw_ccw , first_rotation_angle, 5th_axis_around
4. Set the _*5x*_rotary_axes parameter to define the linear axes which have a rotary axis that rotates about them. (default setting is ZYX) supports several machine configurations where axis rotate around YX, ZY, ZX, XY, XZ Once defined this parameter will rotate (manually or automatically) defined coordinate system, resulting in constant dev_angle = 0 value.
5. The **tilt_axis_dir** parameter defines the direction in which the 5th Axis tilts the workpiece (in towards the machine or out towards the machine operator) when we wish to position the

workpiece in five axis, indexed positioning application. CCW is a default value.

6 tilt_axis_dir_cw_ccw = Y Figure parameter enables choosing opposite angle pairs in operations. tilt_axis_dir_cw_ccw = Y cancel calculation without dev_angle. Default tilt_axis_dir_cw_ccw = N

7 first_rotation_angle for XY & XZ have to be set X. Others - Z.

8 5th_axis_around parameter defines around which axis is "wrapped" operation rotated

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Notes:

1 These paramters are effective when the user defines the coordinate systems.

2 Alternatively, the user can define a coordinate system using a SolidWorks sketch drawn on a the workplane in the desired orientation. Up until the development of this option this was the mode in which users would define a coordinate system such that there would be no need to employ a program rotation macro function (eg. G68 X0. Y0. R[dev_angle]) .

CAM Part Illustration - Cam Part with two coordinate systems:
Example No. 1

1 Coordinate System No. 1: Located at an orthogonal orientation of the three linear axes. (e.g. Axes A=0, B=0, C=0)

2 Coordinate System No. 2: Requires a theoretical rotational translation around each of the three linear axes or an equivalent rotation of the two rotational axes in the CNC machine in order to orient the workplane normal to the tool axis.

Figure 1: CAM Part with two coordinate systems defined:

Example number 1: CAM Part with a post processor that does not use the *_5x_*rotary_axes parameter to limit the part rotation to the two rotary axes. Alternatively, the post processor may incorporate the *_5x_*rotary_axes parameter and have its value set to ZYX.

The following is the coordinate system data for coordinate system number two:

Figure 2: Coordinate System Dialog for ZYX instance

Note that in order to position from coordinate system number one to coordinate system number two, SolidCAM calculates the axial rotations necessary around each of the three linear axes.

The "@tmatrix" section of the post processor gives the following output and is summarized in the subsequent table (table 1):

```
@tmatrix
rotate_angle_x:-35.264T                    rotate_angle_y:-45.000T
rotate_angle_z:90.000T

x_angle_const_z:35.264T y_angle_const_z:-45.000T dev_angle_z:-45.000T
opposite_x_angle_const_z:144.736T    opposite_y_angle_const_z:135.000T
opposite_dev_angle_z:120.000T

x_angle_const_y:-54.736T z_angle_const_y:135.000T dev_angle_y:60.000T
```

opposite_x_angle_const_y:54.736T opposite_z_angle_const_y:45.000T opposite_dev_angle_y:0.000T

y_angle_const_x:-54.736T z_angle_const_x:45.000T dev_angle_x:-30.000T opposite_y_angle_const_x:54.736T opposite_z_angle_const_x:-135.000T opposite_dev_angle_x:150.000T

Notes on Rotational Axis Assignment

- **A** axis – Rotates about the **X** axis
- **B** axis – Rotates about the **Y** axis
- **C** axis – Rotates about the **Z** axis

No.	*Machine Rotary Axes*	Constant Axis in trace	tilt_axis_dir	A Axis Rotate_X	B Axis Rotate_Y	C Axis Rotate_Z	Dev_Angle
1	ZYX (ABC)	none	Not Defined	-35.264	-45.000	90.000	none
2	ZY (BC)	const_x	Default	None	-54.736	45.000	-30.000
3	ZY (BC)	const_x	Opposite	None	54.736	-135.000	150.000
4	ZX (AC)	const_y	Default	-54.736	None	135.000	60.000
5	ZX (AC)	const_y	Opposite	54.736	None	45.000	0.000
6	YX (AB)	const_z	Default	35.264	-45.000	None	-45.000
7	YX (AB)	const_z	Opposite	144.736	135.000	None	120.000

Table 1: Axis Rotations for the ZYX instance

Example number 2: CAM Part with a post processor that uses the _5x_rotary_axes parameter to limit the part rotation to the two active, rotary axes. (See figure 3)

Figure 3: 5 Axis milling machine with ZY kinematic configuration (no rotary axis rotating about the X axis)

1. Definition of *.mac parameter
   Set the _5x_rotary_axes = ZY
   This means that The X Axis does not have a rotary axis rotating about it.
2. When we define the coordinate systems we see that the second coordinate system is forcibly oriented in according to the machine kinematics. In other words, the part is oriented according to the ability of the two rotational axes to position the workplane normal to the tool axis. (See Figure 4)
3. When the part is oriented as shown, no program rotation is necessary (G68 X0 Y0 R[dev_angle]).

Figure 4: Coordinate systems oriented according to the ZY configuration

4. The following are the axis Rotations calculated by SolidCAM in order to orient the workpiece in moving from coordinate system number one to coordinate system number two:

Note that there is no rotation defined around the X axis. This is due to the fact that the _5x_rotary_axes paramter was set to ZY. This notifies the post processor that the machine does not have a rotary axis capable of rotating about the X axis. This being the case, the rotation around the X axis is clamped to zero and the resulting rotations are calculated around the Z and Y axes such that they will position the XY plane normal to the tool axis.

The "@tmatrix" section of the post processor gives the following output for the ZY case:

```
@tmatrix
rotate_angle_x:0.000T rotate_angle_y:-54.736T rotate_angle_z:45.000T

x_angle_const_z:35.264T y_angle_const_z:-45.000T dev_angle_z:-30.000T
opposite_x_angle_const_z:144.736T    opposite_y_angle_const_z:135.000T
opposite_dev_angle_z:150.000T
x_angle_const_z_dir:cw y_angle_const_z_dir:ccw dev_angle_z_dir:ccw

x_angle_const_y:-54.736T z_angle_const_y:135.000T dev_angle_y:90.000T
opposite_x_angle_const_y:54.736T     opposite_z_angle_const_y:45.000T
opposite_dev_angle_y:-90.000T
x_angle_const_y_dir:ccw z_angle_const_y_dir:cw dev_angle_y_dir:cw

y_angle_const_x:-54.736T z_angle_const_x:45.000T dev_angle_x:0.000T
opposite_y_angle_const_x:54.736T    opposite_z_angle_const_x:-135.000T
opposite_dev_angle_x:180.000T
y_angle_const_x_dir:ccw z_angle_const_x_dir:cw dev_angle_x_dir:cw
```

The following table summarizes this instance:

No.	*Machine Rotary Axes*	Constant Axis in trace	tilt_axis_dir	A Axis Rotate_X	B Axis Rotate_Y	C Axis Rotate_Z	Dev_Angle
1	Angular Rot.	const_x		0.000	-54.736	45.000	0.000
2	ZY (BC)	const_x	Default	0.000	-54.736	45.000	0.000
3	ZY (BC)	const_x	Opposite	0.000	54.736	-135.000	180.000
4	ZX (AC)	const_y	Default	-54.736	0.000	135.000	90.000
5	ZX (AC)	const_y	Opposite	54.736	0.000	45.000	-90.000
6	YX (AB)	const_z	Default	35.264	-45.000	0.000	-30.000
7	YX (AB)	const_z	Opposite	144.736	135.000	0.000	150.000

Table 2: Results of the @tmatrix calculations for the ZY configuration.

Example No. 3: Changing the _5x_rotary_axes paramter from "ZY" to "ZX"

Figure 5: 5 Axis milling machine with ZX kinematic configuration (no rotary axis rotating about the Y axis)

No matter which linear axis is "frozen" by the _5x_rotary_axes paramter, the G-code derived from the post processor will be identical. The only difference will be in the angular rotation performed by the axes in order to correctly position the linear axes. For example, if the _5x_rotary_axes paramter is altered from "ZY" to "ZX" then the angular rotations calculated in the Coordinate System Dialog will be as follows:

The "@tmatrix" section of the post processor gives the following output for the ZX instance:

```
@tmatrix
rotate_angle_x:-54.736T rotate_angle_y:0.000T rotate_angle_z:135.000T

x_angle_const_z:35.264T y_angle_const_z:-45.000T dev_angle_z:-120.000T
opposite_x_angle_const_z:144.736T          opposite_y_angle_const_z:135.000T
opposite_dev_angle_z:60.000T
x_angle_const_z_dir:cw y_angle_const_z_dir:ccw dev_angle_z_dir:ccw

x_angle_const_y:-54.736T z_angle_const_y:135.000T dev_angle_y:0.000T
opposite_x_angle_const_y:54.736T            opposite_z_angle_const_y:45.000T
opposite_dev_angle_y:-180.000T
x_angle_const_y_dir:ccw z_angle_const_y_dir:cw dev_angle_y_dir:cw
y_angle_const_x:-54.736T z_angle_const_x:45.000T dev_angle_x:-90.000T
opposite_y_angle_const_x:54.736T          opposite_z_angle_const_x:-135.000T
opposite_dev_angle_x:90.000T
y_angle_const_x_dir:ccw z_angle_const_x_dir:cw dev_angle_x_dir:ccw
angle_4x_around_x:-54.736T angle_4x_around_y:0.000T
```

The following table summarizes the data for this instance:

No.	*Machine Rotary Axes*	Constant Axis in trace	tilt_axis_dir	A Axis Rotate_X	B Axis Rotate_Y	C Axis Rotate_Z	Dev_Angle
1	Angular rot.			-54.736	0.000	135.000	0.000
2	ZY (BC)	const_x	Default	0.000	-54.736	45.000	-90.000
3	ZY (BC)	const_x	Opposite	0.000	54.736	-135.000	90.000
4	ZX (AC)	const_y	Default	-54.736	0.000	135.000	0.000
5	ZX (AC)	const_y	Opposite	54.736	0.000	45.000	-180.000
6	YX (AB)	const_z	Default	35.264	-45.000	0.000	-120.000
7	YX (AB)	const_z	Opposite	144.736	135.000	0.000	60.000

Figure 6: Coordinate System Orientation for the ZX configuration.

Note also that the orientation of the second coordinate system in the ZX scenario is perpendicular to that which was obtained in the ZY scenario. Once again this is due to two reasons:

1. The part is oriented according to the ability of the machine's two rotational axes to orient the part normal to the tool axis.
2. There is no need for a program rotation using the controller's macro function (G68 X0. Y0. R[dev_angle]).

Example No. 4: Use of the "**tilt_axis_dir**" parameter
In this instance we'll return to the "ZY" configuration for the "*_5x_rotary_axes*" parameter as in example number 2, except that this time we'll set the "**tilt_axis_dir**" parameter to CCW instead of CW. The physical significance of this is that the rotary axis that rotates about the Y axis tilts in the opposite direction when positioning the axes (workpiece) according to an indexed coordinate system.

Upon selection of the second coordinate system we'll notice that the +X direction is forced in the opposite direction of that which was set in the "**tilt_axis_dir = CW**" option.

Figure 7: Coordinate Systems for the ZY configuration where **tilt_axis_dir = CCW**

The "@tmatrix" section of the post processor gives the following output for this instance (*5x* rotary axes = ZY & tilt axis dir = CCW):

```
@tmatrix          ==> mac_number:1 position:2 home_user_name:''

rotate_angle_x:0.000T rotate_angle_y:54.736T rotate_angle_z:-135.000T
rotate_angle_x_dir:cw rotate_angle_y_dir:cw rotate_angle_z_dir:ccw
x_angle_const_z:35.264T y_angle_const_z:-45.000T dev_angle_z:150.000T
opposite_x_angle_const_z:144.736T opposite_y_angle_const_z:135.000T
opposite_dev_angle_z:-30.000T
x_angle_const_z_dir:cw y_angle_const_z_dir:ccw dev_angle_z_dir:cw
x_angle_const_y:-54.736T z_angle_const_y:135.000T dev_angle_y:-90.000T
opposite_x_angle_const_y:54.736T            opposite_z_angle_const_y:45.000T
opposite_dev_angle_y:-270.000T
x_angle_const_y_dir:ccw z_angle_const_y_dir:cw dev_angle_y_dir:ccw
y_angle_const_x:-54.736T z_angle_const_x:45.000T dev_angle_x:-180.000T
opposite_y_angle_const_x:54.736T          opposite_z_angle_const_x:-135.000T
opposite_dev_angle_x:0.000T
```

The following table summarizes the data for this instance:

No.	*Machine Rotary Axes*	Constant Axis in trace	tilt_axis_dir	A Axis Rotate_X	B Axis Rotate_Y	C Axis Rotate_Z	Dev_Angle
1	Angular Rot.	const_x		0.000	54.736	-135.000	0.000
2	ZY (BC)	const_x	Default	0.000	-54.736	45.000	-180.000
3	ZY (BC)	const_x	Opposite	0.000	54.736	-135.000	0.000
4	ZX (AC)	const_y	Default	-54.736	0.000	135.000	-90.000
5	ZX (AC)	const_y	Opposite	54.736	0.000	45.000	-270.000
6	YX (AB)	const_z	Default	35.264	-45.000	0.000	150.000
7	YX (AB)	const_z	Opposite	144.736	135.000	0.000	-30.000

Final Note:
The Rotational Displacements are only calculated when creating or editing a coordinate system. Simply changing the _5x_rotary_axes paramter in the *.mac file without editing the axis selection of the corresponding coordiante system will not affect the Rotational displacement values shown in the Coordiante System Dialog.

Conclusions:

Upon comparing the three tables we derived from creating the three CAM Parts (converting ZY to ZX and changing CW to CCW), each with a different kinematic build represented by a different "frozen" axis and the direction in which it is tilted, the following points are borne out:

1. The data for any and all of the combinations possible are incorporated in to the "@tmatrix" section of the post processor regardless of the configuration (ZYX, ZY, ZX or YX) in which it was obtained.
2. The only difference in the data obtained upon using a different kinematic option will be in the value of the "dev_angle" parameter.
3. The value of the "dev_angle" parameter will be perpendicular (90 degrees) to its value in an alternative kinematic setup (eg. Changing ZY to ZX).
4. Within a given kinematic setup (eg. ZY, ZX or YX), the value of the "dev_angle" parameter in the default option will always be diametrically opposed (180 degrees) to "dev_angle" value obtained in the "opposite" variation.
5. Changing the "**tilt_axis_dir**" parameter from CW to CCW switches the "dev_angle" values between the default and the "opposite" options. This is due to the fact that the coordinate system is essentially built in the opposite direction.

3.1.2.17. positive_4x_dir_only type: logical {Y/N}

This parameter define the direction of the rotation of SolidCAM 4_Axis Simultaneous operation to be positive.

3.1.2.18. tilt_axis_dir_CW_CCW type: logical {Y/N}

This parameter enables choosing opposite angle pairs in operations.
tilt_axis_dir_cw_ccw = Y cancel calculation without dev_angle where dev_angle represents the angle in the work plane by which the program must be rotated.
Default tilt_axis_dir_cw_ccw = N

3.1.2.19. turn_home_x type: numeric (x, y, z)

This parameter define the orientation of the X-axes of the **Turning Coordinate System** in Mill_&_Turn_Full machine respectively relative to the **Machine Coordinate System #1 (Position #1)**:

For example:

turn_home_x = 0.0 1.0 0.0

With such parameters definition, the X-axis of the **Turning Coordinate System** is codirectional to the Y-axis of the **Machine Coordinate System #1 (Position #1)**;

The **Turning Coordinate System** is used for the definition of turning operations, Material boundary and Clamp.

> If the **turn_home_x** variable is not specified in the controller definition file, the axes of the **Turning Coordinate System** is collinear to the respective axes of the **Milling Coordinate System(turn_home_x = 1.0 0.0 0.0**).

3.1.2.20. turn_home_y type: numeric (x, y, z)

This parameter define the orientation of the Y-axes of the **Turning Coordinate System** in Mill_&_Turn_Full machine respectively relative to the **Machine Coordinate System #1 (Position #1)**:

For example:

turn_home_y = -1.0 0.0 0.0

With such parameters definition, the Y-axis is codirectional to the negative direction of the X-axis of the **Machine Coordinate System #1 (Position #1)**.

The **Turning Coordinate System** is used for the definition of turning operations, Material boundary and Clamp.

> If the **turn_home_y** variable is not specified in the controller definition file, the axes of the **Turning Coordinate System** is collinear to the respective axes of the **Milling Coordinate System (turn_home_y = 0.0 1.0 0.0).**

3.1.2.21. pos_to_coord **type: logical {Y/N}**

This parameter provide calculation of tool path in part coordinate system. (xhpos, yhpos, zhpos, xhcenter, yhcenter, zhcenter, xhstart, yhstart, zhstart). Arcs that are not in the planes XY, ZX and YZ are divided to lines.

3.1.3. Program numbers

3.1.3.1. prog_num_min type: integer

Minimum allowed program number.

3.1.3.2. prog_num_max type: integer

Maximum allowed program number.

3.1.3.3. prog_num_dflt type: integer

Default program number {prog_num_min <.. < prog_num_max}.

3.1.3.4. get_prog_num type: logical {Y/N}

This parameter decides whether the user is asked to give the program number in the Part dialog.

3.1.3.5. proc_num_min type: integer

Minimum allowed procedure number.

3.1.3.6. proc_num_max type: integer

Maximum allowed procedure number.

3.1.3.7. proc_num_dflt type: integer

Default first procedure number {proc_num_min <..< proc_num_max}.

3.1.3.8. get_proc_num type: integer

This parameter decides whether the user is asked to give the first procedure number in the Part dialog.

3.1.4. Procedures control

3.1.4.1. full_gcode type: logical {Y/N}

This parameter decides whether the (X, Y, Z) coordinates are modal or not. If they are not, this means that in every line of the G-code, all 3 coordinates must be written even though they might not have changed from the previous G-code line.

3.1.4.2. gen_procs type: integer (enumerator) {Y,N,C, D}

Indicates whether procedures can be generated in the G-code.

- If Yes, Procedures will be generated (in the main program level). Each job will be generated as procedure that will be called from the main program.
- If No, Procedures will not be generated (in the main program level).
- If C, Procedures will be generated only if they do not include further procedure calls.
- If D, This procedure-generation gives the following results:

  1. There is only one level of sub-programs.
  2. @call_proc is changed by @call_prms (subroutine call with parameters).
  3. A drill sub_program is generated for one drill or more (in the other modes a sub-program is generated only if there is more than one drill-hole) to get the same structure of sub-programs.
  4. In the movement sub-program, all the necessary G0 positioning are entered and all the movements in the Z direction are incremental to be able to call this sub-program, with parameters, as many times as needed.
  5. The numbers of calls in the main program depend on the depth and the down step.

     For example:
     - If the depth is 10 and down step 2, the result is:

       G65 P1000 L5

     - If the depth is 10 and down step 3, the result is:

G65 P1000 L3
G65 P1000 L1

6. Before the call to the sub-program, you have to create a movement to the relevant absolute Z- position from which the incremental movement in the sub-program will start.

Example:

gen_procs = Y
gen_internal_proc = Y

```
------Main program-------
O5000 (.TAP)
M01
N1 M6 T1
G43 H1 D31 G0 X8. Y20. Z50. S3000 M3
M8
M98 P1 (F-profile-T1)
M30

O1
(---------------------)
(F-PROFILE-T1 - PROFILE)
(---------------------)
G0 X8. Y20. Z10.
Z2.
G1 Z-5. F33
M98 P3
G0 Z10.
Y20.
Z-3.
G1 Z-10. F33
M98 P3
G0 Z10.
M99

O3
G1 X8. Y125. F500
M99
```

gen_ procs = N
gen_internal_proc = N

```
-----Main program-------
O5000 (.TAP)
M01
N1 M6 T1
G43 H1 D31 G0 X8. Y20. Z50. S3000 M3
```

```
M8
(---------------------)
(F-PROFILE-T1 - PROFILE)
(---------------------)
  X8. Y20. Z10.
  Z2.
G1 Z-5. F33
  Y125. F500
G0 Z10.
  Y20.
  Z-3.
G1 Z-10. F33
  Y125. F500
G0 Z10.
M98 P9010
M30
```

gen- procs = C
gen_internal_proc = Y

```
------Main program-------
O5000 (.TAP)
G54
M01
N1 M6 T1
G43 H1 D31 G0 X8. Y20. Z50. S3000 M3
M8
(---------------------)
(F-PROFILE-T1 - PROFILE)
(---------------------)
  X8. Y20. Z10.
  Z2.
G1 Z-5. F33
M98 P3
G0 Z10.
  Y20.
  Z-3.
G1 Z-10. F33
M98 P3
G0 Z10.

M30

O3
G1 X8. Y125. F500
M99
```

gen_ procs = D
gen_internal_proc = Y

```
------Main program-------
```

```
O05000 (.MZK)
G43 H1 D1 Z50. M8
G65 P1 Z-5. I0. F500 E33 (F-profile-T1); @call_ prms
M30

O01
G0 X8. Y20.
Z#4
G1 Z#26 F#8
G1 Y125. F#9
G0 Z50.
M99
```

3.1.4.3. drill_proc

type: logical {Y/N}

If several drill jobs have the same drill-points and this parameter is Yes, then the drill-points for all the drill-jobs are put in a single separate procedure. If No, then the drill-points are generated in every job.

Example:

drill_proc = Y

```
O1
(--------------)
(D-D-T3 - DRILL)
(--------------)
G0 X17. Y50. Z50.
G98 G81 Z2. R5. F100
M98 P3 (d)
M99
O2
(--------------)
(D-D-T4 - DRILL)
(--------------)
G0 X17. Y50. Z50.
G98 G84 Z-1.8 F50
M98 P3 (d)
M99
O3
(----------)
(D - DRILLS)
(----------)
   X27.
   X17. Y20.
   X27.
   X77.
   X87.
   Y50.
   X77.
```

```
G80
M99

drill_proc = N

O1
(--------------)
(D-D-T3 - DRILL)
(--------------)
G0 X17. Y50. Z50.
G98 G81 Z2. R5. F33
   X27.
   X17. Y20.
   X27.
   X77.
   X87.
   Y50.
   X77.
G80
M99
O2
(--------------)
(D-D-T4 - DRILL)
(--------------)
G0 X17. Y50. Z50.
G98 G81 Z-2. R5. F33
   X27.
   X17. Y20.
   X27.
   X77.
   X87.
   Y50.
   X77.
G80
M99
```

3.1.4.4. turn_proc

type: logical {Y/N}

This parameter determines whether **SolidCAM** will generate a separate procedure for the geometric points of a turning process ('Y'), or whether the points will be generated immediately after the cycle.

3.1.4.5. gen_internal_proc

type: logical {Y/N}

This parameter indicates whether internal procedures of the job will be generated.

- If Yes, internal procedures will be generated.
- If No, internal procedures will not be generated.

Note:

In order to obtain G-code that contains as much as possible calls to procedures, give 'Y' to the parameters 'gen_procs' and 'gen_internal_procs'. In order to obtain G-code that has no calls to procedure, give 'N' to both of these parameters.

3.1.4.6. turn_common_proc

type: logical {Y/N}

This parameter determines whether or not to generate a common geometric points procedure for several cycles.

3.1.4.7. gen_1_line_proc

type: logical {Y/N}

This parameter is used for turning cycles. It specifies the G-code format if the cycle geometry is a single line. Usually the cycle geometry is given in a G-code procedure.

- If Yes, a geometry procedure will be generated as any other geometry.
- If No, the geometry procedure will not be generated, and the geometry details will be given only in the turning command.

3.1.4.8. optimize_jobs_loop

type : logical {Y/N}

- If Yes, **SolidCAM** saves tool pathes among continuous jobs that have the same Edit operations.

Example:
optimize_jobs_loop = Y

```
O5000 (.TAP)
G54
M98 P9011
M01

M98 P1 (F-profile1-T1)
M98 P2 (D-drill1-T1)
G10G91 L2 P1 X60. Y0. Z0.
G90
#22 = #22 + 1
G1
END 2
G10G91 L2 P1 X-120. Y-30. Z0.
G90
#21 = #21 + 1
G1
END 1
G10G91 L2 P1 X0. Y60. Z0.
G90
M98 P9010
```

```
M30
O1
```

optimize_jobs_loop = N

```
O5000 (.TAP)
G54
M98 P9011
M01

M98 P1 (F-profile1-T1)
G10G91 L2 P1 X60. Y0. Z0.
G90
#22 = #22 + 1
G1
END 2
G10G91 L2 P1 X-120. Y-30. Z0.
G90
#21 = #21 + 1
G1
END 1
G10G91 L2 P1 X0. Y60. Z0.
G90
#21 = 0
WHILE [#21 LT 2] DO 1
#22 = 0
WHILE [#22 LT 2] DO 2
M98 P2 (D-drill1-T1)
G10G91 L2 P1 X60. Y0. Z0.
G90
#22 = #22 + 1
G1
END 2
G10G91 L2 P1 X-120. Y-30. Z0.
G90
#21 = #21 + 1
G1
END 1
G10G91 L2 P1 X0. Y60. Z0.
G90
M98 P9010
M30
O1
```

3.1.4.9. seq_sub_number type: logical {Y/N}

Determines whether **SolidCAM** will renumber the output G-Code so that there will be no gaps in the sub-program numbering. Add the following marks in the output G_code:

- {nb,'//G65P'} line before

{nb,'G65P'label }.

- {nb,'??O'} line before
  {nl,'O'label}

Note:

- The syntax of the mark should be printed exactly like the printed line (no extra spaces).
- If the commands "open file", "close file", "delete file", "copy file" are used in GPP variable seq_sub_number must be set to Y.

seq_sub_number = Y

Example:

seq_sub_number = Y

```
O5000 (.TAP )
M98 P8060

G56 P122 Z-5. A5000. F5000. H0.(F-profile-T4)

G56 P123 Z-30. A33. F100. H0.(F-profile-T5)

G56 P124 Z-5. A33. F100. H0.(P-profile1-T5)

G56 P125 Z0. A33. F100. H0.(S-slot-T7)

G65 P126 J81. Z-10. R3. F100.(D-drill-T1)

M98 P8060

M30
O0122


M99
O0123


M99
O0124

M99
O0125


M99
O0126


M99
```

```
O0127
(- CLOSE PROGRAM -)
M30
%

seq_sub_number = N

O5000 (.TAP )
M98 P8060

G56 P111 Z-5. A5000. F5000. H0.(F-profile-T4)

G56 P112 Z-30. A33. F100. H0.(F-profile-T5)

G56 P113 Z-5. A33. F100. H0.(P-profile1-T5)

G56 P114 Z0. A33. F100. H0.(S-slot-T7)

G65 P109 J81. Z-10. R3. F100.(D-drill-T1)

M98 P8060
M30
O0111

M99
O0112

M99
O0113

M99
O0114

M99
O0109

M99
O0110
(- CLOSE PROGRAM -)
M30
```

3.1.4.10. Loop_exist

type: logical {Y/N}

If loop_exist = 'N', the pcode @loop has not been generated in the case of transform.
Instead, pcode @change_ref_point will be generated.
In the case of rotate, the pcode of @rotate will be generated instead of pcode @loop.

Example:

Loop_exist = Y

```
%
O5000 (.TAP)

G54
M98 P9011
M01

 (TOOL -1- MILL DIA 6.0 R0. MM )
G90 G00 G40 G54
G43 H1 D31 G0 X7. Y12.5 Z50. S1000 M3
M8
#21 = 0
WHILE [#21 LT 2] DO 1
#22 = 0
WHILE [#22 LT 2] DO 2
M98 P1 (F-profile-T1)
M98 P2 (D-drill-T1)

G90
#22 = #22 + 1
G1
END 2

G90
#21 = #21 + 1
G1
END 1

G90
M98 P9010
M30
O1
(---------------------)
(F-PROFILE-T1 - PROFILE)
(---------------------)
M99
O2

(-----------------)
(D-DRILL-T1 - DRILL)
(-----------------)
G0 X15. Y15. Z10.
G98 G81 Z-5. R2. F33
M98 P3 (drill)
M99
O3
(-------------)
(DRILL - DRILLS)
```

```
(--------------)
   X25.
G80
M99
%

Loop_exist = N


%
O5000 (.TAP)

G54
M98 P9011
M01

 (TOOL -1- MILL DIA 6.0 R0. MM )
G90 G00 G40 G54
G43 H1 D31 G0 X7. Y12.5 Z50. S1000 M3
M8
M98 P1 (F-profile-T1)
M98 P2 (D-drill-T1)
G10G91 L2 P1 X60. Y0. Z0.
G90
M98 P1 (F-profile-T1)
M98 P2 (D-drill-T1)
G10G91 L2 P1 X60. Y0. Z0.
G90
G10G91 L2 P1 X-120. Y30. Z0.
G90
M98 P1 (F-profile-T1)
M98 P2 (D-drill-T1)
G10G91 L2 P1 X60. Y0. Z0.
G90
M98 P1 (F-profile-T1)
M98 P2 (D-drill-T1)
G10G91 L2 P1 X60. Y0. Z0.
G90
G10G91 L2 P1 X-120. Y30. Z0.
G90
G10G91 L2 P1 X0. Y-60. Z0.
G90
M98 P9010
M30
O1
(---------------------)
(F-PROFILE-T1 - PROFILE)
(---------------------)

M99
O2
(-----------------)
(D-DRILL-T1 - DRILL)
```

```
(----------------)

M98 P3 (drill)
M99
O3
(-------------)
(DRILL - DRILLS)
(-------------)
  X25.
G80
M99
%
```

3.1.4.11. same_sub_numbers type: logical {Y/N}

If same_sub_numbers = "Y", all G-code programs that are created in a part with splits have subroutines that start with the same number of the first block.

Note:
In order this parameter will be activated the parameter seq_sub_number must be set to 'Y'.

Example:

same_sub_numbers = Y
seq_sub_number = Y

```
O5000 (.TAP )
M98 P8060

G56 P109 Z-5. A5000. F5000. H0.(F-profile-T4)

M98 P8060
M30
O0109

M99
O0110
(- CLOSE PROGRAM -)
M30
%
------- split -------
%
O5001 (.TAP )
M98 P8060

G56 P109 Z-30. A33. F100. H0.(F-profile-T5)

M98 P8060
M30
O0109
```

```
M99
O0110
(- CLOSE PROGRAM -)
M30
%
```

same_sub_numbers = N
seq_sub_number = Y

```
%
O5000 (.TAP )
M98 P8060

G56 P109 Z-5. A5000. F5000. H0.(F-profile-T4)

M98 P8060
M30
O0109

M99
O0110
(- CLOSE PROGRAM -)
M30
%
------- split -------
%
O5001 (.TAP )
M98 P8060

G56 P111 Z-30. A33. F100. H0.(F-profile-T5)

M98 P8060
M30
O0111

M99
O0112
(- CLOSE PROGRAM -)
M30
%
```

3.1.4.12. init_var_after_split type: logical {Y/N}

All gpp variables will be initialized in every gcode program in part with splits.

3.1.4.13. software_transform

type: logical {Y/N}

Determines whether **SolidCAM** will enable the enhancements of the transformation feature: several transformations can be performed on one operation (or group of operations), and an additional transformation can be performed on transformed operations. SolidCAM will not use the machine transformation functions and the tool path will be calculated according to the transformation definition.

3.1.4.14. software_transform4x

type: logical {Y/N}

Determines whether **SolidCAM** will enable the enhancements of the transformation 4_axis feature. The tool path will be calculated according to the angle that defined for transformation.

3.1.5. Home

3.1.5.1. num_homes

type: integer

Number of homes available in the CNC machine.

3.1.5.2. dflt_home

type: integer {1 .. num_homes}

The number of the default homes of the CNC machine.

3.1.5.3. home_data_at_start

type: logical {Y/N}

Defines the location where the **@home_data** will be printed either at the beginning of the program after @def_tool or in the end of the program after @end_of_program. The @home_data includes the information of the new home position, rotation of the home etc…

3.1.6. Positioning

3.1.6.1. dflt_start

type: numeric (x, y, z)

This is the default starting position of the tool at the start of the manufacturing of the Part. This value can be changed inside **SolidCAM** through the Part Options field.

3.1.6.2. dflt_end

type: numeric (x, y, z)

This is the default end position of the tool at the end of the manufacturing of the Part. This value can be changed inside **SolidCAM** through the Part Options field.

3.1.6.3. set_z_chng type: logical {Y/N}

This parameter decides how the (Z) value changes during the tool-change.

- If Yes, the tool change occurs at the (Z) position defined by the dflt_tool_chng point.
- If No, then the (Z) position of the tool-change is decided by the controller.

This flag can be changed inside **SolidCAM** through the Part Options field.

3.1.6.4. dflt_tool_chng type : numeric (x, y, z)

Default tool change place.

3.1.6.5. Orient_tool_with_B type: logical {Y/N}

This parameter determined if the B axes turret will orient as the tool orientation defined in the Turning operation of Mill Turn application.

3.1.6.6. First_Turret_type type: integer (enumerator)

(`Rotary_Turret, Linear_Turret, B_axis_Turret`)

This parameter defines the first default turret in the Turning operation of Mill Turn application.

3.1.7. Compensation

3.1.7.1. comp_exist type: logical {Y/N}

- Tells SolidCAM whether there is a tool-radius compensation ability in the CNC machine.
- If No, This option is disabled in the Job dialog.

Note:

Even if the CNC machine has a tool-radius compensation capability, the user can decide not to use this machine feature in case he wants to generate G-Code that does not use the tool-compensation feature of the machine.

3.1.7.2. comp_arc_arc type: logical {Y/N}

Tells **SolidCAM** whether the machine controller can activate tool-radius compensation between two connected arcs.

3.1.7.3. comp_arc_line type: logical {Y/N}

Tells **SolidCAM** whether the machine controller can activate tool-radius compensation between a connected line and arc.

3.1.7.4. comp_line_line type: logical {Y/N}

Tells **SolidCAM** whether the machine controller can activate tool-radius compensation between two connected lines.

3.1.7.5. next_angle type: logical {Y/N}

If Yes, the next block direction angle is added to blocks which are not followed by an XY block.

3.1.7.6. comp_x_start type: logical {Y/N}

Specifies how the tool is positioned at the start of the first block, after the tool-radius compensation is activated.

3.1.7.7. comp_by_arcs type: logical {Y/N}

- If Yes, an arc is generated when the machine controller activates tool-radius compensation at the intersection of two lines.
- If No, a line is generated when the machine controller activates compensation at the intersection of two lines.

This option is effect only on Simulation tool-path.

3.1.7.8. Delta_for_TOOL_H type: integer

The delta address of the offset table in the machine controller. Used for the Documentation option only.

3.1.7.9. comp_by_zero_tool type: logical {Y/N}

Tells **SolidCAM** whether the tool-radius compensation is zero (if Yes) or tool radius (if No).

3.1.7.10. BS_tools_off_delta type: integer

This parameter defines the delta offset number of Back Spindle tools from the main spindle tools numbers.

3.1.8. Line Definitions

3.1.8.1. divide_to_segments

type: logical {Y/N}

Tells **SolidCAM** whether or not to divide line to segments.

Example:

divide_to_segments = Y
segment_length = 0.5

```
%
O5000 (.TAP)

M98 P9011
M01

M98 P101 (F-profile-T1)
M98 P9010
M30
O101
(---------------------)
(F-PROFILE-T1 - PROFILE)
(---------------------)
G0 X-3.002 Y-2. Z10.
  Z2.
G1 Z1.5 F33
  Z1.
  Z0.5
  Z0.
  Z-0.5
  Z-1.
G41 G1 Y-1.5
  Y-1.
  Y-0.5
  Y0.
  Y0.5
  Y1.
  Y1.5
  Y2.
  Y2.5
  Y3.
  Y3.5
  Y4.
  Y4.5
  Y5.
  Y5.5
  Y6.
  Y6.5
  Y7.
  Y7.5
```

```
  Y8.
  Y8.5
  Y9.
  Y9.5
  Y10.
  Y10.5
  Y11.
G40 G1 X-3.002
G0 Z10.
M99
%
```

divide_to_segments = N

```
%
O5000 (.TAP)

G54
M98 P9011
M01

M98 P101 (F-profile-T1)
M98 P9010
M30
O101
(---------------------)
(F-PROFILE-T1 - PROFILE)
(---------------------)
G0 X-3.002 Y-2. Z10.
  Z2.
G1 Z-1. F100
G41 G1 Y11.
G40 G1 X-3.002
G0 Z10.
M99
%
```

3.1.8.2. segment_length

type: numeric

This parameter defines the segment length (when line is divided into linear segments).

3.1.9. Arc Definitions

3.1.9.1. arc_exist type: logical {Y/N}

The arc_exist parameter enables you to define the default state and availability of the Approximate arcs by lines. The value of this parameter is defined by two booleans: the first one defines the availability of the arcs command; the second one defines the default state of the arc command. If it is N the arc is divided into linear segments.

The default value of the arc_exist parameter in the MAC-file is Y Y.

3.1.9.2. arc_3d type: logical {Y/N}

Tells **SolidCAM** whether or not the CNC machine has helical arcs. If it doesn't, a helical arc is divided into linear segments.

Note:

Helical Arcs are generated when there is a limit on a curved surface.

Example:

arc_3d = Y

```
%
O5000 (.TAP)

G54
M98 P9011
M01
M98 P1 (P- POCKET -T1)

M98 P9010
M30
O1
(--------------------)
(P- POCKET -T1 - POCKET)
(--------------------)
G0 X182.414 Y32.5 Z10.
  Z2.
G3 X165.856 Y40.05 Z0. R10. F100
  X171.015 Y22.598 Z-2. R10.
  X173.813 Y42.402 R-10. F300
  X171.015 Y22.598 R-10.
G1 X172.414 Y32.5
  X177.5
  Y51.538
  X174.919 Y54.119
G2 X172.414 Y32.5 R38.
```

```
G0 Z10.
M99
%
```

arc_3d = N

```
%
O5000 (.TAP)

G54
M98 P9011
M01

M98 P1 (P- POCKET -T1)
M98 P9010
M30
O1
(--------------------)
(P- POCKET -T1 - POCKET)
(--------------------)
G0 X182.414 Y32.5 Z10.
  Z2.
G1 X182.271 Y34.185 Z1.852 F100
  X181.846 Y35.822 Z1.704
  X181.151 Y37.364 Z1.556
  X180.207 Y38.767 Z1.407
  X179.039 Y39.991 Z1.259
  X177.682 Y41. Z1.111
  X176.174 Y41.766 Z0.963
  X174.559 Y42.267 Z0.815
  X172.882 Y42.489 Z0.667
  X171.192 Y42.425 Z0.519
  X169.537 Y42.077 Z0.37
  X167.964 Y41.455 Z0.222
  X166.518 Y40.577 Z0.074
  X165.241 Y39.468 Z-0.074
  X164.17 Y38.159 Z-0.222
  X163.334 Y36.689 Z-0.37
  X162.758 Y35.099 Z-0.519
  X162.458 Y33.434 Z-0.667
  X162.443 Y31.743 Z-0.815
  X162.713 Y30.074 Z-0.963
  X163.261 Y28.473 Z-1.111
  X164.07 Y26.988 Z-1.259
  X165.118 Y25.661 Z-1.407
  X166.375 Y24.529 Z-1.556
  X167.805 Y23.626 Z-1.704
  X169.366 Y22.976 Z-1.852
  X171.015 Y22.598 Z-2.
G3 X173.813 Y42.402 R-10. F300
```

```
  X171.015 Y22.598 R-10.
G1 X172.414 Y32.5
  X177.5
  Y51.538
  X174.919 Y54.119
G2 X172.414 Y32.5 R38.

G0 Z10.
M99
%
```

3.1.9.3. arc_3d_4x type: logical {Y/N}

Tells **SolidCAM** whether or not the CNC machine has arcs with deferent depth on the 4 axis. If it doesn't, an arc is divided into linear segments

3.1.9.4. arc_quadrants type: logical {Y/N}

Tells **SolidCAM** whether or not it needs to divide the arc into quadrants.

Example:

arc_quadrants = Y

```
%
O5000 (.TAP)

G54
M98 P9011
M01
N1 M6 T1
M8

M98 P1 (F-profile-T1)
M98 P9010
M30
O1
(---------------------)
(F-PROFILE-T1 - PROFILE)
(---------------------)
G0 X26. Y-4. Z9.
  Z1.
G1 Z-6. F33
G2 X-4. Y26. R30. F100
  X26. Y56. R30.
  X56. Y26. R30.
  X26. Y-4. R30.
G0 Z9.
M99
```

```
%
```

arc_quadrants = N

```
%
O5000 (.TAP)

G54
M98 P9011
M01

M8
M98 P1 (F-profile-T1)
M98 P9010
M30
O1
(---------------------)
(F-PROFILE-T1 - PROFILE)
(---------------------)
G0 X26. Y-4. Z9.
  Z1.
G1 Z-6. F33
G2 X26. Y56. R-30. F100
  X26. Y-4. R-30.
G0 Z9.
M99
%
```

3.1.9.5. arc_gt_180

type: logical {Y/N}

Tells **SolidCAM** whether or not the machine has arcs greater than 180 degrees. If it doesn't, such an arc is split into two arcs.

Example:

arc_gt_180 = Y

```
(---------------------)
(F-PROFILE-T1 - PROFILE)
(---------------------)
G0 X43. Y100. Z10.
  Z2.
G1 Z-10. F33
G3 X151.816 Y123.75 R-57. F100
G0 Z10.
M99
```

arc_gt_180 = N

```
  (---------------------)
(F-PROFILE-T1 - PROFILE)
(---------------------)
G0 X43. Y100. Z10.
  Z2.
G1 Z-10. F33
G3 X112.155 Y44.311 R57. F100
  X151.816 Y123.75 R57.
G0 Z10.
M99
```

3.1.9.6. arc_max_chord type: numeric

Max chord length (when arc is divided into linear segments).

3.1.9.7. arc_max_angle type: numeric

Max angle size (when arc is divided into linear segments).

3.1.9.8. arc_max_radius type: numeric

The maximum arc radius value above which the arc is divided into linear segments.

3.1.9.9. arc_min_length type: numeric

The smallest arc value below which the arc is converted into a line.

3.1.9.10. arc_zx_yz type: logical {Y/N}

If Yes, it means that **SolidCAM** will generate G_Code that includes arcs in plane ZX (G18) and in plane YZ (G19).
If No, the arc is divided to into linear segments.

3.1.10. Epsilon Values

3.1.10.1. eps_angle type: numeric

The smallest arc angle below which the arc is converted into a line.

3.1.10.2. zero_value type: numeric

The smallest value below which a coordinate is rounded to zero.

3.1.10.3. movement_precision type: integer

This parameter defines the number of digits after the decimal point for coordinate values.

3.1.10.4. min_delt_arc_rad type: numeric

If tool-radius compensation is active, each arc radius must not be smaller than the tool radius plus this value.

3.1.10.5. safety_dist type: numeric

This parameter defines a default value for the 'safety_dist' parameter used in the various job data-screens.

3.1.10.6. feed_precision type: integer

This parameter defines the number of digits after the decimal point for Feed values.

3.1.10.7. spin_precision type: integer

This parameter defines the number of digits after the decimal point for Spin values.

3.1.11 Feed-Spin

3.1.11.1. rapid_feed type: numeric

This parameter defines the feed rate of the rapid positioning movement of the machine. Units: MM/MIN or INCH/MIN as defined by current units setting.

3.1.11.2. max_spin type: numeric

This is the highest spin rate allowed in the machine in cutting movements. The spin value you specify is limited by this value.

If CSS option is used (in Turning) this value is used to limit the machine spin rate.

3.1.11.3. max_feed type: numeric

The highest feed rate allowed in the machine in cutting movements. The feed value you specify is limited by this value.

3.1.11.4. spin_direction type: integer (enumarated) {CCW/CW)

This option is used to specify the spin direction in the G-code programs.

3.1.11.5. acceleration type: numeric

This parameter defines the acceleration of the CNC machine.

3.1.12. Timing

3.1.12.1. time_factor type: numeric

The tool path time calculated in the simulation process is multiplied by this factor. It is used to improve the accuracy of the working time calculations.

3.1.12.2. block_time type: numeric

This parameter determines the extra time (in seconds) of every movement block. It is added to every block in order to improve the accuracy of the working time calculation.

3.1.12.3. change_tool_time type: numeric

This parameter determines the time (in seconds) of tool change; it is used for working time calculations.

3.1.12.4. calc_job_time type: logical {Y/N}

Tells **SolidCAM** whether to calculate the job time.

3.1.13 Coolant_options

Tells **SolidCAM** whether and which coolant options are supported by the current CNC-machine.

3.1.13.1. Flood_coolant type: logical {Y/N}

Tells **SolidCAM** whether or not the the CNC machine support the Flood_coolant option.

3.1.13.2. Mist_coolant type: logical {Y/N}

Tells **SolidCAM** whether or not the the CNC machine support the Mist_coolant option.

3.1.13.3. HP_Flood_coolant type: logical {Y/N}

Tells **SolidCAM** whether or not the CNC machine support the HP_Flood_coolant option.

3.1.13.4. LP_Flood_coolant type: logical {Y/N}

Tells **SolidCAM** whether or not the CNC machine support the LP_Flood_coolant option.

3.1.13.5. HP_Through_coolant

type: logical {Y/N}

Tells **SolidCAM** whether or not the CNC machine support the HP_Through_coolant option.

3.1.13.6. LP_Through_coolant

type: logical {Y/N}

Tells **SolidCAM** whether or not the CNC machine support the LP_Through_coolant option.

3.1.13.7. Air_Blast_coolant

type: logical {Y/N}

Tells **SolidCAM** whether or not the CNC machine support the Air_Blast_coolant option.

3.1.13.8. Minimum_Quantity_L

type: logical {Y/N}

Tells **SolidCAM** whether or not the CNC machine support the Minimum_Quantity_L option.

3.1.14. CAM-Part Options

3.1.14.1. options

type: integer (enumerated)

{INTEGER/LOGICAL/NUMERIC/STRING}

This parameter enables you to define new user-defined parameters. The values of these parameters are defined to be entered in the Mac options list dialog box during the CAM-Part definition. These parameters can be used later in GPPL.

Example:

options = abc INTEGER

Defines a parameter of the integer type with the name abc.

SolidCAM enables you to define a language-dependent Mac-options. In this case the language extension has to be added to the options command.

Example:

options_chi = Parameter INTEGER

This command enables you to define the Mac-option available in Chinese language environment.

The following extensions are available:

_chi	Chinese	_ita	Italian
_cze	Czech	_jap	Japanese
_dan	Danish	_kor	Korean
_eng	English	_pol	Polish
_fre	French	_por	Portugu
_ger	German	_rus	Russian
_heb	Hebrew	_spa	Spanish
_hun	Hungaria n	_tur	Turkish

3.1.15. Clamp Options

3.1.15.1 Clamp_option

type: integer (enumerated)

{INTEGER/LOGICAL/NUMERIC/STRING}

With this variable, SolidCAM enables you to set user-defined parameters used in Back Spindle operations. This variable can be used more than once, defining an additional parameters. The values of the specific variable can be defined using the Back Spindle Operation options dialog box.

Example:

`clamp_options` = opt1 Logical

Defines a parameter of the logical type with the name opt1.

SolidCAM enables you to define a language-dependent operation options. In this case the language extension has to be added to the `clamp_options` command.

Example:

`clamp_options` _chi = Parameter INTEGER

This command enables you to define the operation option available in Chinese language environment.

3.1.16. Operation Options

3.1.16.1. job_opt_type

type: integer (enumerated)

{INTEGER/LOGICAL/NUMERIC/STRING}

With this variable, **SolidCAM** enables you to set user-defined parameters used in machining operations. This variable can be used more than once, defining an additional parameters. The values of the specific variable can be defined using the Operation options dialog box.

Example:

job_opt_type = coolant Logical

Defines a parameter of the logical type with the name coolant.

SolidCAM enables you to define a language-dependent operation options. In this case the language extension has to be added to the job_opt_type command.

Example:

job_opt_type_chi = Parameter INTEGER

This command enables you to define the operation option available in Chinese language environment.

3.1.17. Drill Cycle

3.1.17.1. drill_type

Type: Integer (enumerator)

{*DRILLING/F_DRILL/PECK/TAPPING/BORING/R_BORING/F_BORING*}

This variable enables you to specify the available drilling options. This variable can be used more than once, defining an additional drilling cycles. Defined drilling cycles can be chosen for the specific drilling operation in the **Drill operation** dialog box.

Example:

drill_type = drill DRILLING Y

where **drill** is the cycle name that will be displayed in the **Drill operation** dialog box; **Drilling** is the cycle type ID that defines the cycle G-Code that will be chosen, **Y** is the logical flag that defines either the CNC-controller can perform such cycle.

SolidCAM enables you to define a language-dependent drill cycles. In this case the language extension has to be added to the **drill_type** command.

Example:

drill_type_chi = drill DRILLING Y

This command enables you to define the drill option available in Chinese language environment.

3.1.18. Turning Cycles

3.1.18.1. turn_type

Type: Integer (enumerator) {*INTEGER/LOGICAL/NUMERIC/STRING*}

With this variable, SolidCAM enables you to set user-defined parameters used in turning operations. This variable can be used more than once, defining an additional parameters. The values of the specific variable can be defined using the Operation options dialog box.

Example:

turn_type = Parameter Logical

Defines a parameter of the logical type with the name **Parameter**.

SolidCAM enables you to define a language-dependent operation options. In this case the language extension has to be added to the **turn_type** command.

Example:

turn_type_chi = Parameter INTEGER

This command enables you to define the operation option available in Chinese language environment.

3.1.19. Threading Cycles

3.1.19.1. thread_type

Type: Integer (enumerator) {INTEGER/LOGICAL/NUMERIC/STRING}

With this variable, SolidCAM enables you to set user-defined parameters used in threading operations. This variable can be used more than once, defining an additional parameters. The values of the specific variable can be defined using the Operation options dialog box.

Example:

thread_type = Parameter Logical

Defines a parameter of the logical type with the name Parameter.

SolidCAM enables you to define a language-dependent operation options. In this case the language extension has to be added to the thread_type command.

Example:

thread_type_chi = Parameter INTEGER

This command enables you to define the operation option available in Chinese language environment.

3.1.20. Grooving Cycles

3.1.20.1. groove_type

Type: Integer (enumerator) {INTEGER/LOGICAL/NUMERIC/STRING}

With this variable, SolidCAM enables you to set user-defined parameters used in grooving operations. This variable can be used more than once, defining an additional parameters. The values of the specific variable can be defined using the Operation options dialog box.

Example:

groove_type = Parameter Logical

Defines a parameter of the logical type with the name Parameter.

SolidCAM enables you to define a language-dependent operation options. In this case the language extension has to be added to the groove_type command.

Example:

groove_type_chi = Parameter INTEGER

This command enables you to define the operation option available in Chinese language environment.

3.1.21. Turning definitions

3.1.21.1. turning_cycle type: logical {Y/N}

This parameter determines whether the machine has a turning cycle.

3.1.21.2. groove_cycle type: logical {Y/N}

This parameter determines whether the machine has a groove cycle.

3.1.21.3. combined_cycles type: logical {Y/N}

This parameter determines whether the machine has a combined cycle process which supports Rough/Copy, semi-finish and finish movements together in one cycle. If not, **SolidCAM** will generate three different cycles, one for each movement.

3.1.21.4. rough_retreat type: logical {Y/N}

This parameter determines whether the rough process of the machine's cycle retreats to the start point ('Y'), or stays on the last point ('N').

3.1.21.5. finish_retreat type: logical {Y/N}

This parameter determines whether the finish process of the machine's cycle retreats to the start point ('Y'), or stays on the last point ('N').

3.1.21.6. semi_finish_retreat type: logical {Y/N}

This parameter determines whether the semi-finish process of the machine's cycle retreats to the start point ('Y'), or stays on the last point ('N').

3.1.21.7. fanuc_cycle type: logical {Y/N}

This parameter determines the simulation method of a turning rough cycle.

- If Yes, the simulation is identical to the FANUC machine cycle.
- If No, the simulation is identical to the OKUMA machine cycle.

3.1.22. Fourth axis

3.1.22.1. init_cpos type:logical {Y/N}

This parameter defines whether the machine can define the angle of the home i.e., the machine can set the current rotation angle to be a different given angle.

For example:

'init_cpos' should be 'Y' if the machine can be set so that the current rotation angle of 390 is set to 30.

3.1.22.2. polar_4x type : logical {Y/N}

If Yes, enables eficient G-Code for machines with forth axis, that know how to break tool path in polar units, into small lines.

3.1.22.3. cartez_4x type : logical {Y/N}

If Yes, enables eficient G-Code for machines with forth axis, that know how to break tool path in cartezian units, into small lines.

3.1.22.4. set_dir type : logical {Y/N}

If Yes, enables G-Code that uses C axis of machines with forth axis (CW/CCW). This enables use of normalized C units.

3.1.22.5. Fourth_axis_letter type: integer {C}

Defines the fourth axes letter in the show data simulation screen.

3.1.23. Sim Five axis

3.1.23.1. kinematic_type type: integer (enumerator)

{TABLE_TABLE , HEAD_HEAD, HEAD_TABLE}

This parameter determine the cinematic type of the machine: there are three different common types of 5 axis machines:

♦. HEAD_HEAD both rotation axes are mounted on the head of the machine

♦ TABLE_TABLE both rotation axes are mounted on the table

♦ HEAD_TABLE one rotation axis is mounted on the head another one on the table of the machine

3.1.23.2. spindle_direction type: numeric (x, y, z)

This parameter defines the spindle direction.
Default value: 0.0000 0.0000 1.0000

3.1.23.3. rotate_axis_dir1 type: numeric (x, y, z)

This parameter defines the directions of the first rotation axes.
Default value: 0.0000 0.0000 -1.0000

3.1.23.4. rotate_axis_dir2 type: numeric (x, y, z)

This parameter defines the directions of the second rotation axes
Default value: 0.0000 -1.0000 0.0000

Note:

If the spindle direction is parallel to z axis then the C axis must be always the first rotation axis. You will get an invalid machine configuration if the C axis is defined as the second rotation axis.

3.1.23.5. rot_axis_base_pnt1

type: numeric (x, y, z)

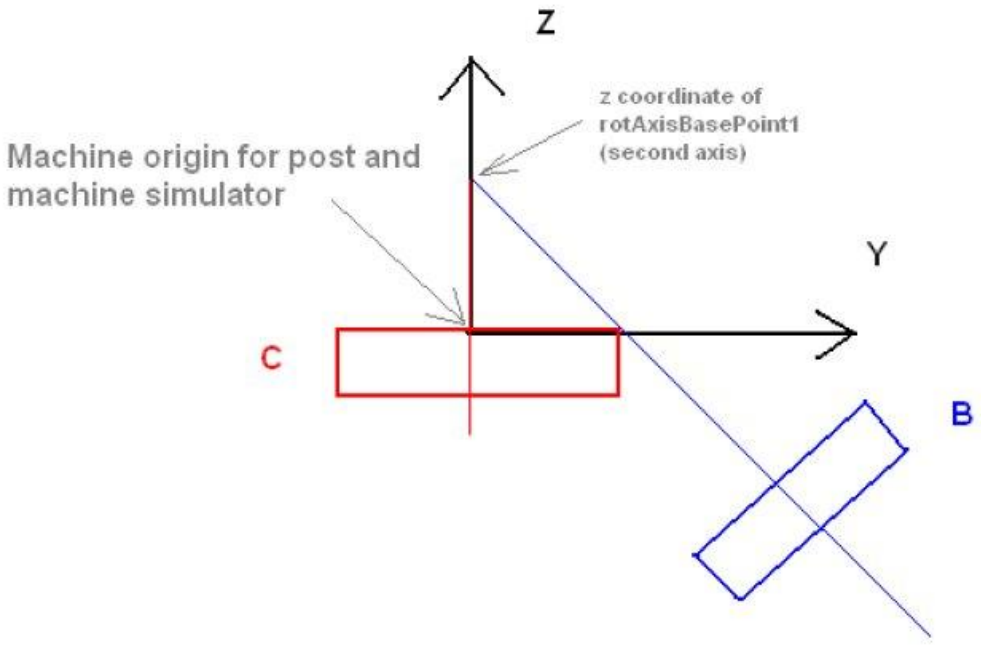
This parameter defines the base points of the first rotation axes.
Default value: 0.0000 0.0000 0.0000

3.1.23.6. rot_axis_base_pnt2

type: numeric (x, y, z)

This parameter defines the base points of the second rotation axes.
Default value: 0.0000 0.0000 0.0000

In general, the rotAxisBasePoint0 is expected to be 0,0,0. The z component of the rotAxisBasePoint1 defines the height where lines describing both rotational axes are intersecting. The following picture shows the z component of the second rotary axis base point:



3.1.23.7. pivot_length

type :numeric

This parameter defines the distance from the face of the machine to the rotation point of the two rotary axis.
It is used only in case that kinematic_type is HEAD_HEAD.

3.1.23.8. first_rot_axis_name

type: integer (enumerator) {A, B, C}

This parameter defines the first rotation axis name.
This parameter is related to the two parameters Spindle direction and rotate_axis_dir1.

The common value of this parameter is : C.

3.1.23.9. second_rot_axis_name type: integer (enumerator) {A, B, C}

This parameter defines the first rotation axis name.
This parameter is related to the two parameters Spindle direction and rotate_axis_dir2.
The common values of this parameter are :A or B.

3.1.23.10. machine_simulation ype: string {filename}

This parameter defines the machine simulation name.
The parameter value must include the full path for necessary machine simulation file name as exists in the Sim 5Axes Machine Simulation definition subdirectory.
\SolidCAM2005\Tables\Metric\MachSim\xml

3.1.23.11. rot_axis_min_limit0 type :numeric

This parameter defines the min limit for the rotational axis set in parameter first_rot_axis_name.

3.1.23.12. rot_axis_min_limit1 type :numeric

This parameter defines the min limit for the rotational axis set in parameter second_rot_axis_name.

3.1.23.13. rot_axis_max_limit0 type :numeric

This parameter defines the max limit for the rotational axis set in parameter first_rot_axis_name.

3.1.23.14. rot_axis_max_limit1 type :numeric

This parameter defines the max limit for the rotational axis set in parameter second_rot_axis_name.

3.1.23.15. auto_angle_pair type : logical {Y/N}

This parameter is the auto angle pair selection flag of the post processor. A 5 axis vector can always be mapped into two different angle pairs. This flag is set to true, if the post should determine automatically which pair of angle to use. In this case, the post would select the angle pair that would not create a very large angle change from previous posted position. Some machines can only use one of the angle pairs due to mechanical limitations. In such case, this

flag must be set true and the angle select other pair parameter should be utilized to use the one or the other angle pair.

3.1.23.16. other_angle_pair type : logical {Y/N}

This parameter tells the post to take the one angle pair or the other angle pair (there are always 2 mathematically possible pairs) This parameter is used only if auto angle pair is turned off. If auto angle pair is turned on, then this flag is used to determine the selection of the very first angle pair. After the first move, all subsequent angle pair selections will be performed by the auto selection.

3.1.23.17. angle_change_limit type :numeric

This value in degrees sets the angle change limit in degrees from one posted tool path position to the next one. If the angle change between two tool path positions is larger than this limit, then a retract move is applied by the post. The retract distance is set by the user in a further parameter. The default value is 150 degrees. E.g. if this limit is 100 degree and the C axis is moving from C10 to C170, then such a move will be considered as a large angle change and a retract motion is applied.

3.1.23.18. interplat_angle_step type :numeric

This value is the interpolation angle step in degrees, the post processor will interpolate between posted tool path positions using this angle. The default value is 3 degrees,
E.g. if the C axis moves from C10 to C22, then the interpolator will add C13, C16, C19 moves between C10 and C22.

3.1.23.19. interplat_for_dist type : logical {Y/N}

This parameter sets the interpolator for distance on and off; this is default wise set to false

3.1.23.20. interplat_distance type :numeric

This function sets the interpolation distance in units (mm or inch). The post processor will interpolate between two tool tip positions (part coord.) using this threshold value.
The default value is 1mm for metric units and 0.05 in for English units E.g. if the tool tip moves from 0,0,0 to 0,0,100 and the interpolation distance is set to 10, then 9 moves are added between the start and end moves, the interpolator will add 0,0,10, then 0,0,20 etc.

3.1.23.21. retract_distance type :numeric

This value determines the retract distance of the tool from the part if a large angle change is detected based on the limit defined by angle change limit.
The default value is 100 mm for metric and 4 in for English units

3.1.23.22. center_rot_mac_num type: integer

This parameter defines the home number that around it all the rotation movements of the transformation done.

3.1.23.23. min_inverse_feed type :numeric

This parameter defines the line generation time.
This is the inverse_feed value which used for Line_4x and Line_5x in case that the user defined feed is small or equal 0.001.
If user defined feed is bigger then 0.001 the inverse feed is calculated according to the following formula:

Inverse_feed = <Line length> / feed

3.1.23.24. enable_mx_edit type : logical {Y/N}

If yes, it enable to change inside the 5 Axes Job the value of the following two parameters:

auto_angle_pair
other_angle_pair

3.1.23.25. pole_angle_tolerance **type :numeric**

This parameter defines the pole areas where the rotary axis and spindle direction are parallel.

3.1.23.26. use_machine_limits type : logical {Y/N}

This parameter defines whether to use the machine limits in both translational and rotational axis.
If No, then the machine limits defined in machine definition will be ignored. This is the default setting.

If Yes, then the machine limits defined in machine definition object (both translational and rotational limits) are used.
In this case the result of post processing will be checked against the machine limits and an exception is thrown if the posted tool path is out of the given limits.

Further, this flag implies that the "Auto Angle Pair" selection (see documentation for this item) is based on the machine limits. E.g. if a B axis is limited between 0 and 90 degrees, then the

post will select one of the angle pair results that is within this given range of 0 and 90 degrees. An example is that both B = -30 and B= +30 are possible solutions. In this case, the solution B = -30 is not used and B = +30 is used since +30 degrees is within 0 and 90 degrees. If "Use Machine Limits" is checked, before selecting the angle pair, the two pairs are checked against the angle machine limits (as they are set in the "Machine Definition" tab). If only one pair is valid, this is the pair to be used. If both angle pairs are valid, the one that creates the smallest change is selected, as usual.

3.1.23.27. trans_axis_min_limit

type: numeric (x, y, z)

This parameter defines the min limit for the translation axis.
Default value: -100000, -100000, -100000

3.1.23.28. trans_axis_max_limit

type: numeric (x, y, z)

This parameter defines the max limit for the translation axis.
Default value: 100000, 100000, 100000

3.1.23.29. Use_tool_H_Length

type : logical {Y/N}

This parameter determines whether the tool length offset (H length) will be added to the NC code values (G code) or will be regarded as 0 and tool length correction will be added by activating it on the machine.

3.1.23.30. Use_part_shifting

type : logical {Y/N}

This parameter defines whether to use shifting from machine reference point value defined in Cooordinate system (E.G. MAC1 position 1) or declare it as 0 for G code calculation only. It does not affect the values sent to machine simulation.

3.1.23.31. Use_rot_axis_base_point1

type : logical {Y/N}

This parameter defines whether to use distance from rotational axis value defined in rot_axis_base_point1 or declare it as 0 for G code calculation only. It does not affect the values sent to machine simulation.

3.1.23.32. Use_rot_axis_base_point2

type : logical {Y/N}

This parameter defines whether to use distance from rotational axis value defined in rot_axis_base_point2 or declare it as 0 for G code calculation only. It does not affect the values sent to machine simulation.

3.1.23.33. GCode_part_coordinate type : logical {Y/N}

Machine Tool Control using part coordinates:

There are machine tool controls that can use directly the part coordinate based X,Y,Z values. Heidenhain and Millplus controls are examples of this. A special command like M128 (Heidenhain) or G141 (Millplus) is needed to let the control know that the coordinates in NC program are relative part coordinates. The control resolves the kinematic and also tool length compensation. If you would like to generate such output use Sample Integration and in Machine & Post settings in Writer tab, unselect “Absolute machine coordinates”.

3.1.24. Wire Cut Cycles

3.1.24.1. wc_macro_type

This parameter can be given more than once, defining additional machine (macro) cycles in each line. Each wc_macro_type is followed by:

- Wc_macro_type_name
- The wc_macro_type parameters; these parameters are later prompted in the wc_macro_job screen. All parameters are of numeric type.

3.1.25. Wire Cut parameters

3.1.25.1. lower_guide_level type:numeric

This parameter defines the default value of the wirecut machine lower guide level. You can change this parameter in Home List table.

3.1.25.2. offset_group_name type: string

This parameter defines the filename of wirecut offset table and E-Group definition table. The wirecut offset table will be saved in the file with this name and the ".TAB" extension. The wirecut E-Group definition table will be saved in the file with this name and the ".GRP" extension. The parameter value must include the full path for necessary file from the GPPTOOL subdirectory. For example,

offset_group_name = wire1 - offset table and E-group definition files will be placed in the machines directory (GPPTOOL)

offset_group_name = ..\user\wire2 - offset table and E-Group definition files will be placed in the USER subdirectory

3.1.25.3. u_max

type:numeric

This parameter defines the maximal distance in X axis between lower-guide and upper-guide.

3.1.25.4. v_max

type: numeric

This parameter defines the maximal distance in Y axis between lower-guide and upper-guide.

3.1.25.5. xy_abs

type : logical {Y/N}

- If TRUE, lower-guide coordinates are given in absoloute distance from home position.
- If FALSE, lower-guide coordinates are given in relative distance from previous position.

3.1.25.6. uv_abs

type : logical {Y/N}

- if TRUE, upper-guide coordinates are given in absoloute distance from home position.
- if FALSE, upper-guide coordinates are given in relative distance from previous position.

3.1.25.7. agie

type : logical {Y/N}

Defines whether the CNC wirecut machine controller is agie.

3.2. Examples of [machine.mac] files

3.2.1. FANUC.mac

; FANUC

pre_processor

```
   ;Internal parms

   machine_type          = MILLING
   post_processor        = fanuc
   doc_processor         = fanuc
   gpp_file_ext          = TAP
   mac_holder            = holder
   tool_table_name       = table
   max_g_name_length     = 0
   max_tool_numbers      = 1000
   default_lang          = DEFAULT

   ;Machine Initialize

   machine_plane          = XY
   num_axes               = 4
   num_simult_axes        = 4
   abs_coord              = N
   rotate                 = Y
   mirror                 = Y
   _4th_axes_around       =  X
   first_rotation_angle   = Z
   _5th_axes_around       = Z

   ;Program numbers

   prog_num_min          = 5000
   prog_num_max          = 8999
   prog_num_dflt         = 5000
   get_prog_num          = Y
   proc_num_min          = 1
   proc_num_max          = 8999
   proc_num_dflt         = 1
   get_proc_num          = Y

   ;Procedures control

   full_gcode            = N
   gen_procs             = N
   drill_proc            = N
   gen_internal_proc     = N
```

```
optimize_jobs_loop      = Y
seq_sub_number          = N
loop_exist              = Y
same_sub_numbers        = N
init_var_after_split    = Y

;Home

num_homes               = 6
dflt_home               = 1
home_data_at_start      = N

;Positioning

dflt_start              = 0.0000 200.0000 100.0000, 0.0000 7.8740 3.9370
dflt_end                = 0.0000 200.0000 0.0000, 0.0000 7.8740 0.0000
set_xy_chng             = N N
set_z_chng              = Y N
dflt_tool_chng          = 0.0000 0.0000 0.0000, 0.0000 0.0000 0.0000

;Compensation

comp_exist              = Y N
comp_arc_arc            = Y
comp_arc_line           = Y
comp_line_line          = Y
next_angle              = N
comp_x_start            = N
comp_by_arcs            = N
delta_for_TOOL_H        = 50
comp_by_zero_tool       = N

;Arc definitions

arc_exist               = Y N
arc_3d                  = Y
arc_quadrants           = N
arc_gt_180              = Y
arc_max_chord           = 30.0000, 1.1811
arc_max_angle           = 10.0000
arc_max_radius          = 2000.0000, 78.7402
arc_min_length          = 0.0000, 0.0000
arc_zx_yz               = N

;Epsilon values

eps_angle               = 0.0020
zero_value              = 0.0010, 0.0000
movement_precision      = 0.0010, 0.0000
min_delt_arc_rad        = 0.0100, 0.0004
safety_dist             = 2.0000, 0.0787
```

```
;Feed-Spin

rapid_feed          = 5000.0000, 196.8503
max_spin            = 6000.0000
max_feed            = 6000.0000, 236.2205
spin_direction      = CW

;Timing

time_factor         = 1.0000
block_time          = 0.2000
change_tool_time    = 15.0000

;Coolant_options

;Part options
   options          = G99_X NUMERIC
   options          = G99_Y NUMERIC

;Clamp options

;Job options
job_opt_type        = OPT1 Y  DELY FEAD

;Drill cycles
drill_type          = Drilling Drilling Y
drill_type          = F_Drill F_Drill Y  Delay
drill_type          = Peck Peck Y  Delay
drill_type          = Tapping Tapping Y
drill_type          = Boring Boring Y  Delay
drill_type          = R_Boring R_Boring Y  Delay
drill_type          = F_Boring F_Boring Y  Delay

;Turning cycles

;Threading cycles

;Grooving cycles

;Wire Cut cycles

;Turning definitions
```

```
   ;Fourth axis
   init_cpos              = Y
   polar_4x               = N
   cartez_4x              = N
   set_dir                = N
   fourth_axis_letter     = C

   ;Sim Five axis

   kinematic_type             = HEAD_HEAD
   spindle_direction          = 0.0000 0.0000 1.0000
   rotate_axis_dir1           = 0.0000 0.0000 -1.0000
   rotate_axis_dir2           = 0.0000 -1.0000 0.0000
   rot_axis_base_pnt1         = 0.0000 0.0000 0.0000, 0.0000 0.0000 0.0000
   rot_axis_base_pnt2         = 0.0000 0.0000 0.0000, 0.0000 0.0000 0.0000
   pivot_length               = 0.0000, 0.0000
   first_rot_axis_name        = C
   second_rot_axis_name       = B
   machine_simulation         = HeadHead
   rot_axis_min_limit0        = -100000.0000
   rot_axis_min_limit1        = -100000.0000
   rot_axis_max_limit0        = 100000.0000
   rot_axis_max_limit1        = 100000.0000
   auto_angle_pair            = Y
   other_angle_pair           = Y
   angle_change_limit         = 30.0000
   interplat_angle_step       = 3.0000
   interplat_for_dist         = N
   interplat_distance         = 5.0000, 0.1969
   retract_distance           = 100.0000, 3.9370
   center_rot_mac_num         = 20
   min_inverse_feed           = 100.0000, 3.9370
   enable_mx_edit             = N

endp
```

3.2.2. MAHO.mac

; MAHO-432

```
;Internal parms
machine_type            = MILLING
post_processor          = MAHO432
doc_processor           = MAHO432
gpp_file_ext            = TAP
mac_holder              =  holder
tool_table_name         =  table
max_g_name_length       = 0
max_tool_numbers        = 1000
default_lang            = DEFAULT

;Machine Initialize
machine_plane           = ZX
num_axes                = 4
num_simult_axes         = 4
abs_coord               = N
rotate                  = Y
mirror                  = Y
_4th_axes_around        = Y
first_rotation_angle    = Z
_5th_axes_around        =

;Program numbers
prog_num_min            = 10000
prog_num_max            = 9999999
prog_num_dflt           = 10000
get_prog_num            = Y
proc_num_min            = 10000
proc_num_max            = 99999
proc_num_dflt           = 10000
get_proc_num            = N

;Procedures control
full_gcode              = N
gen_procs               = Y
drill_proc              = Y
gen_internal_proc       = Y
optimize_jobs_loop      = N
seq_sub_number          = N
loop_exist              = Y
same_sub_numbers        = N
init_var_after_split    = Y

;Home
num_homes               = 6
dflt_home               = 1
```

```
home_data_at_start      = N

;Positioning
dflt_start              = 0.0000 100.0000 50.0000, 0.0000 3.9370 1.9685
dflt_end                = 0.0000 100.0000 50.0000, 0.0000 3.9370 1.9685
set_xy_chng             = N N
set_z_chng              = N N
dflt_tool_chng          = 0.0000 100.0000 50.0000, 0.0000 3.9370 1.9685

;Compensation
comp_exist              = Y N
comp_arc_arc            = Y
comp_arc_line           = Y
comp_line_line          = Y
next_angle              = N
comp_x_start            = Y
comp_by_arcs            = N
delta_for_TOOL_H        = 50
comp_by_zero_tool       = N

;Arc definitions
arc_exist               = Y Y
arc_3d                  = Y
arc_quadrants           = N
arc_gt_180              = Y
arc_max_chord           = 2.0000, 0.0787
arc_max_angle           = 10.0000
arc_max_radius          = 2000.0000, 78.7402
arc_min_length          = 0.0000, 0.0000
arc_zx_yz               = N

;Epsilon values
eps_angle               = 0.0020
zero_value              = 0.0010, 0.0000
movement_precision      = 0.0010, 0.0000
min_delt_arc_rad        = 0.0100, 0.0004
safety_dist             = 2.0000, 0.0787

;Feed-Spin
rapid_feed              = 15000.0000, 590.5512
max_spin                = 6000.0000
max_feed                = 15000.0000, 590.5512
spin_direction          = CW

;Timing
time_factor             = 1.0000
block_time              = 0.0000
change_tool_time        = 0.0000

;Part options
options                 = inc_change LOGICAL
options                 = G99_x NUMERIC
options                 = G99_y NUMERIC
```

```
   options                 = G99_z NUMERIC
   options                 = G99_i NUMERIC
   options                 = G99_j NUMERIC
   options                 = G99_k NUMERIC
   options                 = Delta_Mt NUMERIC


   ;Job options

   ;Drill cycles
   drill_type              = G81 Drilling Y
   drill_type              = G83 Peck Y
   drill_type              = G84 Tapping Y
   drill_type              = G73 Peck Y
   ;Wire Cut cycles

   ;Fourth axis

   init_cpos               = Y
   polar_4x                = N
   cartez_4x               = N
   set_dir                 = N
   fourth_axis_letter      = C

   ;Sim Five axis
   kinematic_type          = HEAD_HEAD
   spindle_direction       = 0.0000 0.0000 1.0000
   rotate_axis_dir1        = 0.0000 0.0000 -1.0000
   rotate_axis_dir2        = 0.0000 -1.0000 0.0000
   rot_axis_base_pnt1      = 0.0000 0.0000 0.0000, 0.0000 0.0000 0.0000
   rot_axis_base_pnt2      = 0.0000 0.0000 0.0000, 0.0000 0.0000 0.0000
   pivot_length            = 0.0000, 0.0000
   first_rot_axis_name     = C
   second_rot_axis_name    = B
   machine_simulation      = HeadHead
   rot_axis_min_limit0     = -100000.0000
   rot_axis_min_limit1     = -100000.0000
   rot_axis_max_limit0     = 100000.0000
   rot_axis_max_limit1     = 100000.0000
   auto_angle_pair         = Y
   other_angle_pair        = Y
   angle_change_limit      = 30.0000
   interplat_angle_step    = 3.0000
   interplat_for_dist      = N
   interplat_distance      = 5.0000, 0.1969
   retract_distance        = 100.0000, 3.9370
   center_rot_mac_num      = 20
   min_inverse_feed        = 100.0000, 3.9370
   enable_mx_edit          = N

endp

_
```

CHAPTER 4

4.1. Internal Fast Post-Processor

The Fast-Processor supports the following CNC-Controllers.

FANUC
TIGER_6L
TIGER_TL
_426_PARM
_426PRMCR
MAKINO_W
FANUC_3D
MAHO432_3D
_426_PARM_3D
SIN810_4_3D
OKUMA_3D
FANUC_3D_JAP
ROEDERS
MIKRON23
ROEDERS4
FANUC_3D_KOR

The postprocessor name defined in the mac file must be proceed with '*';
post_processor = *426_parm_3D

4.1.1 Introduction

The Program's name is 'GPPToolExe.exe'.
GPPToolExe.exe is located on the following folder:
\Program Files\SolidCAM2009\SolidCAM
It allows you to choose generate G-code and Cam settings.

4.1.2. Start Program

Choose the menu item "Start" to start the Program and generate G-code.
A dialog box titled "SOLIDCAM-Parts" will appears. Choose the required part. The Gcode of this part will be generated.

If you want to generate G-code with traces click on the check box of "Gcode trace" in the dialog box Settings -> Mac Settings.

The Program produces a G-Code file named as the Part name. The G-Code file is placed in the directory of the chosen Part.

4.1.3. CAM Settings

In the settings dialog you can change the path to your post-processor files and to your user-directory.

There are the following related pages available within the SolidCAM Settings dialog:

- User Directories settings
- Default CNC-Controller

User Directories Settings

The user directory defines the default folder in which CAM-Parts and G-Code files created with SolidCAM are stored. Whenever you load a CAM-Part, SolidCAM will browse the user directory for SolidCAM-Part files (***.prt**). All newly created CAM-Part files will be placed in the user directory by default.

Default CNC-controller settings

Post-processor files directory

GPP files with the extensions ***.mac** and ***.gpp** are post-processor files used by SolidCAM.

- The ***.mac** file contains information about the CNC-machine, e.g. number of simultaneous axes, available cycles, default tool positioning, etc..
- The ***.gpp** file translates the calculated tool path into G-Code. The G-Code format, cycle definitions, etc. of your G-Code file is controlled through this file.

You have to specify the path to the folder where you keep the ***.mac** and ***.gpp** files you have received from SolidCAM. The post-processors that come with the evaluation or demo version are installed in the SolidCAM program directory.

CNC-controllers

SolidCAM enables you to define the default machine controllers:

- **Milling CNC-Controller**
- **Turning CNC-Controller**
- **Milling&Turning CNC-Controller**
- **WireCut CNC-Controller**

These post-processors you selected will be used as the default machine, which means it will appear in the CAM-Part Data dialog as the controller for the new CAM-Part. Naturally, you can change the controller for the CAM-Part with the list field if you want to use another machine controller.

4.2. User Documentation

This option enables you to generate documentation files in different formats for example: Html, Excel, txt, etc...

4.2.1. Mac Doc_processor

You can customize the Documentation output of SOLIDCAM by editing the machine *.mac file and the Doc-processor *.dpp file of your CNC-controller.
The documentation postprocessor includes two files: <machine_name>.dpp and <machine_name>.mac.
These files have to be located on the post-processor files directory defined in the SolidCAM Settings:

\Program Files\SOLIDCAM2009\Gpptool

A parameter named doc_processor has to be defined in the file: machine_name>.mac
The parameter is defined as follows:

doc_processor = <machine_name>

4.2.2. SOLIDCAM User Documentation Commands

When the user asks for the generation of the User Documentation, the documentation is then generated according to the [MACHINE.MAC] and [MACHINE.DPP] files.

There are some new GPPL commands that are helpful in generating the documentation file :

- Create the doc file at the beginning of the documentation generation process:
  { '!! open file = c:\\name.ext !!' }

- Close the doc file at the end of the documentation generation process:
  { '!! close file = c:\\name.ext !!' }

- Copy doc file
  { '!! copy file = c:\\copy_from_name.ext !!' }

- Delete temporary file
  { '!! delete file = c:\\temporary_file_name.ext !!' }

4.2.3. Example of User Documentation

The following example generates the file in Html format.named tool_table.html

1	OBR		Machine description	Arrow					
2	PAR		Type machine	0					
3	MZA		Work material	None					
.									
4	TPR		Part name	PROFILE					
5	TPR		Job name	F-1-T1					
6	PAR		Down step						3.
7	PAR		Toolpath length						1051.426
8	PAR		Surface offset						0.
9	PAR		Wall offset						0.
10	PAR		Floor offset						0.
11	PAR		Island offset						
12	PAR		Number passed						2.
13	PAR		Feed rate						100.
14	PAR		Feed Z						33.
15	PAR		Feed finish						100.
16	PAR		Spin rate						1000.
17	PAR		Spin finish						1000.
18	PAR		Job time						8.349
19	INS		Tool message						
20	PAR		Tool ID	0-0					
21	PAR		Tool material	None					
22	PAR		Holder_description						
.									

The following command needs to be added to the <machine>.dpp file:

Step 1: Define the Variables:

```
@init_post
   global integer tool_count
   global string tool_def<<20,50>>
   global integer job_count
```

```
   global string job_def<<20,150>>
endp
```

Step 2 – Enter values to the variable

```
@start_of_job
  message = msg

job_count = job_count + 1
    job_def<<1,job_count>> =  job_name
    job_def<<2,job_count>> =  tostr(down_step)
    job_def<<3,job_count>> =  tostr(toolpath_length)
    job_def<<4,job_count>> =  tostr(surface_offset)
    job_def<<5,job_count>> =  tostr(wall_offset)
    job_def<<6,job_count>> =  tostr(floor_offset)
    job_def<<7,job_count>> =  tostr(island_offset)

Npr=(abs(depth/down_step)-round(abs(depth/down_step),0))
If Npr > 0 then
Np=round(abs(depth/down_step),0)+1
else
Np=round(abs(depth/down_step),0)
endif

    job_def<<8,job_count>> =  tostr(Np)
    job_def<<9,job_count>> =  tostr(feed_rate)
    job_def<<10,job_count>> = tostr(z_feed)
    job_def<<11,job_count>> = tostr(finish_feed)
    job_def<<12,job_count>> = tostr(spin_rate)
    job_def<<13,job_count>> =  tostr(finish_spin)
    job_def<<14,job_count>> = tostr(job_dtime)
    job_def<<15,job_count>> =  tool_message

t_langth =tostr(tool_ID_number:'8.0(p)')
t1_langth=left( t_langth,4)
t2_langth=right( t_langth,4)

    job_def<<16,job_count>> = t1_langth+'-'+ t2_langth
    job_def<<17,job_count>> =  tool_material
    job_def<<18,job_count>> = holder_description

; {'(MSG, 'message')'}
endp
```

```
@def_tool
    {nb,'(TOOL NUMBER '  tool_NUMBER ' tool_length '  tool_length ' tool_teeth_number '
tool_teeth_number }
    {' corner_radius ' corner_radius}

   tool_count = tool_count + 1
    tool_def<<1,tool_count>> =  tostr(tool_number:integer_def_f)
    tool_def<<2,tool_count>> =  tostr(tool_offset)
    tool_def<<3,tool_count>> =  tostr(tool_length )
    tool_def<<4,tool_count>> =  tostr(tool_teeth_number:integer_def_f)
    tool_def<<5,tool_count>> =  tostr(corner_radius)
    tool_def<<6,tool_count>> =  tostr(tool_type)
    tool_def<<7,tool_count>> =  tostr(tool_feed_z)
    tool_def<<8,tool_count>> =  tostr(tool_feed_finish)
    tool_def<<9,tool_count>> =  tostr(tool_spin_finish)
    tool_def<<10,tool_count>> = tostr(tool_id_number:integer_def_f)
    tool_def<<11,tool_count>> = tostr(tool_angle)
    tool_def<<12,tool_count>> = tool_user_type
    tool_def<<13,tool_count>> =  tostr(program_number:integer_def_f)
    tool_def<<14,tool_count>> =  g_file_name
    tool_def<<15,tool_count>> =  'DMU70_M'
    tool_def<<16,tool_count>> =  ' '
    tool_def<<17,tool_count>> =  tool_message
endp
```

step 3 – Call @doc procedure that will generate the documentation.

```
@end_of_file

   {nb, ' '}
   call @doc
endp
```

Step 4 – Commands generating the documentation.
The procedure has to include a command at the beginning to open the doc file you want to generate and to close it at the end.

```
@doc

   local string t_num
    local integer i num
    local string job_table_file


    job_table_file = 'f:\\SolidCAM2009\\Gpptool\\job_table.html'

      {nl,'!!open file=' job_table_file '!!'}
{nl,'<html>'}
{nl,''}
{nl,'<head>'}
{nl,'<meta http-equiv="Content-Language" content="en-gb">'}
{nl,'<meta http-equiv="Content-Type" content="text/html; charset=windows-1252">'}
{nl,'<meta name="GENERATOR" content="Microsoft FrontPage 4.0">'}
{nl,'<meta name="ProgId" content="FrontPage.Editor.Document">'}
{nl,'<title>SolidCAM SetUp Sheet</title>'}
{nl,'</head>'}
{nl,''}
{nl,'<body>'}
{nl,''}
;
{nl,'  </table>'}
{nl,'  </left>'}

{nl,'  <table border="1" width="81%">'} ; ñîçäàíèå ðàìêè

num=num+1
t_num =tostr(num:'8.0(p)')
{nl,'    </tr>'}
{nl,'      <td>'t_num'</td>'}
{nl,'      <td>OBR</td>'}
{nl,'      <td> </td>'}
{nl,'      <td>Machine description</td>'}
{nl,'      <td>'machine_descr'</td>'}
{nl,'      <td> </td>'}
{nl,'      <td> </td>'}
{nl,'      <td> </td>'}
{nl,'      <td> </td>'}
{nl,'      <td> </td>'}
```

```
{nl,'   </tr>'}
;
num=num+1
t_num =tostr(num:'8.0(p)')
{nl,'   </tr>'}
{nl,'     <td>'t_num'</td>'}
{nl,'     <td>PAR</td>'}
{nl,'     <td> </td>'}
{nl,'     <td>Type machine</td>'}
{nl,'     <td>'job_machine_type'</td>'}
{nl,'     <td> </td>'}
{nl,'     <td> </td>'}
{nl,'     <td> </td>'}
{nl,'     <td> </td>'}
{nl,'     <td> </td>'}
{nl,'   </tr>'}
;
num=num+1
t_num =tostr(num:'8.0(p)')
{nl,'   </tr>'}
{nl,'     <td>'t_num'</td>'}
{nl,'     <td>MZA</td>'}
{nl,'     <td> </td>'}
{nl,'     <td>Work material</td>'}
{nl,'     <td>'work_material'</td>'}
{nl,'     <td> </td>'}
{nl,'     <td> </td>'}
{nl,'     <td> </td>'}
{nl,'     <td> </td>'}
{nl,'     <td> </td>'}
{nl,'   </tr>'}
;
{nl,'   </tr>'}
{nl,'     <td bgcolor="#C0C0C0">.</td>'}
{nl,'     <td bgcolor="#C0C0C0"> </td>'}
{nl,'     <td bgcolor="#C0C0C0"> </td>'}
{nl,'     <td bgcolor="#C0C0C0"> </td>'}
{nl,'     <td bgcolor="#C0C0C0"> </td>'}
{nl,'     <td bgcolor="#C0C0C0"> </td>'}
{nl,'     <td bgcolor="#C0C0C0"> </td>'}
{nl,'     <td bgcolor="#C0C0C0"> </td>'}
{nl,'     <td bgcolor="#C0C0C0"> </td>'}
{nl,'     <td bgcolor="#C0C0C0"> </td>'}
{nl,'   </tr>'}
```

```
    i = 1
  while i <= job_count
        if i <= job_count

num=num+1
t_num =tostr(num:'8.0(p)')
{nl,'    </tr>'}
{nl,'      <td>'t_num'</td>'}
{nl,'      <td>TPR</td>'}
{nl,'      <td> </td>'}
{nl,'      <td>Part name</td>'}
{nl,'      <td>'f_name '</td>'}
{nl,'      <td> </td>'}
{nl,'      <td> </td>'}
{nl,'      <td> </td>'}
{nl,'      <td> </td>'}
{nl,'      <td> </td>'}
{nl,'    </tr>'}
;
num=num+1
t_num =tostr(num:'8.0(p)')
{nl,'    </tr>'}
{nl,'      <td>'t_num'</td>'}
{nl,'      <td>TPR</td>'}
{nl,'      <td> </td>'}
{nl,'      <td>Job name</td>'}
{nl,'      <td>'job_def<<1,i>>'</td>'}
{nl,'      <td> </td>'}
{nl,'      <td> </td>'}
{nl,'      <td> </td>'}
{nl,'      <td> </td>'}
{nl,'      <td> </td>'}
{nl,'    </tr>'}
;
num=num+1
t_num =tostr(num:'8.0(p)')
{nl,'    </tr>'}
{nl,'      <td>'t_num'</td>'}
{nl,'      <td>PAR</td>'}
{nl,'      <td> </td>'}
{nl,'      <td>Down step</td>'}
{nl,'      <td> </td>'}
{nl,'      <td> </td>'}
{nl,'      <td> </td>'}
{nl,'      <td> </td>'}
```

```
{nl,'     <td> </td>'}
{nl,'     <td>'job_def<<2,i>>'</td>'}
{nl,'   </tr>'}
;
num=num+1
t_num =tostr(num:'8.0(p)')
{nl,'   </tr>'}
{nl,'     <td>'t_num'</td>'}
{nl,'     <td>PAR</td>'}
{nl,'     <td> </td>'}
{nl,'     <td>Toolpath length</td>'}
{nl,'     <td> </td>'}
{nl,'     <td> </td>'}
{nl,'     <td> </td>'}
{nl,'     <td> </td>'}
{nl,'     <td> </td>'}
{nl,'     <td>'job_def<<3,i>>'</td>'}
{nl,'   </tr>'}
;
num=num+1
t_num =tostr(num:'8.0(p)')
{nl,'   </tr>'}
{nl,'     <td>'t_num'</td>'}
{nl,'     <td>PAR</td>'}
{nl,'     <td> </td>'}
{nl,'     <td>Surface offset</td>'}
{nl,'     <td> </td>'}
{nl,'     <td> </td>'}
{nl,'     <td> </td>'}
{nl,'     <td> </td>'}
{nl,'     <td> </td>'}
{nl,'     <td>'job_def<<4,i>>'</td>'}
{nl,'   </tr>'}
;
num=num+1
t_num =tostr(num:'8.0(p)')
{nl,'   </tr>'}
{nl,'     <td>'t_num'</td>'}
{nl,'     <td>PAR</td>'}
{nl,'     <td> </td>'}
{nl,'     <td>Wall offset</td>'}
{nl,'     <td> </td>'}
{nl,'     <td> </td>'}
{nl,'     <td> </td>'}
{nl,'     <td> </td>'}
```

```
{nl,'     <td> </td>'}
{nl,'     <td>'job_def<<5,i>>'</td>'}
{nl,'   </tr>'}
;
num=num+1
t_num =tostr(num:'8.0(p)')
{nl,'   </tr>'}
{nl,'     <td>'t_num'</td>'}
{nl,'     <td>PAR</td>'}
{nl,'     <td> </td>'}
{nl,'     <td>Floor offset</td>'}
{nl,'     <td> </td>'}
{nl,'     <td> </td>'}
{nl,'     <td> </td>'}
{nl,'     <td> </td>'}
{nl,'     <td> </td>'}
{nl,'     <td>'job_def<<6,i>>'</td>'}
{nl,'   </tr>'}
;
num=num+1
t_num =tostr(num:'8.0(p)')
{nl,'   </tr>'}
{nl,'     <td>'t_num'</td>'}
{nl,'     <td>PAR</td>'}
{nl,'     <td> </td>'}
{nl,'     <td>Island offset</td>'}
{nl,'     <td> </td>'}
{nl,'     <td> </td>'}
{nl,'     <td> </td>'}
{nl,'     <td> </td>'}
{nl,'     <td> </td>'}
{nl,'     <td> </td>'}
;{nl,'     <td>'job_def<<7,i>>'</td>'}
{nl,'   </tr>'}
;
num=num+1
t_num =tostr(num:'8.0(p)')
{nl,'   </tr>'}
{nl,'     <td>'t_num'</td>'}
{nl,'     <td>PAR</td>'}
{nl,'     <td> </td>'}
{nl,'     <td>Number passed</td>'}
{nl,'     <td> </td>'}
{nl,'     <td> </td>'}
{nl,'     <td> </td>'}
```

```
{nl,'     <td> </td>'}
{nl,'     <td> </td>'}
{nl,'     <td>'job_def<<8,i>>'</td>'}
{nl,'   </tr>'}
;
num=num+1
t_num =tostr(num:'8.0(p)')
{nl,'   </tr>'}
{nl,'     <td>'t_num'</td>'}
{nl,'     <td>PAR</td>'}
{nl,'     <td> </td>'}
{nl,'     <td>Feed rate</td>'}
{nl,'     <td> </td>'}
{nl,'     <td> </td>'}
{nl,'     <td> </td>'}
{nl,'     <td> </td>'}
{nl,'     <td> </td>'}
{nl,'     <td>'job_def<<9,i>>'</td>'}
{nl,'   </tr>'}
;
num=num+1
t_num =tostr(num:'8.0(p)')
{nl,'   </tr>'}
{nl,'     <td>'t_num'</td>'}
{nl,'     <td>PAR</td>'}
{nl,'     <td> </td>'}
{nl,'     <td>Feed Z</td>'}
{nl,'     <td> </td>'}
{nl,'     <td> </td>'}
{nl,'     <td> </td>'}
{nl,'     <td> </td>'}
{nl,'     <td> </td>'}
{nl,'     <td>'job_def<<10,i>>'</td>'}
{nl,'   </tr>'}
;
num=num+1
t_num =tostr(num:'8.0(p)')
{nl,'   </tr>'}
{nl,'     <td>'t_num'</td>'}
{nl,'     <td>PAR</td>'}
{nl,'     <td> </td>'}
{nl,'     <td>Feed finish</td>'}
{nl,'     <td> </td>'}
{nl,'     <td> </td>'}
{nl,'     <td> </td>'}
```

```
{nl,'     <td> </td>'}
{nl,'     <td> </td>'}
{nl,'     <td>'job_def<<11,i>>'</td>'}
{nl,'   </tr>'}
;
num=num+1
t_num =tostr(num:'8.0(p)')
{nl,'   </tr>'}
{nl,'     <td>'t_num'</td>'}
{nl,'     <td>PAR</td>'}
{nl,'     <td> </td>'}
{nl,'     <td>Spin rate</td>'}
{nl,'     <td> </td>'}
{nl,'     <td> </td>'}
{nl,'     <td> </td>'}
{nl,'     <td> </td>'}
{nl,'     <td> </td>'}
{nl,'     <td>'job_def<<12,i>>'</td>'}
{nl,'   </tr>'}
;
num=num+1
t_num =tostr(num:'8.0(p)')
{nl,'   </tr>'}
{nl,'     <td>'t_num'</td>'}
{nl,'     <td>PAR</td>'}
{nl,'     <td> </td>'}
{nl,'     <td>Spin finish</td>'}
{nl,'     <td> </td>'}
{nl,'     <td> </td>'}
{nl,'     <td> </td>'}
{nl,'     <td> </td>'}
{nl,'     <td> </td>'}
{nl,'     <td>'job_def<<13,i>>'</td>'}
{nl,'   </tr>'}
;
num=num+1
t_num =tostr(num:'8.0(p)')
{nl,'   </tr>'}
{nl,'     <td>'t_num'</td>'}
{nl,'     <td>PAR</td>'}
{nl,'     <td> </td>'}
{nl,'     <td>Job time</td>'}
{nl,'     <td> </td>'}
{nl,'     <td> </td>'}
{nl,'     <td> </td>'}
```

```
{nl,'     <td> </td>'}
{nl,'     <td> </td>'}
{nl,'     <td>'job_def<<14,i>>'</td>'}
{nl,'   </tr>'}
;
num=num+1
t_num =tostr(num:'8.0(p)')
{nl,'   </tr>'}
{nl,'     <td>'t_num'</td>'}
{nl,'     <td>INS</td>'}
{nl,'     <td> </td>'}
{nl,'     <td>Tool message</td>'}
{nl,'     <td>'job_def<<15,i>>'</td>'}
{nl,'     <td> </td>'}
{nl,'     <td> </td>'}
{nl,'     <td> </td>'}
{nl,'     <td> </td>'}
{nl,'     <td> </td>'}
{nl,'   </tr>'}
;
num=num+1
t_num =tostr(num:'8.0(p)')
{nl,'   </tr>'}
{nl,'     <td>'t_num'</td>'}
{nl,'     <td>PAR</td>'}
{nl,'     <td> </td>'}
{nl,'     <td>Tool ID</td>'}
{nl,'     <td>'job_def<<16,i>>'</td>'}
{nl,'     <td> </td>'}
{nl,'     <td> </td>'}
{nl,'     <td> </td>'}
{nl,'     <td> </td>'}
{nl,'     <td> </td>'}
{nl,'   </tr>'}
;
num=num+1
t_num =tostr(num:'8.0(p)')
{nl,'   </tr>'}
{nl,'     <td>'t_num'</td>'}
{nl,'     <td>PAR</td>'}
{nl,'     <td> </td>'}
{nl,'     <td>Tool material</td>'}
{nl,'     <td>'job_def<<17,i>>'</td>'}
{nl,'     <td> </td>'}
{nl,'     <td> </td>'}
```

```
{nl,'     <td> </td>'}
{nl,'     <td> </td>'}
{nl,'     <td> </td>'}
{nl,'   </tr>'}
;
num=num+1
t_num =tostr(num:'8.0(p)')
{nl,'   </tr>'}
{nl,'     <td>'t_num'</td>'}
{nl,'     <td>PAR</td>'}
{nl,'     <td> </td>'}
{nl,'     <td>Holder_description</td>'}
{nl,'     <td>'job_def<<18,i>>'</td>'}
{nl,'     <td> </td>'}
{nl,'     <td> </td>'}
{nl,'     <td> </td>'}
{nl,'     <td> </td>'}
{nl,'     <td> </td>'}
{nl,'   </tr>'}
;
{nl,'   </tr>'}
{nl,'     <td bgcolor="#C0C0C0">.</td>'}
{nl,'     <td bgcolor="#C0C0C0"> </td>'}
{nl,'     <td bgcolor="#C0C0C0"> </td>'}
{nl,'     <td bgcolor="#C0C0C0"> </td>'}
{nl,'     <td bgcolor="#C0C0C0"> </td>'}
{nl,'     <td bgcolor="#C0C0C0"> </td>'}
{nl,'     <td bgcolor="#C0C0C0"> </td>'}
{nl,'     <td bgcolor="#C0C0C0"> </td>'}
{nl,'     <td bgcolor="#C0C0C0"> </td>'}
{nl,'     <td bgcolor="#C0C0C0"> </td>'}
{nl,'   </tr>'}
         else
  endif
            i = i + 1
    endw

        {nl,'!!close file='job_table_file'!!'}
endp
```

CHAPTER 5

5. GPPL language

5.1. Introduction

General Post Processor Language (GPPL) is a high-level programming language used to control the generation of G-code files out of **SolidCAM**'s internal language.

This chapter describes the GPPL language, its structure and functions. Although there are many examples in this chapter, you are also urged to see the examples in the next chapter, where the building blocks of GPPL are assembled together to form a complete general post processor definition.

5.2. GPPL Variables

5.2.1. Variable definition

A GPPL variable should adhere to the following rules:

- The first character should be a letter.
- All the other characters should be either a letter, digit or '_'.
- A variable name should not exceed 27 characters.

Note that GPPL does not distinguish between lower case and upper case (CAPITAL) letters.

Examples:

xpos , gcode_f , x0

5.2.2. Variable types

GPPL supports four types of variables:

- integer - can hold signed, integer numbers in the range of (-999999999, +999999999).
- numeric - can hold any number in the range of (-1.E300, +1.E300).
- logical - can hold the logical values TRUE (1) or FALSE (0).
- string - can hold any sequence of ASCII characters; the number of characters is unlimited.

5.2.3. Variable attributes

Every GPPL variable has two attributes associated with it. These attributes are defined and updated automatically by GPPL, but can also be changed directly by the user. These attributes are:

1. change attribute

This attribute is set to TRUE when a variable is first assigned a value. The next time the variable is assigned a value, if this value is different from the previous value then the change attribute is set to TRUE; if it is the same as the previous value, the change attribute is set to FALSE.

2. active attribute

This attribute is TRUE for most system variables. It is set to FALSE only for variables which are optional in certain conditions: The 'message' variable in '@call' procedure, and all user defined drill variables (as defined by 'drill-cycle' parameters in the [machine.mac] file). Local and global variables always have their active attribute set to TRUE, unless explicitly changed by the user by the attribute assignment statement.

5.2.4. Variables groups

A GPPL variable may fall into one of three groups; once a variable is defined to be in a certain group, its group cannot be changed. Variable groups are:

1. System variables

Under this group you can find all the system variables, that you can use for developing your postprocessor. These variables will be described in chapter 6. Note that you are not allowed to change the type of these variables.

2. Global user-defined variables

These variables are known (and can be changed or used) all over the GPPL procedures. They are most useful for inter-procedure data exchange. Global variables are initialized to zero and retain their previous value until assigned a new value.

3. Local user-defined variables

These variables are known (and can be changed or used) only in the GPPL procedure that defined them. They are unknown outside that procedure and their value is lost when the procedure is ended. Local variables are initialized to zero.

4. Internal variables

Under this group you can find all the internal variables, that pass the machining data information to the appropriate Tool path command. These variables will be described in chapter 7.

5. MAC external variables

Under this group you can find MAC external variables that is used to set user-defined fields in the Part-Option and Job-Option screen.

5.2.5. Array
General

- Variable

A defined place in memory with a defined purpose and name. Variables can be of different types and different sizes. For example, a variable that is defined as an integer (i.e. can have whole values) will have two bytes in the memory.

A series of variables that have a certain logical relationship between them and are placed together are called array variables. Array variables are variables of the same type and name which can be differentiated only by their index.

For example, we want to save the first one hundred prime numbers. The array variable can be named PRIMES, its type can be defined as "integer" and its size can be 100. The first primary number will therefore be stored in the first place in this variable, the second primary number will be stored in the second place and so on.

The above is an example of a vector i.e., a variable with one dimension. It is also possible to define a variable with two or more dimensions. A two-dimensional variable is called a matrix. A simple example of a matrix is the multiplication table. A vector has one index that differentiates between its variables. A matrix, on the other hand, has two indexes: the first index symbolizes the number of the row and the second index symbolizes the number of the column.

Definition

Definition of an array variable:

local/global numeric/integer/string var_name<<i1, i2 ...>>

when 0 < i1 , i2 < 10000

The array variables are similar to the rest of the variables in GPPTOOL. You have to remember to use indexes when working with the array variables.

Examples:

1. vec<<4>> symbolizes the fourth element in the vector vec.
2. mat<<2,3>> symbolizes the element in the second line, in the third column in the matrix mat.

   Below are complete examples of variables in GPPTOOL, including the definition, use of the variables and indexes.

5.3. GPPL Constants

GPPL supports the following constants types:

1. Integer constants:

Holds integer values in the range (-999999999, +999999999).

Examples:

1 , -123 , -99999

2. Numeric constants:

Holds any numeric value in the range (-1.E300, +1.E300). A numeric constant must have a decimal point (to distinguish it from integer constant), and may optionally have an exponent part (the letter 'E' immediately followed by the exponent value).

Examples:

1. , -123.0 , .123 , -0.23 , 1.2E2 (=120.) , 1.2E-2 (=0.012)

3. Logical constants:

Either 1 or 0. GPPL has two system variables i.e., TRUE and FALSE, which have the values 1 and 0 respectively.

4. String constants:

Holds any sequence of ASCII characters. A string constant must be surrounded by either single quotes (') or by double qoutes ("). A string constant might include the following characters:

a. Printable characters: "Normal" characters (a, b, ..., z, 0, 1, ..., 9 etc). Note that GPPL distinguishes between lower case and upper case (CAPITALS) letters.

b. Special characters: Few useful non-printable characters might be used by their mnemonic, preceded by a back-slash (\):

\n	-	(ASCII 10) new line character.
\r	-	(ASCII 13) new line character.
\t	-	(ASCII 9) tabulator character.
\\	-	the back-slash character itself (\).

c. Any character (hexadecimal notation): GPPL gives you the ability to include any character in the string constant by typing its hexadecimal (base 16) value. The notation is:

\xnn - where nn are two hexadecimal digits defining the ASCII value of the character. Note that two hexadecimal digits must be specified, and that the ASCII character NUL (\x00) cannot be used.

Examples:

'abcdefg'	- (or "abcdefg")
'AbcdefG' "	- (the NULL string. Its length is 0)
'SUBROUTINES : '	- (note the blanks (spaces) at the end)
'no, no, no!"	- (error: must begin and terminate with the same qoute type.)
'abc\txyz'	- (note the TAB character).
'abc\x04xyz'	- (note the EOT (hex 04) character).

5.4. GPPL Expressions

Expressions in GPPL might be of numeric type (i.e expressions which produce integer/numeric values), of logical type (which produce logical TRUE/FALSE values), or of string type (which produce string values). Any expression basically consists of one or more operands, separated by operators which specifies the operation to be performed. The operands are either constants, variables or sub-expressions. The expression might contain any number of parentheses to change the normal sequence of evaluation. For example, in the expression (1+2-3), the numbers 1,2,3 are the operands and the characters +,- are the operators. You may use parantheses to change the operators' priorities or to clarify the expressions.

5.4.1. Expression types

GPPL supports four types of expressions: integer, numeric, logical and string expressions.

1. Integer expression:

Any expression which includes integer or logical sub-expressions, but includes at least ONE integer sub-expression.

Examples:

1+(2-3) , tool_number+50

2. Numeric expression:

Any expression which includes integer or logical or numeric sub-expressions, but includes at least ONE numeric sub-expression.

Examples:

1.+(2-3) , xpos , ypos*100

3. Logical expression:

Any expression which includes integer or logical expressions, and results in TRUE/FALSE (1/0) value.

Examples:

xpos > -100 and xpos < 100 , FALSE , tool-number = 5

4. String expression:

Any expression which includes only string sub-expressions.

Examples:

'G-code generated on '+ date

5.4.2. Operators

GPPL supports three types of operators: integer/numeric, logical and string operators.

integer/numeric operators:

+,-,*,/ basic arithmetic operators

logical operators:

NOTATION: TRUE means 1, FALSE means 0

and	-	TRUE if both operands are TRUE.
or	-	TRUE if any of its operands is TRUE.
not	-	TRUE if its argument is FALSE.
eq (or '==')	-	TRUE if both operands are equal.
ne (or '<>')	-	TRUE if both operands are different.
le (or '<=')	-	TRUE if first operand is less than or equal to the second.
lt (or '<')	-	TRUE if first operand is less than the second.
ge (or '>=')	-	TRUE if first operand is greater than or equal to the second.
gt (or '>')	-	TRUE if first operand is greater than the second.

string operators:

+	string concatenation. (concatenation is the operation of appending one string to the end of another string to form a new, longer string).

5.4.3. Operators precedence

The numeric/logical operators are evaluated according to the following precedence table (priority goes top down, left to right):

variable constant function (...)
- (unary)
* /
+ -
gt ge lt le eq ne
not
and
or

Examples:

1+2*3 - 1+(2*3)

not xpos gt 100 and xpos lt -100 - (not (xpos>100)) and (xpos<(-100))

5.4.4. Conversions

Conversion is the process used to evaluate any expression which consists of operands from different types. For example, trying to add an integer number and a numeric one should give a meaningful result.

GPPL uses a very simple (yet powerful) mechanism to handle conversions:

1st operand	2nd operand	result
numeric	logical/integer/numeric	numeric
integer	logical/integer	integer
logical	logical	logical
string	string	string

All other possibilities are meaningless and GPPL produces a proper error message (e.g., string and integer conversion).

Examples:

10+1.2 - 11.2 (numeric)

xpos gt 100	-	Convert 100 to 100. and compare; result is logical
'abc'+1	-	error (string expression cannot be converted).
'abc'+'xyz'	-	'abcxyz'

5.5. GPPL statements

5.5.1. Global declaration

Format:

global <type> <var1>, <var2>, ...

Description:

This statement declares a variable to be global of type <type>. A global variable is one that is known (and can be used) all over the procedures. It retains its previous value until it assigned a new value. <type> should be logical, integer, numeric or string. It's advisable to declare all the global variables in the procedure '@init-post'.

Examples:

```
global numeric current_loc_x, current_loc_y
global logical first_time
global string  line
```

5.5.2. Local declaration

Format:

local <type> <var1>, <var2>, ...

Description:

This statement declares a variable to be local of type <type>. A local variable is one that is known (and can be used) only in the procedure in which it is declared. Every time the procedure is started the variable is initialized to 0 (integer/numeric), FALSE (logical), and " (string). <type> should be logical, integer, numeric or string.

Examples:

```
local numeric current_loc_x, current_loc_y
local logical condition
local string  line
```

5.5.3. Assignment statements

Format:

<num var> = <num exp>
OR
<str var> = <str exp>

Description:

The assignment statement is used to assign a value to any GPPL variable. The expression to the right of the equal sign is evaluated, converted to the type of the variable to the left of the equal sign, and then assigned. Note that the change attribute is calculated and set accordingly.

Examples:

xpos = 100	-	set variable xpos to 100
ypos = ypos - 100	-	Decrement variable ypos by 100
gcode_f = '5.0(p)'	-	set (string) variable gcode_f to the string'5.0(p)'.

5.5.4. Attribute assignment statements

Format:

change(<var>) = <logical exp>
OR
active(<var>) = <logical exp>

Description:

The attribute assignment statement sets the change/active attribute of any variable. The logical expression at the right of the equal sign is evaluated, and must yield a TRUE/FALSE (1/0) value. Then the attribute is set.

Examples:

change(xpos) = 1	-	set the change attribute of 'xpos' to TRUE.
change(xpos) = true	-	same as above (true is a system variable with a logical value of 1).
active(xpos-1) = 0	-	Error; only variables have attributes. Expressions do not have attributes.

5.5.5. Conditional statements

Format:

if <cond> then
statements
endif

OR

if <cond> then
statements
else
statements
endif

Description:

The condition (<cond>) is evaluated and converted into logical type. If the result is TRUE (1) only the statements between the 'then' and the 'endif' or between the 'then' and the 'else' are executed. Otherwise, no statement is executed at all, or the statements between the 'else' and the 'endif' are executed. The keyword 'then' is optional and may be omitted. Conditional statements can be nested up to 8 levels.

Example:

```
if direction eq CCW then          ; results in either TRUE or FALSE
   gcode = 3                  ; execute ONLY if TRUE
else                          ;
   gcode = 2                  ; execute ONLY if FALSE
endif                             ;
```

5.5.6. Subroutine Calls

Format:

```
while <cond>
   statements
endw
```

Description:

The condition (<cond>) is evaluated and converted into logical type. If the result is FALSE, then the statements until the 'endw' are skipped (not executed). Otherwise, these statements are executed and the above process is repeated.

While statements can be nested up to 8 levels.

Example:

```
logical integer i
i = 1
while i < = 5
   {nl, 'I=', i }
   i = i + 1
endw
```

The above code will generate 5 blocks (lines) with 5 different values (1...5) for i.

5.5.7. Procedure Calls

Format:

call @<proc name>

Description:

This statement suspends the regular execution of the program, executes the statements in the procedure '@<proc name>', then resumes the regular execution.

Example:

```
mode = TRUE -       set mode to TRUE
call @stop_tool     -       execute procedure '@stop_tool'
mode = FALSE        -       set mode to FALSE
```

5.5.8. Procedure definition

Format:

```
@<proc name>
        (procedure body)
endp
```

Description:

The procedure definition is made up of three parts:

1. The name of the procedure
2. The body of the procedure
3. The end of the procedure

Example:

```
@stop_tool
  (operational command)
endp
```

5.5.9. Comment

Format:

; any text

Description:

All the text after the ';' till the end of the line is simply ignored.

Example:

gcode = 1 ; this is a comment and is ignored.

5.5.10. G-code generation

Format:

{ <item1>, <item2>, ... }

Note:

The comma (,) is optional.

Description:

The generate statement is used to generate the G-code. All the items in the statement are evaluated, and then written to the G-code file. Each <item> can be:

- A variable of any kind (e.g. {xpos}).
- An expression of any kind; it should appear between brackets (e.g. {(2*xpos)}).

Each item can optionally have a "display format" to control the way it will be generated. It might be explicitly written in conjunction to the item itself (e.g. {xpos: '5.3'}) or GPPL tries to find it according to the following rules:

(assume that the variable to be generated is 'xxx')

- Search for a system or global string variable named 'xxx_f'; if it exists, use it as the display format.

- Search for a local string variable named 'xxx_f'; if it exists, use it as the display format.

- If the variable is of integer/logical type, use the system variable named 'def_integer_f' as the display format.

- If the variable is of numeric type, use the system variable named 'def_numeric_f' as the display format.

This mechanism gives you full control over the G-code generation format.

Examples:

{xpos}	-	use 'xpos_f'
{(2*xpos)}	-	use 'def_numeric_f'
{xpos:'5.3z'}	-	use this specific format

5.5.10.1. Conditional generation (modality)

GPPL supports conditional generation of items. A "modal group" is a group of items surrounded by square brackets ([...]). For example:

{ ['G', gcode, 'X', xpos, ' (FIRST POINT)'] }

GPPL uses a simple rule to decide if the modal group should be generated: If at least ONE item of the modal group is required to be generated - all the group will be generated. An item is required to be generated if both its active and change attributes are TRUE.

The conditional generation is especially designed for modal G-code generation. For example, if a previously generated block was a 'G1' block (in procedure '@line' for example), and the current block is going to be also a 'G1' block, the 'G1' does not have to be generated. The way GPPL handles this is simply be defining the appropriate group as a modal group, as in the following example:

{ ['G', gcode] }

If the system variable 'gcode' has changed from the previous time it was used it, the string 'G1' will be generated; if has not changed then the string 'GI' will not be generated.

Examples:

gcode = 1	-	if previous value was 1, set change flag to FALSE
{nb, ['G'gcode], ' X'xpos, ' Y'ypos}	-	N125 X123.45 Y-12.3 note that 'G1' was not generated.
{nb, [' X'xpos], [' Y'ypos]}	-	Assume change(xpos) = FALSE change(ypos) = TRUE The generated block will be: N125 Y-12.3
{nb, [' X'xpos, ' Y'ypos]}	-	Assume change(xpos) = TRUE change(ypos) = TRUE The generated block will be: N125 X123.45 Y-12.3

Note:

G-field modality is an important, heavily used feature of the G-code languages. GPPL gives special care for that facility. Consider the following examples:

```
(1) N10  G1  X12.3  Y-5.
    N15   X35.  Y7.14      ; G-field omitted.
    N20  G0  X0.  Y0.

(2) N10  G1  X12.3   Y-5
    N15        X35.    Y7.14  ; Blanks reserve space of G-field for
    N20  G0  X0.       Y0.    ; readability
```

The GPPL code used for block N15 in the first example is the following:

```
gcode = 1
{nb, ['G' gcode], ' X' xpos, 'Y' ypos}
```

The GPPL code used for block N15 in the second example is a little bit more complicated:

```
gcode = 1
if change(gcode) then
  {nb, 'G' gcode, ' X' xpos, ' Y' ypos}
else
  {nb, '  ', ' X' xpos, ' Y' ypos} ; reserve space
endif
```

It would be better if we could write the second example in more condensed code (as in the first example). GPPL enables us to do so. If the system variable 'gcode_space' equals TRUE, GPPL will produce the second example's G-code, even if the GPPL generation statement is:

```
  {nb, ['G' gcode], ' X' xpos, ' Y' ypos}
```

5.5.10.2. Display format

The display format is a string expression that defines how the item should be printed. It has the following components:

<sign><leading-zeroes><integer> . <fraction><trailing-zeroes><options>

<sign> sign control:

'+' - Put '+' sign to indicate positive numbers.

'-' - Put ' ' sign to indicate positive numbers.

none - put sign only for negative numbers.

<leading-zeroes> leading zeroes control:

' ' - Precede number with leading blanks (spaces).

'z' - Precede number with leading zeroes.

none - do not append anything.

<integer> integer part control. This component might be either 'M' or 'M/m', where:

M - number of digits before the decimal point.

/m - minimum number of digits that must be generated. Default: 1.

. - decimal point.

<fraction> fraction part control. This component might be either 'N' or 'N/n', where:

N - number of digits after the decimal point. Default is 0 for integer expressions, 3 for numerics.

/n - minimum number of digits that must be generated. Default:0

<trailing-zeroes> trailing zeroes control:

' ' - append number with trailing blanks (spaces).

'z' - append number with trailing zeroes.

none - do not append anything.

<**options**>: Miscellaneous formatting options, that must be surrounded by brackets, and may be separated for readability purposes by blanks. The options may be specified either as lower-case letters or as CAPITAL letters. The options are:

*s - scaling factor. The number to be generated is multiplied by 's' before generation (s stands for any number, including non-integer ones).

/s - scaling factor. The number to be generated is divided by 's' before generation (s stands for any non-zero number, including non-integer ones).

d - Delete if zero; if the number to be generated is zero, nothing is generated.

n - No decimal point; the number is generated without the decimal point.

p - Conditional decimal point; the number is generated without decimal point if its fraction part is equal to zero.

i - Invert sign; the sign of the number is inverted, then it is generated.

Examples:

- {'|', (123.456):'5.2', '|'} ===> |123.46|

  - up to 5 places before the decimal point.

  - up to 2 places after the decimal point

  - number is rounded as neccessary.

- {'|', (123456):'5.2', '|'} ===> |123456.|

  - 5 places before the decimal point are not enough. GPPL will not truncate any significant digits, so the number takes as much places as required.

  - fraction part equal to zero. Note the decimal point (see next example).

- {'|', (123456):'5.2(p)', '|'} ===> |123456|

  - fraction part equal to zero. 'p' option - remove the decimal point in such a case.

♦ {'|', (-12.3):' 5.3z', '|'} ===> | -12.300|

- This number is preceded by 3 leading blanks (the sign is not counted towards the 5 places limit).
- 2 trailing zeroes are added.

♦ `{'|', (-12.3):' 5.3z(n)', '|'} ===> | -12300|`

- 'n' option removes the decimal point.

♦ `{'|', (1.234):'+5.0(*100)', '|'} ===> |+123.|`

- the number is multiplied by 100 before generation.
- a sign is always generated.

♦ `{'|', (-1234):'+5.0(/2.54i)', '|'} ===> |+486.|`

- the number is divided by 2.54 before generation.
- the 'i' option inverts the number's sign.
- a sign is always generated.

♦ `{'|', (12.345):'8/5.7/4', '|'} ===> |00012.3450|`

- at least 5 places before the decimal point are required.
- at least 4 places after the decimal point are required.
- leading/trailing zeroes are added.

5.5.11. While Statement

Format:

```
while <cond>
   statements
endw
```

Description:

The condition (<cond>) is evaluated and converted into logical type. If the result is FALSE, then the statements until the 'endw' are skipped (not executed). Otherwise, these statements are executed and the above process is repeated.

While statements can be nested up to 8 levels.

Example:

```
logical integer i
i = 1
while i < = 5
   {nl, 'I=', i }
   i = i + 1
endw
```

The above code will generate 5 blocks (lines) with 5 different values (1...5) for i.

5.5.12. Trace statement

Format:

trace <procedures>:<trace-level>

Description:

GPP will produce trace information while generating G-Code. The trace information will be generated only for those procedures which are defined in <procedures> list (see examples below). The <trace-level> determines how much information will be generated. The <trace-level> value must be in the range of 1 to 5, where 5 gives the maximum trace information available.

This information is of great interest in the development phase of a new post-processor; it can significantly shorten the time required to develop such a post-processor.

Examples:

trace “all”: 1	- All procedures will be traced with the minimum trace information available.
trace "@line,@arc":5	- only procedures '@line' and '@arc' will be traced, generating the maximum available information.

5.6. GPPL Internal functions

GPPL supports a set of internal ("built-in") functions. Use these functions whenever you need. There are four categories of functions: numeric, string, logical and generation functions.

Following is a complete explanation of each function:

5.6.1. Numeric functions

- **abs** (number)

Parameters:

number: any numeric expression.

Description:

This function returns the absolute value of the number.

Examples:

abs(12.3-8) ==> 4.3
abs(8-12.3) ==> 4.3

- **acos** (number)

Parameters:

number: any numeric expression in the range [-1, 1].

Description:

This function returns the arc-cosine of the number. The angle returned is in degrees in the range [0, 180].

Examples:

acos(1) ==> 0
acos(-1) ==> 180

♦ **ang** (x, y)

Parameters:

x - X-axis coordinate of a point.
y - Y-axis coordinate of a point.

(x and y both should not be zero.)

Description:

This function returns the angle between vector to the point and the positive direction of the X axis. The angle is returned in degrees in the range [-180, 180]. (see 'atan2' function).

Examples:

ang(5,5) ==> 45
ang(-3, 0) ==> 180
ang(5, -5) ==> -45

♦ **asin** (number)

Parameters:

number - any numeric expression in the range [-1, 1].

Description:

This function returns the arc-sine of the number. The angle returned is in degrees in the range [-90, 90].

Examples:

asin(1) ==> 90
asin(-0.5) ==> -30

♦ **atan** (number)

Parameters:

number - any numeric expression.

Description:

This function returns the arc-tangent of the number. The angle returned is in degrees in the range [-90, 90].

Examples:

atan(1) ==> 45
atan(-1) ==> -45

♦ **atan2** (y, x)

Parameters:

y - Y axis coordinate of a point.
x - X axis coordinate of a point.

(y and x should not be both zero)

Description:

This function returns the angle defined by the point and the positive direction of the X axis. The angle is returned in degrees in the range [-180, 180] (see 'ang' function).

Examples:

atan2(5,5) ==> 45
atan2(-3, 0) ==> -90
atan2(5, -5) ==> 135

♦ **cos** (angle)

Parameters:

angle - any numeric expression (angle is in degrees).

Description:

This function returns the cosine value of the angle.

Examples:

```
cos(90)          ==> 0
cos(810)         ==> 0
cos(540)         ==> -1
cos(acos(1))     ==> 1
```

♦ **dist** (x, y)

Parameters:

x - X axis coordinate of a point.
y - Y axis coordinate of a point.

Description:

This function returns the distance between the point and the origin of the axis system (point (0,0)). Dist(x, y) is equivalent to sqrt(x*x + y*y).

Examples:

```
dist(3, 4)          ==> 5
dist(-3, 4)    ==> 5
dist(12, -5)        ==> 13
```

♦ **exp** (number)

Parameters:

number - any numeric expression.

Description:

This function returns the value of e (the base of natural logarithms) to the power of number.

Examples:

exp(0) ==> 1
exp(1) ==> 2.718281828...
exp(-0.5) ==> 0.606530659...

♦ **frac** (number)

Parameters:

number - any numeric expression.

Description:

This function returns the fraction part of the number.

Examples:

frac(12.345) ==> 0.345
frac(-12.345) ==> 0.345
frac(12) ==> 0

♦ **int** (number)

Parameters:

number - any numeric expression.

Description:

This function returns the integer part of the number. The value is truncated, not rounded.

Examples:

int(12.345) ==> 12
int(-12.345) ==> -12
int(frac(12.3)) ==> 0

♦ **log** (number)

Parameters:

number - any positive numeric expression.

Description:

This function returns the value of the natural logarithm of the number.

Examples:

log(1) ==> 0
log(2.718281828) ==> 1 (approximately)

♦ **log10** (number)

Parameters:

number - any positive numerical expression.

Description:

This function returns the value of the base 10 logarithm of the number.

Examples:

log10(1) ==> 0
log10(10) ==> 1
log10(1000) ==> 3

♦ **mod** (a, b)

Parameters :

a : any numeric expression.
b : any numeric expression.

Description :

This function returns the remainder R of a / b, such that a = i * b + R, where i is an integer number, R has the same sign as a, and abs(r) < abs(b).

Examples :

mod(5, 2) ==> 1
mod(-17, 3) ==> -2
mod(9.2, 4) ==> 1.2

♦ **pow** (b, p)

Parameters:

b - any numeric expression.
p - any numeric expression.

Note:

if b equals zero, p must be positive;
if b is less than zero, p must be integer.

Description:

This function returns the value of b to the power of p.

Examples:

pow(10, 3) ==> 1000
pow(0, 12) ==> 0
pow(25, 0.5) ==> 5
pow(-2, 2) ==> 4
pow(-2, 3.5) ==> error. see note limitation above.

♦ **round** (number, dig)

Parameters:

number - any numeric expression.
dig - number of digits to round (must be integer).

Description:

This function returns the number rounded to the required number of digits either after or before the decimal point. Note that it is possible to round the number to the left of the decimal point by giving a negative number for dig (see examples below).

Examples:

round(12.3456, 1) ==> 12.3
round(12.3456, 3) ==> 12.346
round(12.5, 0) ==> 13
round(-12.5, 0) ==> -13
round(123.4, -1) ==> 120
round(126.4, -1) ==> 130
round(123, -3) ==> 0

♦ **round2val** (c, d)

Parameters:

c - any numeric expression.
d - any numeric expression.

Description:

This function returns c rounded to smallest multiple of d.

Examples:

round2val(730, 360) ==> 720
round2val(17.5, 2) ==> 18
round2val(8.5, 2.1) ==> 8.4

♦ **sign** (number)

Parameters:

number - any numeric expression.

Description:

This function returns an integer number, representing the sign of the number. The values returned are:

-1 - if the number is less than zero.
0 - if the number is equal to zero.
1 - if the number is greater than zero.

Examples:

sign(123.4) ==> 1
sign(-123.4) ==> -1
sign(cos(90)) ==> 0

♦ **sin** (angle)

Parameters:

angle - any numerical expression (angle is in degrees).

Description:

This function returns the sine value of the angle.

Examples:

sin(90) ==> 1
sin(990) ==> -1
sin(540) ==> 0
sin(asin(1)) ==> 1

♦ **sqrt** (number)

Parameters:

number - any non-negative numeric expression.

Description:

This function returns the square root of the number. This function is equivalent to 'pow(number, 0.5)'.

Examples:

sqrt(25) ==> 5
sqrt(0) ==> 0
sqrt(-4) ==> error. Only non-negative numbers have real square root.

♦ **square** (number)

Parameters:

number - any numeric expression.

Description:

This function returns the value of the number squared. It is equivalent to 'pow(number, 2)'.

Examples:

square(5) ==> 25
square(-5) ==> 25
square(0) ==> 0

♦ **tan** (angle)

Parameters:

angle - any numerical expression (angle is in degrees).

Description:

This function returns the tangent value of the angle.

Examples:

tan(45) ==> 1
tan(90) ==> 1.632455E16 (approximation of infinity)
tan(540) ==> 0

♦ **todeg** (angle)

Parameters:

angle - any numeric expression (angle is in radians).

Description:

This function returns the angle (which is assumed to be in radians) into its equivalent in degrees.

Examples:

```
todeg(0)      ==> 0
todeg(1)      ==> 57.295779...
todeg(pi)     ==> 180  (note that 'pi' is a system variable with the value 3.1415926...)
```

♦ **torad** (angle)

Parameters:

angle - any numeric expression (angle is in degrees).

Description:

This function returns the angle (which is assumed to be in degrees) into its equivalent in radians.

Examples:

```
torad(0)              ==> 0
torad(57.295779)      ==> 1 (approximately)
torad(180)            ==> 3.1415926...
```

5.6.2. String functions

♦ date

Parameters:

none.

Description:

This function returns the string value of the current date in the format 'DD-MMM-YYYY' where DD is the current day, MMM is the current month and YYYY is the current year.

Examples:

date ==> "12-Apr-1994"

♦ **dup** (string, count)

Parameters:

string - the string expression to be duplicated.
count - any non-negative numeric expression.

Description:

This function returns a string value, consisting of the string 'string' duplicated 'count' times.

Examples

dup ('abc', 3) ==> 'abcabcabc'
dup (date, 2) ==> '26-Nov-198926-Nov-1989'

♦ **instr** (str, sub_str)

Parameters:

str - the string expression to be searched.
sub_str - the string expression to be searched for.

Description:

This function searches for the first appearance of the sub_str in str and returns its position from the beginning of str. If sub_str was not found the function returns 0. Note that GPPL does distinguish between lower and upper case letters.

Examples:

```
instr('abcd', 'cd')        ==> 3
instr('abcd', 'x')         ==> 0
instr('abcd', 'Cd')        ==> 0 (lower/upper case sensitivity)
instr('abcdabcd', 'cd')    ==> 3 (the first occurance is taken)
```

♦ **left** (str, num)

Parameters:

str - any string expression.
num - any positive numeric expression.

Description:

This function returns the sub-string which consists of num left characters of str. If str is too short, all str is returned (see function 'right').

Examples:

```
left('abcdef', 4) ==> 'abcd'
left('abcdef', -2)==> error. (meaningless request)
left('xyz', 6)     ==> 'xyz'  (there are no 6 left characters).
```

♦ **lower** (string)

Parameters:

string - any string expression.

Description:

This function returns the same string, where all upper case (CAPITAL)letters (A-Z) are replaced by their lower case equivalent (a-z). Please note that the original string is left unchanged. If you want to change a certain string into lower case you must use an assignment statement (see examples below).

Examples:

```
lower('TITLE')         ==> 'title'
lower('Title no. 1')   ==> 'title no. 1'
line = lower(line)     ==> converts string variable 'line' into lower case.
```

♦ **rev** (string)

Parameters:

string - any string expression.

Description:

This function returns the same string while reversing the order of its characters.

Examples:

rev('abcd') ==> 'dcba'
rev('123') ==> '321'

♦ **right** (str, num)

Parameters:

str - any string expression.
num - any positive numeric expression.

Description:

This function returns the sub-string which consists of the num right characters of str. if str is too short, all str is returned (see function 'left').

Examples:

right('abcdef', 4) ==> 'cdef'
right('abcdef',-2) ==> error.(meaningless request)
right('xyz', 6) ==> 'xyz' (there are no 6 right characters).

♦ **space** (len)

Parameters:

len - any non-negative numeric expression.

Description:

This function returns a string of blanks (spaces) of length len. If len is zero, then a null string is returned. This function is equivalent to 'dup(' ', length)'.

Examples:

space(5) ==> ' '
space(0) ==> '' (the null string)
space(-3) ==> error

♦ **strlen** (string)

Parameters:

string - any string expression.

Description:

The function returns the length of the string, i.e. the number of characters in the string.

Examples:

strlen('abcd') ==> 4
strlen('abcd ') ==> 5 (note the blank at the end of the string)
strlen('') ==> 0 (length of null string is zero)

♦ **substr** (string, from, len)

Parameters:

string - any string expression.
from - position from beginning of string where sub-string starts. 'from' must be in the range [1, strlen(string)].
len - length of the sub-string to extract

Description:

This function returns the sub-string of length len starting in the string from position 'from', and with length len. If 'from + len' is greater than strlen(string), the returned sub-string is of length less than len.

Examples:

substr('abcdefg',5,2) ==> 'ef'
substr('abcdefg',5,4) ==> 'efg' (no more characters)
substr('abcdefg',9,2) ==> error (9 is not legal position)

♦ time

Parameters:

none.

Description:

This function returns the string value of the current time in the format 'HH:MM:SS' where HH is the current hour, MM is the current minutes and SS is the current seconds.

Examples:

time ==> 10:17:30 (10 AM, 17 minutes, 30 secs)
time ==> 22:17:30 (10 PM, 17 minutes, 30 secs)

♦ tonum (string)

Parameters:

string - any string expression, which holds a legal numerical value (see description below).

Description:

This function converts the number represented in the string from string format to a numeric format. Valid number in the string must have the following format:

[spaces] [sign] [digits] [.digits] [E [sign] digits]

spaces	-	blanks (' ').
sign	-	none ('+' assumed), '+' or '-'.
digits	-	any sequence of decimal digits (0-9).
.digits	-	decimal point, followed by any sequence of digits.
E	-	beginning of the exponent part.
sign	-	none '+' or '-'; the exponent sign.
digits	-	exponent value.

The reverse operation of 'tonum' is the function 'tostr'. See its description below.

Examples:

tonum(' 12') ==> 12
tonum('-12.34') ==> -12.34
tonum('12.3e2') ==> 1230
tonum('-12E-1') ==> -1.2

♦ **tostr** (number [:format])

Parameters:

number - any numeric expression.
format - format definition (optional)

Description:

This function converts the number into string notation according to the format specification 'format'. If 'format' is omitted, the string is converted according to a default format. See chapter C.5.10 for a detailed description of 'format' options.

Examples:

tostr(12.345) ==> '12.345'
tostr(12.3456) ==> '12.346' (default format is '5.3').
tostr(12.3456:'4.0') ==> '12.'

♦ **trim** (string)

Parameters:

string - any string expression.

Description:

This function returns the same string as in the string, but removes all its trailing blanks.

Examples:

trim('abcd') ==> 'abcd' (nothing to trim)

trim('abcd ') ==> 'abcd'

♦ **upper** (string)

Parameters:

string - any string expression.

Description:

This function returns the same string, where all the lower case letters (a-z) are replaced by their upper case (CAPITAL) equivalent (A-Z). Please note that the original string is left unchanged. If you want to change a certain string into upper case, you must use an assignment statement (see examples below).

Examples:

upper('TITLE') ==> 'TITLE'

upper('Title no. 1') ==> 'TITLE NO. 1'

line = upper(line) ==> converts string variable line into upper case.

5.6.3. Logical functions

♦ **active** (variable)

Parameters:

variable - any local/global/system variable.

Description:

This function returns the value TRUE/FALSE (1/0) according to the current status of the active attribute of the variable. The active attribute is set to TRUE in the following cases:

- If the variable can be used in the current procedure.
- When the variable is assigned a value.
- When the user explicitly uses the 'active' attribute assignment statement.

This function is most useful when checking for conditional execution ('if' statement), or when generating modal items (see section C.5.10). See also the description of function 'change' later in this chapter.

Examples:

active(xpos) - TRUE/FALSE as active flag of xpos

active(123) - Error. Expressions does not have an active attribute.

active(xpos)=active(xnext) - Sets the active attribute of variable xpos to be the same as the active attribute of variable xnext.

♦ **change** (variable)

Parameters:

variable - any local/global/system variable.

Description:

This function returns the value TRUE/FALSE (1/0) according to the current status of the change attribute of the variable. The change attribute is set to TRUE in the following cases:

- When the variable is assigned a new value.
- When the user explicitely uses the 'change' attribute assignment statement.

This function is most useful when checking for conditional execution ('if' statement), or when generating modal items (see section C.5.10). See also the description of function 'active' earlier in this chapter.

Examples:

change(xpos)	-	TRUE/FALSE as change flag of xpos.
change(123)	-	Error. Expressions does not have an change attribute.
change(xpos) = change(xnext)	-	Sets the change attribute of variable xpos to be the same as the change attribute of variable

♦ **even** (number)

Parameters:

number - any numeric expression.

Description:

This function is TRUE only if the number is even.

Examples:

even(8) ==> TRUE
even(13) ==> FALSE
even(4.2) ==> FALSE

♦ **odd** (number)

Parameters:

number - any numeric expression.

Description:

This function is TRUE only if the number is odd.

Examples:

odd(7) ==> TRUE
odd14) ==> FALSE
odd(3.2) ==> FALSE

CHAPTER 6

6. GPPtool System variables

There are three types of system variables that are available for use in the GPPL procedures that define how each **SolidCAM** tool-path command is translated into G-code (see Chapter 7). These three types of variables are:

1. Variables that are defined in **SolidCAM** and passed to GPPtool.
2. Variables that are defined at the start of the [machine.gpp] file (in the @init_post section).
3 Variables which have special values and cannot be assigned new values.

6.1. Variables that are defined in SolidCAM and passed to GPPtool

- gcode — type: integer

The number of the last-developed G-Code.

- `mcode` — type: integer

The number of the last-developed M-Code.

- `rotated` — type: logical

TRUE if the current JOB is a rotated one.

- `mirrored` — type: logical

TRUE if the current JOB is a mirrored one.

- `prev_command` — type: string

The name of the previous **SolidCAM** tool-path command that was executed.

- `current_command` — type: string

The name of the current **SolidCAM** tool-path command that is being executed.

- `next_command` type: string

The name of the next **SolidCAM** tool-path command that is going to be executed.

- `first_user_proc` type: integer

Number of the first user-defined G-Code procedure. These procedures are normally included in the '@end_of_file' procedure and are appended at the end of the G-Code file that is generated from the translation of the **SolidCAM** tool-path commands.

6.2. Variables that are defined at the start of the [machine.gpp] file

G-Code format

- `remove_blanks` type: logical

  {TRUE/FALSE}

If TRUE, all blanks (spaces) are removed out of the generated G-Code file. This leads to more compact G-code files (in terms of memory), but to a less readable G-code.

- `gcode_space` type: logical

  {TRUE/FALSE}

If TRUE, G-field that was omitted due to modality is filled with spaces to keep the field after in fixed column. See description in chapter 5.5.10.

- `gcode_f` type: string

Display format for G field.

- `mcode_f` type: string

Display format for M field.

- `numeric_def_f` type: string

Default display format for numeric values.

- `integer_def_f` type: string

Default display format for integer values.

- `xpos_f` type: string

Display format for X values.

- `ypos_f` type: string

Display format for Y values.

- `zpos_f` type: string

Display format for Z values.

♦ `apos_f` type: string

Display format for angle of 4th axis.

♦ `feed_f` type: string

Display format for the feed field.

♦ `end_block_text` type: string

String appended to the end of each block.

Block Numbers

♦ `blknum_letter` type: string

The character used for the numbering field (usually the letter 'N').

♦ `blknum_exist` type: logical

{TRUE/FALSE}

Decides whether the G-Code of the machine can have Block numbering or not.

♦ `blknum_gen` type: logical

{TRUE/FALSE}

Decides whether to generate block numbering (note that the blocks will be numbered ONLY if both 'blknum_exist' and 'blknum_gen' are true.

♦ `blknum_f` type: string

Display format for Block-Numbering field.

♦ `blknum_delta` type: integer

Difference between the numbering of two consecutive blocks.

♦ `blknum` type: integer

Initial value: number of the first block. During execution of the GPP program, this variable holds the number of the next block to be generated.

♦ `blknum_max` type: integer

The maximum allowed block number.

- `skipline` type: logical

  {TRUE/FALSE}

Decide whether or not to generate new line at the start of the next block
It effect if the next block start with ‘nb’ command and not ‘nl’ command.

- `num_user_procs` type: integer

Number of user procedures in the G-code. This is defined in '@end_of_file.'

Example:

For detailed explanation of display format options see section 5.5.10 in this manual.

@init_post

```
numeric_def_f = '5.3'    ; point will always appear (5. and not 5)
integer_def_f   = '5.0(p)'
gcode_f         = '2.0(p)'
mcode_f         = '2.0(p)'
xpos_f          = '5.3(p)'     ; point will not always appear (5 and not  5.1)
ypos_f          = '5.3(p)'
zpos_f          = '5.3(p)'
apos_f          = '5.3(p)'
feed_f          = '4.0(p)'
end_block_text  = "       ; do not append anything
blknum_letter   =   'N'    ; use 'N' as block numbering letter
blknum_gen      = FALSE    ; do not generate block numbers
blknum_exist    = TRUE     ; blocks might be numbered in this
                           ; particular machine
blknum_f        = '5.0(p)' ; use up to 5 digits for block numbers
                           ; (no dec point)
blknum          =    5     ; start block numbers from 5
blknum_delta    =    5     ; block will be numbered as 5, 10, ...
blknum_max      = 32000    ; block numbers can not exceed this limit
num_user_procs  =    1     ; one user procedure is defined in
                           ; '@end_of_file' procedure.
remove_blanks   = FALSE    ; leave blanks in generated G-Code file

endp
```

6.3. Variables which have special values

- `PI` type: numeric

value: 3.1415926535... (15 digits)

The value of the mathematical constant pi.

- `FALSE` type: logical

value: 0

The logical value of false condition.

- `TRUE` type: logical

value: 1

The logical value of true condition.

- `inch_system`

if TRUE, inch units; otherwise mm units.

CHAPTER 7

7. GPPtool commands

7.1. SolidCAM Tool-Path commands

These are the **SolidCAM** internal tool-path commands. All the tool-paths calculated in **SolidCAM**, by the various jobs, are saved in this language. When the user asks for the generation of G-code, then the saved tool-path commands file is translated to a G-code file according to the [MACHINE.MAC] and [MACHINE.GPP] files.

Each tool-path command has parameters that are assigned values by **SolidCAM**; the parameter list is given with the tool-path command decription. Some parameters are optional i.e. they are not available for some of the CNC controllers. You can check if a parameter is active or not, for the particular CNC controller you are working with, by using the logical function 'active'.

Upon entry to a procedure, GPPtool assigns values only to the procedure's parameters. GPPtool does not change other system/global variables or parameters of other procedures; they retain their previous value. Therefore, it is possible to use inside the current executed procedure all the parameters of a previously executed procedure.

Note :

Whenever a tool-path command variable has a pre-defined value (e.g. variable arc_direction in '@arc' might have CW or CCW), you should test that variable against these constants.

Following is a complete description of all the **SolidCAM** tool-path commands together with their parameters:

@absolute_mode

Parameters:

None

Description:

This command enters the program into absolute coordinate position mode.

Examples:

```
@absolute_mode        ; FANUC
   gcode = 90
   {nb, 'G'gcode}
   skipline = FALSE  ; generate next command on same line
endp
```

@arc

Parameters:

xpos, ypos, zpos	type: numeric	Tool-position at end of arc in local coordinate system
xhpos, yhpos, zhpos	type: numeric	Tool-position at end of arc in part coordinate system.
feed	type: numeric	Feed-rate of movement.
xcenter, ycenter	type: numeric	Absolute center of arc.
xhcenter, yhcenter, zhcenter	type: numeric	Absolute center of arc in part coordinate system.
xcenter_rel, ycenter_rel	type: numeric	Center of arc relative to the start point.
radius	type: numeric	Arc-radius.
start_angle, end_angle	type: numeric	Start and end angles of arc (in degrees).
arc_direction	type: integer	Arc-direction {CW, CCW}.
arc_plane	type: integer	Arc-plane {XY, YZ, ZX}.
arc_size	type: numeric	Arc size (in degrees).
next_direction	type: numeric	Direction of the next XY block (if the next block is not an XY block).
zstart	type: numeric	Z value at start of arc.
xhstart, yhstart, zhstart	type: numeric	Coordinate value at start of arc. in part coordinate system.

Description:

This command generates the arc feed-positioning G-code.

Examples:

```
@arc            ; FANUC
   if arc_direction eq CCW then
      gcode = 3
   else             ; CW
      gcode = 2
   endif
   {nb, ['G'gcode], [' X'xpos], [' Y'ypos], [' Z'zpos]}
   if arc_size eq 360 then
      {' I'xcenter_rel, ' J'ycenter_rel}
   else
      if arc_size gt 180 then
         radius = -radius
      endif
      {' R'radius}
   endif
   {[' F'feed]}
endp

@arc        ; MAHO-432
  if arc_direction eq CCW then
     gcode = 3
else             ; CW
      gcode = 2
endif
if machine_plane eq ZX then
       xpos = -xpos
endif
   {nb, ['G'gcode], [' X'xpos], [' Y'ypos], [' Z'zpos]}
if arc_size gt 180 then
   {[' I'xcenter_rel], [' J'ycenter_rel]}
else
   {' R'radius}
endif
   {[' F'feed]}
endp
```

@arc4x_cartesian

Parameters:

xpos, cpos, zpos	type : numeric	Tool-position at end of arc.
feed	type : numeric	Feed-rate of movement.
xcenter, ycenter	type : numeric	Absoloute center of arc.
xcenter_rel, ycenter_rel	type : numeric	Center of arc relative to the start point.
radius	type : numeric	Arc-radius.
start_angle, end_angle	type : numeric	Start and end angles of arc (in degrees).
arc_direction	type : integer	Arc-direction {CW, CCW}
arc_plane	type : integer	Arc-plane {XY, YZ, ZX}
arc_size	type : numeric	Arc-size (in degrees).
zstart	type : numeric	Z value at start of arc.
dc	type : numeric	Delta of cpos
dir4x	type : integer	Direction of C axis {CW, CCW}

Description:

This command generates the arc feed-positioning G-code. End position is defined by cartesian coordinates (xpos, cpos).

@arc4x_polar

Parameters:

xpos, cpos, zpos	type : numeric	Tool-position at end of arc in polar coordinates.
feed	type : numeric	Feed-rate of movement.
xcenter, ycenter	type : numeric	Absoloute center of arc.
xcenter_rel, ycenter_rel	type : numeric	Center of arc relative to the start point.
radius	type : numeric	Arc-radius.
start_angle, end_angle	type : numeric	Start and end angles of arc (in degrees).
arc_direction	type : integer	Arc-direction {CW, CCW}
arc_plane	type : integer	Arc-plane {XY, YZ, ZX}
arc_size	type : numeric	Arc-size (in degrees).
zstart	type : numeric	Z value at start of arc.
dc	type : numeric	Delta of cpos
dir4x	type : integer	Direction of C axis {CW, CCW}

Description:

This command generates the arc feed-positioning G-code arc in polar coordinates.

@call_prms

Parameters:

label	type : integer Name (number) of subroutine to be called.
start_line	type : function Block number of subroutine start.
end_line	type : function Block number of subroutine start.
call_prms_num	type : integer Number of parameters to pass to the subroutine.
call_prms array	type : numeric array The parameters to pass to the subroutine.

Description:

This command generates a subroutine call with parameters.

@call_proc

Parameters:

label	type: integer	Name (number) of subroutine to be called.
proc_count	type: integer	Number of times to execute the subroutine.
parm1,parm2,parm3	type: numeric	Procedure parameters (optional).
message	type: string	Optional text that describes the subroutine.
start_line	type: function	Block number of subroutine start.
end_line	type: function	Block number of subroutine end.

For first level procedure the following parameters can be used:

Parameters for all job type

job_type type: string Can be one of the following:
{"pocket", "profile", "drill","slot","trans_surf",
"3-d model", "multy-drill", "3-d drill","3-d engraving",
"5x_advanced","5x_face","5x_pen_trace","5x_port_mach",
"5x_swarf","5x_turbine", "5x_2_5_axis","5x_3axis","5x_4axis"
"turn", "drill","thread", "groove"
"profile", "4_axis", "constant_angle","macro", "variable_angle"}
};

job_machine_type type: integer The type of the current job
{milling, turning, wire_cut}.

Parameters for Miling jobs

mac_number type: integer Machine home to be used.
rot_axis_type type: integer The type of a milling job when using simultaneous 4th axis. {AXIS4_NONE, AXIS4_FACE, AXIS4_TOP, AXIS4_RADIAL}.

tool_side type: integer Side location of the tool in relation to the profile.
{tool_side_left,tool_side_right,tool_side_middle
}

Parameters for Drill jobs

drill_type type: integer Drill type, as defined in 'machine.mac' file.

d_drill_type type: integer Internal drill type
{D_Drilling, D_F_Drill, D_Peck,
D_Tapping, D_Boring,
D_R_Boring, D_F_Boring}.

Parameters for Turning jobs

work_type	type: integer	For Grooving job {groove_rough, groove_prof, cut, ang_groove}. For Turning job ROUGH, COPY, PROFILE}. For Threading Job {ONCE, MULTIPLE}.
semi_finish	type: integer	TRUE if semi finish process is needed.
finish	type: logical	TRUE if finish process is needed.
process_type	type: integer	{LONG, FACE}.
turning_mode	type: integer	for LONG: {INTERNAL,EXTERNAL} for FACE: {BACK, FRONT}.
rough_offset	type: integer	Type of rough offset.
rough_offset_dist, rough_offset_x, rough_offset_z	type: numeric	offsets for ROUGH/COPY process.
semi_offset_x, semi_offset_z	type: numeric	offsets for semi_finish process.F
down_step	type: numeric	distance between two consecutive turning movements.
down_step_type	type: integer	Determines whether the thread should be done in one step or by multi step {DS_VALUE, DS_LIST}.
num_down_steps	type: integer	Number of down steps (if it is a multi step thread).
lead_unit	type: integer	{MM, PITCH_INCH}.
lead	type: numeric	lead of thread (pick to pick).
side_step	type: numeric	Distance between each two groove-cut steps.
min_diameter	type: numeric	Minimal diameter of thread.
start_pnt	type: numeric	Start position point of the job.
end_pnt	type: numeric	End position point of the job.

External cycle parameters

Parameters may be defined by the user in the [machine.mac] file. These parameters define the 'turn_type', ‘drill_type’, ‘groove_type’ and thread_type’ types. For each type defines the parameters required for it. The value of the parameters of each type set on the current job.

Parameters for Wire_cut jobs

wire_inserted; type: integer 1 if wire inserted, 0 otherwise

Description:

This command generates a subroutine call. Usage of the functions 'start_line' and 'end_line' is limited to generate statements only; for further description of their behaviour see section 5.6.4 ('generation functions').

Examples:

```
@call_proc          ; FANUC
   if active(parm1) then
      gcode = 65          ; generate G65 macro call type
      {nb, 'G'gcode, ' P'label}
      {' A'parm1, [' B'parm2], [' C'parm3]}
   else
      {nb, 'M98 P'label}  ; generate normal M98 subroutine call
                          ; type
   endif
   if proc_count gt 1 then
      {' L'proc_count}    ; repeatition factor
   endif
   {[' ('message, ')']}    ; optional descriptive text
endp
```

@change_ref_point

Parameters:

xhome,yhome,zhome	type: numeric	Position of new home location.
absolute	type: logical	TRUE if the change ref point coordinates are absolute; FALSE if relative.
ref_point_init	type: logical	TRUE if changed back to the original value

Description:

This command generates the G-Code block required to change the HOME location.

Examples:

```
@change_ref_point
   ; Given in absolute mode
   gcode = 92
   {nb, 'G'gcode, ' X'xhome, ' Y'yhome, ' Z'zhome}
endp
```

@change_tool

Parameters:

tool_number	type: integer	Number of tool to be changed to.
tool_diameter	type: numeric	Diameter of tool to be changed to.
tool_length	type: numeric	The length of the tool relative to the length of the first tool (as defined in milling tools table).
corner_radius	type: numeric	The corner radius of the tool.
tool_direction	type: integer	Direction of spin of tool {CW, CCW}.
first_tool	type: logical	TRUE if this is the first tool in the progam.
last_tool	type: logical	TRUE if this is the last tool change in the program.
next_tool_number	type: integer	Number of next tool.
next_tool_machine_type	type: integer	Machine type of next tool.
xnext,ynext,znext	type: numeric	Position to move to after tool change.
spin	type: numeric	Spin rate.
tool_id_number	type: integer	Identification number of the tool.
next_tool_id_number	type: integer	Identification number of the next tool.
xtool,ytool,ztool	type: numeric	Coordinates of tool-change position. (Optional).
tool_name	type: string	Name of the tool.
group_tool_name	type: string	Name of the group tool.
holder_name	type: string	Name of the holder of the tool.
group_holder_name	type: string	Name of the group holder of the tool.
tool_description	type: string	Description of the tool.
holder_description	type: string	Description of the holder.
total_tool_length	type: numeric	The length of the tool.

cutting_tool_length type: numeric The length of the cutting tool.

work_material type: string Kind of the stock material.
Used for feed calculation.

tool_material type: string Kind of the tool material.
Used for feed calculation.

d_offset type: integer The d offset address

h_offset type: integer The h offset address

hlength type: numeric

number_of_jobs_used_tool type: integer Number of jobs that use this tool number

Description:

This command generates the G-code required to change the tool.

Examples:

```
@change_tool       ; MAHO-432
  {nb, '(* TOOL 'tool_number ' - DIA 'tool_diameter '*)'}
  {nb, 'M9'}
  ; The tool is stopped by M6
  {nb, 'T'tool_number, ' M6'}
  xpos = xnext
  ypos = xnext
  zpos = tool_start_plane
  call @rapid_move       ; generate G0 block
  direction = CCW
  call @start_tool       ; generate G4 block
endp
```

@chng_tool_cnext

Parameters:

cnext type : numeric Normalized cpos

Description:

This command normalizes cpos.

@compensation

Parameters:

side	type: integer	Side of compensation {COMP_LEFT, COMP_RIGHT} or no compensation{COMP_OFF}.
offset_number	type: integer	The tool number in tool table (it may be used here or in'@change_tool').
tool_offset offset_radius	type: numeric	The tool offset radius.

Description:

This command decides whether tool-compensation is active and if yes, at what side.

Examples:

```
compensation      ; FANUC , MAHO-432
   if side eq COMP_LEFT then
      gcode = 41
   endif
   if side eq COMP_RIGHT then
      gcode = 42
   endif
   if side eq COMP_OFF then
      gcode = 40
   endif
   {nb, 'G'gcode, ' '}
   skipline = FALSE    ; next G-Code will be generated on the
                         same block, not on a new one.
endp
```

@def_tool

Parameters:

tool_number	type: integer	The number of the tool.
tool_offset	type: numeric	The tool radius.
tool_id_number	type: integer	Identification number of the tool.
tool_name	type: string	Name of the tool.
group_tool_name	type: string	Name of the group tool.
holder_name	type: string	Name of the holder of the tool.
group_holder_name	type: string	Name of the group holder of the tool.
tool_description	type: string	Description of the tool.
holder_description	type: string	Description of the holder.
total_tool_length	type: numeric	The length of the tool.
cutting_tool_length	type: numeric	The length of the cutting tool.
work_material	type: string	Kind of the stock material.
Used for feed calculation.		
tool_material	type: string	Kind of the tool material.
Used for feed calculation.		
d_offset	type: integer	The d offset address
h_offset	type: integer	The h offset address
hlength	type: numeric	

Description:

This command defines the tool characteristics.

Examples:

```
@def_tool       ; FANUC
   {nb, '(G10 L12 P', (tool_number+50), ' R'tool_offset, ')'}
endp
```

@def_turn_tool

Parameters:

tool_number	type: integer	The number of the tool.
tool_id_number	type: integer	Identification number of the tool.
message	type: string	descriptive message for tool change.
tool_direction	type: integer	{CW/CCW}.
tool_mode	type: integer	left/right tool.
tool_origin	type: integer	Tool reference point {T_TANGENT, T_CENTER, T_DEFINE}.
tool_type	type: integer	tool family {EXT_ROUGH, TURN_DRILLING, EXT_THREAD, EXT_GROOVE, EXT_CONTOUR, INT_FACE_BACK, INT_THREAD, INT_GROOVE, INT_CONTOUR, INT_ROUGH}.

Description:

This command defines the tool characteristics.

Examples:

```
@def_turn_tool        ; FANUC
   {nb, '(G10 L12 P', (tool_number+50) ')'}
endp
```

@delay

Parameters:

delay_period type: numeric Delay amount.

Description:

This command generates the G-Code block required to cause a delay.

Examples:

```
@delay          ; FANUC
   gcode = 4
   {nb, 'G'gcode, ' P'delay_period:integer_def_f}
                        ;'delay_period' is numeric, and FANUC
                        ; requires it to be generated
                        ; without the decimal point.
endp

@delay          ; MAHO-432
   gcode = 4
   {nb, 'G'gcode, ' X'delay_period:'5.1(p)'}
                        ; no more that 1 digit after the
                        ; (optional) decimal point.
 endp
```

@drill

Parameters:

xpos, ypos, zpos	type: numeric	Position of point to be drilled in local coordinate system
xhpos, yhpos, zhpos	type: numeric	Position of point to be drilled in part coordinate system
drill_type	type: integer	Drill type, as defined in 'machine.mac' file.
d_drill_type	type: integer	Internal drill type {D_Drilling, D_F_Drill, D_Peck, D_Tapping, D_Boring, D_R_Boring, D_F_Boring}.
drill_lower_z	type: numeric	Drill lower-level.
drill_upper_z	type: numeric	Drill upper-level (including the safety distance).
drill_clearance_z	type: numeric	The level the tool rises to when moving from one hole to another.
drill_depth	type: numeric	(drill_upper_z-drill_lower_z).
down_step	type: numeric	Depth of down-step.
num_down_steps	type: integer	Number of down-steps (last step can be shorter than others).
feed	type: numeric	Feed-rate.
spin	type: numeric	Spin rate.

In addition to the above parameters, more parameters may be defined by the user in the 'machine.mac' file. These parameters define the 'drill_type', and for each type, defines the parameters required for it. See examples below.

Examples:

FANUC:
(here is a portion from the FANUC.MAC file):

```
      drill_type      = Drilling  Y              ; G81
      drill_type      = F_Drill   Y Delay        ; G82
      drill_type      = Peck      Y Delay        ; G83
      drill_type      = Tapping   Y Delay        ; G84
      drill_type      = Boring    Y Delay        ; G85
      drill_type      = R_Boring  Y Delay        ; G86
      drill_type      = F_Boring  Y Delay        ; G89
```

Seven 'drill_type' are defined here: 'Drilling', 'F_Drill', 'Peck', 'Tapping', 'Boring', 'R_Boring' and 'F_Boring'. Each drill type has its own parameters. For example: if 'drill_type' is 'Peck', then parameter 'Delay' has a valid value.

(here is the GPPL procedure for drilling):

```
@drill
   call @rapid_move       ; generate G0 block to (xpos,ypos,zpos)
    gcode = 98
    {nb, 'G'gcode, ' '}
    if drill_type eq drilling then
       gcode = 81
    endif
    if drill_type eq f_drill then
       gcode = 82
    endif
    if drill_type eq peck then
       gcode = 83
    endif
    if drill_type eq tapping then
       gcode = 84
    endif
    if drill_type eq boring then
       gcode = 85
    endif
    if drill_type eq r_boring then
       gcode = 86
    endif
    if drill_type eq f_boring then
       gcode = 89
    endif
    {'G'gcode, ' Z'drill_lower_z, ' R'drill_upper_z}
    if drill_type eq peck then
       {' Q'down_step}
    endif

    if drill_type eq f_drill or drill_type eq tapping then
       {' P'delay:integer_def_f}
    endif
    {' F'feed}
endp
```

@drill4x_cartesian

Parameters:

xpos, cpos	type : numeric	Coordinate of the drill-point.
dc	type : numeric	Delta of cpos
dir4x	type : integer	Direction of C axis {CW, CCW}
first_drill	type : logical	(see @drill_point)

Description:

This command generates the G-Code block required to define a drill-point. Drill position is defined by cartesian coordinates (xpos, cpos).

@drill_point

Parameters:

first_drill	type: logical	Defines whether this is the first drill-point of a cycle or not. In some machines, the first drill is executed by '@drill'.
xpos, ypos, zpos	type: numeric	Coordinates of the drill-point in local coordinate system. Only two of them have to be used according to the machine plane.
xhpos, yhpos, zhpos	type: numeric	Coordinates of the drill-point in part coordinate system.
xhupos, yhupos, zhupos	type: numeric	Coordinates of the drill-point on the upper plane in part coordinate system

Description:

This command generates the G-Code block required to define a drill-point.

Examples:

```
@drill_point       ; FANUC
   if not first_drill then
      {nb, '   ', [' X'xpos], [' Y'ypos], [' Z'zpos]}
   endif
endp

@drill_point           ; MAHO-432
   gcode = 79
   {nb, 'G'gcode, [' X'xpos], [' Y'ypos], [' Z'zpos]}
endp
```

@drill4x_pnt

Parameters:

xpos, ypos, zpos cpos	type:numeric	Coordinates of the drill-point. Only two of them have to be used according to the machine plane ('cpos' is always used).
first_drill	type:logical	Defines whether this is the 1st drill-point of a cycle or not. In some machines, the 1st drill is executed by '@drill'.

Description:

This command generates the G-code block required to define a drill-point when using simultaneous 4th axis.

Examples:

```
@drill4x_pnt    ; FAN_0TC
   if not first_drill then
      {nb,'  ',[' X'xpos],[' Z'zpos ],[' C'cpos]}
   endif
endp
```

@drill4x_polar

Parameters:

xpos, cpos	type : numeric	Coordinate of the drill-point.
dc	type : numeric	Delta of cpos
dir4x	type : integer	Direction of C axis {CW, CCW}
first_drill	type : logical	(see @drill_point)

Description:

This command generates the G-Code block required to define a drill-point. Drill position is is defined by polar coordinates (xpos * cos(cpos), xpos * sin(cpos)).

@end_drill

Parameters:

None.

Description:

This command generates the G-Code block required to terminate the drill-cycle.

Examples:

```
@end_drill          ; FANUC
   gcode = 80
   {nb, 'G'gcode}
endp

@end_drill          ; MAHO-432
   ; No end_drill - always active
   ; Note that the procedure MUST present, although it contains
   ; no executable code generation.
endp
```

@end_job_procs

Parameters:

none

Description:

This command generates the required Gcode for end of job procedures.

Example:

```
@end_job_procs   ; FANUC
   {nb, 'M99'}
endp
```

@end_loop

Parameters:

label	type: integer	Name (number) of the loop.
loop_level	type: integer	Loop nesting.
loop_count	type: integer	Number of times the loop is executed.
start_line	type: function	Block number of loop start.
end_line	type: function	Block number of loop end.

Description:

This command generates the G-code needed to end a loop.

Examples:

```
@end_loop       ; FANUC
   local integer var_num

   var_num = loop_level + 20
   {nb '#', var_num, ' = #', var_num, ' + 1'}
   {nb 'END ', loop_level}
endp

@end_loop       ; MAHO
   gcode=14
   loop_count = loop_count - 1
   {nb, 'G'gcode, ' N1='start_line, ' N2='end_line, ' J'loop_count}
endp
```

@end_of_file

Parameters:

None

Description:

Executed at the end of the G-Code file generation. It may contain user defined procedures. Use the following properties for automatic numbering of these procedures:

- Specify their number in 'num_user_procs' (in '@init_post').
- Use variable 'first_user_proc' as the first procedure number.
- Use 'first_user_proc'+1 for the second one etc...

Examples:

```
@end_of_file        ; FANUC
   label = first_user_proc
   call @proc          ; generate 'Onnnn' block
   {nb, '(--------------------)'}
   {nb, '(-   CHANGE TOOL    -)'}
   {nb, '(--------------------)'}
   {nb, 'G80 G49 G40 M9'}
   {nb, 'G91 G28 Z0.'}
   call @stop_tool     ; genarate 'M5' block
   {nb, 'G90 M1'}
   {nb, 'M6'}
   call @end_proc      ; generate 'M99' block
   {nl, '%'}
endp
```

@end_proc

Parameters:

label	type: integer	Name (number) of the subroutine.
end_of_job	type: logical	TRUE for end of job procedure.
start_line	type: function	Block number of subroutine start.
end_line	type: function	Block number of subroutine end.

Description:

This command generates G-Code for subroutine termination.

Examples:

```
@end_proc       ; FANUC
   {nb, 'M99'}
endp

@end_proc       ; MAHO-432
            ; Since block numbers are used to refer to the
            : subroutine, there is no need to generate any
            ; G-Code blocks.
            ; Note that the procedure MUST be resent, although
            ; it contains no executable code generation
endp
```

@end_program

Parameters:

xpos, ypos, zpos type: numeric End position of the tool.

Description:

This command is executed at the end of the of the main program.

Examples:

```
@end_program        ; FANUC
   {nb, 'M9'}
   call @rapid_move    ; move to (xpos,ypos,zpos)
   {nb, 'M30'}
endp
```

@feed_spin

Parameters:

feed_unit	type: integer	Feed units {MM_MIN / MM_REV}
feed	type: numeric	Feed rate
spin_unit	type: integer	Spin units {RPM/CSS}
spin	type: numeric	Spin rate
spin_direction	type: integer	Spin direction {CW/CCW}

Description:

This command generates a G-code which defines the feed and spin rates for turning jobs.

Example:

```
@feed_spin
   if feed_unit eq MM_MIN then
      gcode = 94
   else
      gcode = 95
   endif
   {nb, 'G' gcode, [ S'spin ] }
endp
```

@fourth_axis

Parameters:

angle type: numeric rotation angle (in degrees).

direction_4x type: integer direction of rotation {CW,CCW}.

xnext, ynext type: numeric next (X,Y) position.

Description:

This command generates the G-code block required to control the fourth-axis rotation.

Examples:

```
@fourth_axis        ; FANUC
   gcode = 0
   {nb, 'G'gcode, ' A'angle}
endp

@fourth_axis        ; MAHO-432
   gcode = 0
   {nb, 'G'gcode, ' B'angle}
endp
```

@groove

Parameters:

work_type	type: integer	{groove_rough, groove_prof, cut, ang_groove}.
process_type	type: integer	{LONG, FACE}.
turning_mode	type: integer	for LONG: {INTERNAL, EXTERNAL} for FACE: {BACK, FRONT}.
first_pos_x, first_pos_z	type: numeric	coordinates of first point of geometry.
last_pos_x, last_pos_z	type: numeric	coordinates of last point of geometry.
second_offset	type: integer	offset number of the other side of the tool.
down_step	type: numeric	down step of the groove.
side_step	type: numeric	distance between each two groove-cut steps.
release_dist	type: numeric	safety release distance of the groove-cut.

In addition to the above parameters, more parameters may be defined by the user in the [machine.mac] file. These parameters define the 'turn_type' and for each type defines the parameters required for it. See the example below.

Description:

This command generates a groove cycle block.

Examples:

```
@groove      ; FANUC  (simplified)

   if process_type eq FACE then
      gcode = 74
   else
      gcode = 75
   endif
   {nb, 'G' gcode, 'R'release_dist}
   {nb, 'G' gcode, 'X'first_pos_x, 'Z'last_pos_z}
   {'P'down_step, 'Q'side_step, 'F'feed}
endp
```

Note:

SolidCAM splits a multiple-lines geometry into single line entities.

@home_data

Parameters:

home_number:1
clearance_plane:50.000 tool_start_plane:70.000
work_upper_plane:0.000 zero_plane:-40.000
rotate_angle_x:0.000T rotate_angle_y:0.000T rotate_angle_z:0.000T
rotate_angle_x_dir:cw rotate_angle_y_dir:cw rotate_angle_z_dir:cw
x_angle_const_z:0.000T y_angle_const_z:0.000T dev_angle_z:0.000T
x_angle_const_z_dir:cw y_angle_const_z_dir:cw dev_angle_z_dir:cw
x_angle_const_y:0.000T z_angle_const_y:0.000T dev_angle_y:0.000T
x_angle_const_y_dir:cw z_angle_const_y_dir:cw dev_angle_y_dir:cw
y_angle_const_x:0.000T z_angle_const_x:0.000T dev_angle_x:0.000T
y_angle_const_x_dir:cw z_angle_const_x_dir:cw dev_angle_x_dir:cw
angle_4x_around_x:0.000T angle_4x_around_y:0.000T
angle_4x_around_x_dir:cw angle_4x_around_y_dir:cw
shift_x:0.000T shift_y:0.000T shift_z:0.000T
part_home_number:1 tool_z_level:500.000
tmatrix_I_1:1.000T tmatrix_I_2:0.000T tmatrix_I_3:0.000T tmatrix_I_4:0.000T
tmatrix_I_5:0.000T tmatrix_I_6:1.000T tmatrix_I_7:0.000T tmatrix_I_8:0.000T
tmatrix_I_9:0.000T tmatrix_I_10:0.000T tmatrix_I_11:1.000T tmatrix_I_12:0.000T
. tmatrix_I_13:0.000T tmatrix_I_14:0.000T tmatrix_I_15:0.000T tmatrix_I_16:1.000T
. x = cosy*cosz*x - sinz*cosy*y + siny*z
.. y = (-sinx*siny*cosz + cosx*sinz)*x + (sinx*siny*sinz + cosx*cosz)*y - sinx*cosy*z
z = (cosx*cosz*siny + sinx*sinz)*x + (-sinz*cosx*siny + sinx*cosz)*y - cosx*cosy*z
around Z
x = x*cos(dev_angle) - y*sin(dev_angle)
y = x*sin(dev_angle) + y*cos(dev_angle)
around Y
z = z*cos(dev_angle) - x*sin(dev_angle)
x = z*sin(dev_angle) + x*cos(dev_angle)
around X
y = y*cos(dev_angle) - z*sin(dev_angle)
z = y*sin(dev_angle) + z*cos(dev_angle)

This contains the same information as in **@tmatrix** .

This command is used at the end of the program to generate a sub-program for each home; we can later call this sub-program from the main program whenever we have to change the home position. If at some later point, the operator needs to change something, he can easily change only in one place (in the home sub-program).

Description:

@home_data contains information about the part home number, machine home number, planes, angles, shifts and transformation matrix.

@home_data location depends on mac variable home_data_at_start:
if “Y” appears after @def_tool
if “N” appears after @end_program.

Example of Deckel-Maho:

```
@home_data

        {nl, '%MM' (6000+part_home_number)}
            {nl,'N' (6000+part_home_number)}
            {nl,'N5 (X) E101=' shift_x ' (Y) E102='shift_y ' (Z) E103=' shift_z }
            {' (A) E111=' (-rotate_angle_x) }
            {' (B) E112=' (rotate_angle_y) }
            {' (C) E113='(-rotate_angle_z)}
            {nl}
endp
```

@home_number

Parameters:

home_number type: integer The number of machine home to be activated.

Description:

This command generates the G-Code required to activate a new machine home. A new home can be set in the Job data-screen.

Examples:

```
@home_number        ; FANUC
   gcode = 53 + home_number
   {nb, 'G'gcode}
endp

@home_number        ; MAHO-432
   ; Note that the procedure MUST present, although it
   ; contains no executable code generation

endp
```

@init_cpos

Parameters:

prev_cpos	type: numeric	Rotation angle of the last block in the previous job. Used for milling jobs when using simultaneous 4th axis and when the value of the 'init_cpos' parameter in the .MAC file is 'Y'.
best_cpos	type: numeric	The best rotation angle to set the machine before the 1st movement block in a new job. See explanation for 'init_cpos' parameter in the machine parameters (chapter 3).

Description:

This command is used before the 1st movement block in a new milling job when using simultaneous 4th axis. It is used to set a new rotation angle for the machine home. It is used only if the 'init_cpos' parameter in the .MAC file is 'Y'. This parameter is used for avoiding unnecessary rotations of the material.

Examples:

```
@init_cpos      ; FAN_0TC
  gcode = 0
  {nb,'G'gcode ' C'prev_cpos}
  gcode = 50
  {nb,'G'gcode ' C'best_cpos}
endp
```

@line

Parameters:

xpos, ypos, zpos	type: numeric	Tool-position at end of movement in local coordinate system
xhpos, yhpos, zhpos	type: numeric	Tool-position at end of movement in part coordinate system
feed	type: numeric	Feed-rate of movement.
next_direction	type: numeric	Direction of the next XY block (if the next block is not an XY block).

Description:

This command generates the line feed-positioning G-code.

Examples:

```
@line          ; FANUC
   gcode = 1
   {nb, ['G'gcode'],[' X'xpos],[' Y'ypos],[' Z'zpos],[' F'feed]}
endp
```

@line_4x

Parameters:

xpos, ypos, zpos, cpos	type: numeric Tool position at the end of the movement.
feed	type: numeric Feed-rate of movement. If 'cpos' is changed in the block, the feed is in Angle/Min , otherwise it is in MM/Min.
next_direction	type: numeric Direction of the next XY block (if the next block is not an XY block).

Description:

This command generates the line feed-positioning G-code when using simultaneous 4th axis.

Examples:

```
@line_4x    ; FAN_0TC
  gcode = 1
  {nb, ['G'gcode],[' X'xpos],[' Z'zpos ],[' C'cpos],[' F'feed]}
endp
```

@line_5x

Parameters:

xpos, ypos, zpos, apos, bpos	type: numeric Tool position at the end of the movement.
feed	type: numeric Feed-rate of movement.
next_direction	type: numeric Direction of the next XY block (if the next block is not an XY block).

Description:

This command generates the line feed-positioning G-code when using 5 axis.

Examples:

```
@line_5x
  gcode = 1
  {nb, '[G'gcode],[' X'xpos] [' Y'ypos] [' Z'zpos] [' A'apos]  [' B'bpos][' F'feed]}
endp
```

@line4x_cartesian

Parameters:

xpos, ypos, zpos	type : numeric	Tool-position at end of movement.
cpos	type : numeric	C positioning of the machine
feed	type : numeric	Feed-rate of movement.
next_direction	type : numeric	Direction of next XY block (if the next block is not an XY block).
dc	type : numeric	Delta of cpos
dir4x	type : integer	Direction of C axis {CW, CCW}

Description:

This command generates the line feed-positioning G-Code. End position is defined by cartesian coordinates.

@line4x_dir

Parameters:

xpos, ypos, zpos	type : numeric	Tool-position at end of movement.
cpos	type : numeric	C positioning of the machine
feed	type : numeric	Feed-rate of movement.
next_direction	type : numeric	Direction of next XY block (if the next block is not an XY block).
dc	type : numeric	Delta of cpos
dir4x	type : integer	Direction of C axis {CW, CCW}

Description:

This command generates the line feed-posiotioning G-Code when using simultaneous 4th axis. 'dir4x' parameter sets the machine rotate direction.

This command is generated if the MAC file parameter set_dir = Y.

@line4x_polar

Parameters:

xpos, ypos, zpos	type : numeric Tool-position at end of movement.
cpos	type : numeric C positioning of the machine
feed	type : numeric Feed-rate of movement.
next_direction	type : numeric Direction of next XY block (if the next block is not an XY block).
dc	type : numeric Delta of cpos
dir4x	type : integer Direction of C axis {CW, CCW}

Description:

This command generates the line feed-posiotioning G-Code. End position is defined by polar coordinates.

@line_on

Parameters:

xpos, ypos, zpos	type: numeric	Tool-position at end of movement.
feed	type: numeric	Feed-rate of movement.
before	type: logical	The move ends a radius before or after the point specified.

Description:

A line feed-positioning command which is shorter or longer in a tool radius length. This command is generated if the MAC file parameter comp_x_start = Y.

Example:

```
@line_on        ; MAHO-432
        if before then
           gcode = 43
        else
           gcode = 44
        endif
        {nb, 'G'gcode, ' '}
  skipline = FALSE
        call @line
endp
```

@loop

Parameters:

label	type: integer	Name (number) of the loop.
loop_level	type: integer	Loop nesting.
loop_count	type: integer	Number of times the loop is executed.
start_line	type: function	Block number of loop start.
end_line	type: function	Block number of loop end.

Description:

This command generates the G-code needed to start a loop.

Examples:

```
@loop          ; FANUC
   local integer var_num

   var_num = loop_level + 20
   {nb, '#'var_num, ' = 0'}
   {nb, 'WHILE [#'var_num, ' LT ',loop_count,'] DO ',loop_level}
endp
```

@m_feed_spin

Parameters:

feed_unit	type: integer	Feed units {MM_MIN / MM_REV}
feed	type: numeric	Feed rate
spin_unit	type: integer	Spin units {RPM/CSS}
spin	type: numeric	Spin rate
spin_direction	type: integer	Spin direction {CW/CCW}

Description:

This command generates a G-code which defines the feed and spin rates for milling.

Example:

```
@feed_spin
   if feed_unit eq MM_MIN then
      gcode = 94
   else
      gcode = 95
   endif
   {nb, 'G' gcode, [ S'spin ] }
endp
```

@machine_plane

Parameters:

machine_plane type: integer {XY, YZ, ZX}

Description:

This command defines the machining plane. This procedure is called only once, because the machine plane is fixed during program generation.

Examples:

```
@machine_plane      ; FANUC
   if machine_plane eq XY
      gcode = 17
   endif
   if machine_plane eq YZ
      gcode = 18
   endif
   if machine_plane eq ZX
      gcode = 19
   endif
   {nb, 'G'gcode}
endp
```

@message

Description:

This command generate the G-Code block required to print a message.

Parameters:

message type: string The message to be printed.

Examples:

```
@message            ; FANUC, MAHO-432
   {nb, '(', message, ')'}
endp
```

@mirror

Parameters:

mirror_type	type: integer	{MIRROR_OFF, MIRROR_X, MIRROR_Y, MIRROR_XY}

Description:

This command generates the G-Code block required to activate the mirror facility.

Examples:

```
@mirror        ; FANUC
   if mirror_type eq MIRROR_OFF then
      {nb, 'G50.1 X0 Y0'}
   else
      {nb, 'G51.1 '}
      if mirror_type eq MIRROR_X then
         {'X1 Y0'}
      endif
      if mirror_type eq MIRROR_Y then
         {'X0 Y1'}
      endif
      if mirror_type eq MIRROR_XY then
         {'X1 Y1'}
      endif
   endif
endp

@mirror        ; MAHO-432
   if mirror_type eq MIRROR_OFF then
      gcode = 72
   else
      gcode = 73
   endif
   {nb, 'G'gcode}

   if mirror_type eq MIRROR_X then
      {' X1'}
   endif
   if mirror_type eq MIRROR_Y then
      {' Y1'}
   endif
   if mirror_type eq MIRROR_XY then
      {' X1 Y1'}
   endif
endp
```

@move4x_cartesian

Parameters:

xpos, ypos, zpos	type : numeric Tool-position at end of movement.
cpos	type : numeric C positioning of the machine
next_direction	type : numeric Direction of next XY block (if the next block is not an XY block).
dc	type : numeric Delta of cpos
dir4x	type : integer Direction of C axis {CW, CCW}

Description:

This command generates the rapid-positioning G-Code.
End position is defined by cartesian coordinates.

@move4x_dir

Parameters:

xpos, ypos, zpos	type : numeric Tool-position at end of movement.
cpos	type : numeric C positioning of the machine
next_direction	type : numeric Direction of next XY block (if the next block is not an XY block).
dc	type : numeric Delta of cpos
dir4x	type : integer Direction of C axis {CW, CCW}

Description:

This command generates the rapid-positioning G-Code when using simultaneous 4th axis. 'dir4x' parameter sets the machine rotate direction.

This command is generated if the MAC file parameter set_dir = Y.

@move4x_polar

Parameters:

xpos, ypos, zpos	type : numeric Tool-position at end of movement.
cpos	type : numeric C positioning of the machine
next_direction	type : numeric Direction of next XY block (if the next block is not an XY block).
dc	type : numeric Delta of cpos
dir4x	type : integer Direction of C axis {CW, CCW}

Description:

This command generates the rapid-positioning G-Code.
End position is defined by polar coordinates.

@move_4x

Parameters:

xpos, ypos, zpos, cpos type:numeric Tool position at end of movement.

Description:

This command generates the rapid-positioning G-code when using simultaneous 4th axis.

Examples:

```
@move_4x    ; FAN_0TC
   gcode = 0
   {nb,'G'gcode,[' X'xpos],[' Z'zpos ],[' C'cpos]}
endp
```

@move_5x

Parameters:

xpos, ypos, zpos, apos, bpos type:numeric Tool position at end of movement.

Description:

This command generates the rapid-positioning G-code when using 5 axis.

Examples:

```
@move_5x
   gcode = 0
   {nb,'G'gcode,[' X'xpos],[' Z'zpos ],[' A'apos] ,[' B'bpos]}
endp
```

@proc

Parameters:

label type: integer Name (number) of the subroutine.

start_line type: function Block number of subroutine start.

end_line type: function Block number of subroutine end.

All the parameters that available in @start_of_job available also in @proc.

Description:

This command generates the subroutine header. Usage of the functions 'start_line' and 'end_line' is limited to generate statements only; for further description of their behaviour see section 5.6.4 ('generation functions').

Examples:

```
@proc          ; FANUC
   {nl, 'O'label}      ; Note the use of 'nl' and not 'nb'. This
                       ; block should not be numbered.
endp
```

@rapid_move

Parameters:

xpos, ypos, zpos	type: numeric	Tool-position at end of movement in local coordinate system
xhpos, yhpos, zhpos	type: numeric	Tool-position at end of movement in part coordinate system
next_direction	type: numeric	Direction of the next XY block (if the next block is not an XY block).

Description:

This command generates the rapid-positioning G-code.

Examples:

```
@rapid_move     ; FANUC
   gcode = 0
   {nb, ['G'gcode], [' X'xpos], [' Y'ypos], [' Z'zpos]}
endp
```

@relative_mode

Parameters:

None

Description:

This command enters the program into relative coordinate positioning mode.

Examples:

```
@relative_mode        ; FANUC,
   gcode = 91
   {nb, 'G'gcode}
   skipline = FALSE   ; generate next command on same line
endp
```

@rotary_info

Parameters:

rot_axis_type type: integer The type of a milling job when using simultaneous 4th axis. {AXIS4_NONE, AXIS4_FACE, AXIS4_TOP, AXIS4_RADIAL}.

radial_diameter type: numeric Material diameter for TOP or WRAP milling jobs, when using simultaneous 4th axis.

center_pos type: numeric Level of material rotation center position. This parameter is relevant for TOP or WRAP milling jobs, when using simultaneous 4th axis.

rot_axis_coord type: integer The type of rot_axis_coordinate (axis4_split, axis4_polar, axis4_cartesian

Description:

This command is used at the begining of every job when using simultaneous 4th axis. This function provides the parameters of the job type, and of the material diameter and rotation center position.

Examples:

```
@rotary_info       ; FAN_0TC
   if rot_axis_type eq axis4_radial
     machine_plane = YZ
   endif
endp
```

@rotate

Description:

This command generates the G-code block required to start/cancel rotation.

Parameters:

rotate_cancel type: logical TRUE if rotation should be cancelled.

angle type: numeric Rotation angle.

Examples:

```
@rotate        ; FANUC
   ; Not exist in FANUC 6M
   if rotate_cancel then
      gcode = 69
      {nb, 'G'gcode}
   else
      gcode = 68
      {nb, 'G'gcode, ' X0 Y0 G91 R'angle}
      {nb, 'G90'}
   endif
endp

@rotate        ; MAHO-432
   gcode = 92
   {nb, 'G'gcode, ' B4='angle}
endp
```

@start_of_file

Parameters:

home_number	type:	integer	Machine home to be used.
g_file_name	type:	string	The G-Code file name to be generated.
full_g_file_name	type:	string	The full G-Code file name to be generated.
part_name	type:	string	The name of the part.

Description:

This command is executed once at the start of the G-Code file (before the tool definition section).

Example 1:

```
          @start_of_file      ; FANUC
             {'%'}
             {nl, 'O'program_number, ' (', g_file_name, ')'}
             if rotate_used then
      gcode = 69
      {nb, 'G'gcode}
             endif
   if mirror_used then
      {nb, 'G50.1 X0 Y0'}
             endif
   {nb, '(SUBROUTINES: O'first_proc_number}
   {    ' .. O' last_proc_number, ')'}
endp
```

Example 2:

Get the file size:

First Step:
set 'print_file_size' = 1 in '@init_post'..
Second Step:
Refer to the value of variable ‘file_size’ as following

```
@start_of_file
          {nl,  ‘$$file_size$$’}
endp
```

@start_of_job

Parameters:

job_name	type: string	The name of the job.
job_type	type: string	Can be one of the following: {"pocket", "profile", "drill","slot","trans_surf", "3-d model", "multy-drill", "3-d drill","3-d engraving", "5x_advanced","5x_face","5x_pen_trace","5x_port_mach", "5x_swarf","5x_turbine", "5x_2_5_axis","5x_3axis","5x_4axis" "turn", "drill","thread", "groove" "profile", "4_axis", "constant_angle","macro", "variable_angle"}
job_machine_type	type: integer	The type of the current job {milling, turning, wire_cut}.
drill_type	type: integer	The type of drill operation. {drilling, peck, boring etc..}
prev_job_mac_type	type: integer	The type of the previous job {milling, turning, wire_cut}.
depth	type: numeric	Job depth. Valid for 2.5D milling jobs.
down_step	type: numeric	Depth of down step used in the job.
safety	type: numeric	Safety distance of the job
compensation	type: logical	Defines whether machine tool radius compensation is used in the job.
max_spin	type: numeric	Maximum spin rate allowed for the machine used for CSS spin rate type in turning.
msg	type: numeric	The comment given for the job.
tool_number	type: integer	The number of tool used by the job.
label	type:integer	Name (number) of the subroutine.
start_line	ype:function	Block number of subroutine start.
end_line	type: function	Block number of subroutine end.
finish_feed	type: numeric	Finish feed rate
feed_rate	type: numeric	Feed rate
spin_unit	type: integer	Spin units {RPM/CSS}
spin_rate	type: numeric	Spin rate
finish_spin	type: numeric	Finish spin rate

Parameters for Milling jobs

Job_clearance_plane type: numeric Z of clearance plane.

Job_upper_plane type : numeric Z of upper plane.

machine_plane type: integer {XY, YZ, ZX} The job working plane. Valid for milling jobs.

tool_length type: numeric The length of the tool used by the job.

z_feed type: numeric Feed rate in Z direction

Parameters for Profile job

cutting_diameter type : numeric Cutting diameter of drill tool for chamfer

tool_side type: integer Side location of the tool in relation to the profile. {tool_side_left,tool_ side_right,tool_side_ middle}

wall_offset type: numeric Wall offsets of the profile job.

clear_offset type: numeric Clear offsets of the job

clear_type type: integer Can be one of the following: {"for_and_back" "forward" }

depth_type type: integer Can be one of the following: { "constant_depth" }, {"slot_with_section" , "defined_depth" }

profile_app_type type: integer Can be one of the following: {"normal" , "arc" , "tangent" , "direct" , "point"}

Parameters for Pocket job

wall_offset type: numeric Wall offsets of the Pocket Job

floor_offset type: numeric Floor offsets of the Pocket Job

island_offset type: numeric Island offsets of the Pocket Job

pocket_app_type type: integer Can be one of the following: {"direct_approach", "vertical_approach" ,"diagonal_approach" ,"helical_approach", "linear_approach"}

Parameters for 4_Axis job

cartesian_mode type: integer 1 for Cartesian mode

polar_mode type: integer 1 for Polar mode

Parameters for '3-d model' job

msc_rough type: integer Can be one of the following: {none, hatch, contour, plunging}

msc_semi_finish, msc_finish type: integer Can be one of the following:

{none, linear, offset_cutting, spiral,
circular_pocket, constant_z, pencil}

Surface_offset	type: numeric Surface offsets
semi_finish_surface_offset	type: numeric Surface offsets for semi_finish process
semi_finish_wall_offset	type: numeric Wall offsets for semi_finish process
semi_finish_floor_offset	type: numeric Floor offsets for semi_finish process
msc_rough_down_step	type: numeric Depth of down step used in rough process
msc_semi_finish_down_step	type :numeric Depth of down step used in semi_finish process
msc_finish_down_step	type: numeric Depth of down step used in finish process
job_lower_plane	type : numeric Z of lower plane

Parameters for Turning jobs

use_cycle	type: logical	Defines wheather machine turning cycle is used in the job.

Description:

This command generates G-code at the beginning of the job. Normally, no code is required here. But if 'gen_procs' equals FALSE (meaning that machine does not have procedures) GPPtool executes the command '@start_of_job', but does not execute the command '@proc'.

Examples:

@start_of_job

```
   {nb,'(',job_name,')'}
   if msg ne ''
      {nb,'('msg,')'}
   endif
   if G64 ne 0
      {nb,'G64'}
   endif
   {nb, 'D'tool_number}
   {' G'gcode}
   if job_type ne 'drill'
     {' G40 G90 '}
      skipline = false
   else
      skipline = true
   endif
endp
```

@start_program

Parameters:

xpos, ypos, zpos type: numeric Start position of the tool

Description:

This command is executed once at the start of the main program.

Examples:

```
@start_program      ; FANUC
   ; after tools definition
   {nb, 'G80 G49 G40'}
   call @home_number        ; see procedure below
endp
@home_number                ; set current home
   gcode = 53 + home_number ; 'home_number' retains its
                            ; previous value assigned in
                                 ; '@start_of_file'
   {nb, 'G'gcode}
endp
```

@start_tool

Parameters:

tool_direction type:integer Direction of tool's rotation {CW, CCW}.

spin type: numeric Spin rate.

Description:

This command generates the G-Code block required to start the tool rotation.

Examples:

```
@start_tool        ; FANUC
   if direction eq CCW then
      mcode = 3
   else         ; CW
      mcode = 4
   endif
   {'S'spin:integer_def_f, ' M'mcode} ; 'spin' is numeric, and
                              ; FANUC requires it to be
                              ; generated without the
                              ; decimal point.
endp

@start_tool        ; MAHO-432
                ; start tool and coolant together
   if direction eq CCW then
      mcode = 13
   else         ; CW
      mcode = 14
   endif
   {'S'spin:integer_def_f, ' M'mcode} ; see note for FANUC above
endp
```

@stop_tool

Parameters:

None

Description:

This command generates the G-Code required to stop the tool rotation.

Examples:

```
@stop_tool          ; FANUC, MAHO-432
   {' M5'}             ; no 'nb' is required. 'M5' appended
                     ; to the previous line.
endp
```

@thread

Parameters:

work_type	type: integer	{ONCE, MULTIPLE}.
process_type	type: integer	{LONG, FACE}.
turning_mode	type: integer	for LONG: {INTERNAL,EXTERNAL} for FACE: {BACK, FRONT}.
is_line	type: logical	TRUE if geometry is single line.
num_points	type: integer	number of geometry points.
first_pos_x, first_pos_z	type: numeric	coordinate of first point of geometry.
last_pos_x, last_pos_z	type: numeric	coordinate of last point of geometry.
depth	type: numeric	full depth of thread.
down_step	type: numeric	down step for threading.
down_step_type	type: integer	Determines whether the thread should be done in one step or by multi step {DS_VALUE, DS_LIST}.
num_down_steps	type: integer	Number of down steps (if it is a multi step thread).
safety	type: numeric	distance to keep between geometry and final movement.
lead_unit	type: integer	{MM, PITCH_INCH}.
lead	type: numeric	lead of thread (pick to pick).
label	type: integer	Name (number) of geometry procedures.
start_line	type: function	Block number of geometry subroutine start.
end_line	type: function	Block number of geometry subroutine end.

In addition to the above parameters, more parameters may be defined by the user in the [machine.mac] file. These parameters define the 'turn_type' and for each type defines the parameters required for it. See the example below.

Description:

This command generates a thread cycle block.

Examples:

```
@thread     ; FANUC   (simplified)
   if work_type eq MULTIPLE then
      gcode = 76
      {nb,'G'gcode,'P'no_last_cut, phase,tool_alfa, 'R'last_cut}
      {nb,'G'gcode, 'X'last_pos_x, 'Z'last_pos_z, 'P'depth}
      {   'Q'down_step, 'F'lead}
   else
      gcode = 92
      {nb, 'G'code, 'X'last_pos_x, 'Z'last_pos_z, 'F'feed}
   endif
endp
```

@tmatrix

Description:

@tmatrix contains information about the part home number, angles, shifts and transformation matrix for multi-sided milling. In this command you can find all the needed information to develop GPP for the various 4 and 5 axis machines.

@tmatrix appears:
1) Before: @home_number.
2) After: @job_info.

Parameters:

rotate_angle_x:0.000T rotate_angle_y:90.000T rotate_angle_z:0.000T
rotate_angle_x_dir:cw rotate_angle_y_dir:cw rotate_angle_z_dir:cw
x_angle_const_z:0.000T y_angle_const_z:90.000T dev_angle_z:0.000T
x_angle_const_z_dir:cw y_angle_const_z_dir:cw dev_angle_z_dir:cw
x_angle_const_y:-90.000T z_angle_const_y:-90.000T dev_angle_y:-90.000T
x_angle_const_y_dir:ccw z_angle_const_y_dir:ccw dev_angle_y_dir:ccw
y_angle_const_x:-90.000T z_angle_const_x:-180.000T dev_angle_x:-180.000T
y_angle_const_x_dir:ccw z_angle_const_x_dir:ccw dev_angle_x_dir:ccw
angle_4x_around_x:0.000T angle_4x_around_y:0.000T
angle_4x_around_x_dir:cw angle_4x_around_y_dir:cw
shift_x:120.000T shift_y:0.000T shift_z:-40.000T
part_home_number:4 tool_z_level:500.000
tmatrix_l_1:0.000T tmatrix_l_2:0.000T tmatrix_l_3:-1.000T tmatrix_l_4:-40.000T
tmatrix_l_5:0.000T tmatrix_l_6:1.000T tmatrix_l_7:0.000T tmatrix_l_8:0.000T
tmatrix_l_9:1.000T tmatrix_l_10:0.000T tmatrix_l_11:0.000T tmatrix_l_12:-120.000T
tmatrix_l_13:0.000T tmatrix_l_14:0.000T tmatrix_l_15:0.000T tmatrix_l_16:1.000T
x = cosy*cosz*x - sinz*cosy*y + siny*z
y = (-sinx*siny*cosz + cosx*sinz)*x + (sinx*siny*sinz + cosx*cosz)*y - sinx*cosy*z
z = (cosx*cosz*siny + sinx*sinz)*x + (-sinz*cosx*siny + sinx*cosz)*y - cosx*cosy*z
around Z
x = x*cos(dev_angle) - y*sin(dev_angle)
y = x*sin(dev_angle) + y*cos(dev_angle)
around Y
z = z*cos(dev_angle) - x*sin(dev_angle)
x = z*sin(dev_angle) + x*cos(dev_angle)
around X
y = y*cos(dev_angle) - z*sin(dev_angle)
z = y*sin(dev_angle) + z*cos(dev_angle)

Explanation of @tmatrix variables:

> rotate_angle_x:0.000T rotate_angle_y:0.000T rotate_angle_z:0.000T
..> rotate_angle_x_dir:cw rotate_angle_y_dir:cw rotate_angle_z_dir:cw

Use this set of parameters to get the 3 rotation angles A, B, C that the controller needs for 5-axis machines (deckel with shop mill controller with tilt and rotting table):

A = rotate_angle_x
B = rotate_angle_y
C = rotate_angle_z

The angles are calculated in the following order:
- Rotation around Z.
- Rotation around Y
- Rotation around X.

This is the base information of the rotation and it is the same value you can see in the home data screen and the rotation angles of the drawing for the relevant part home number.

rotate_angle_x_dir = cw / ccw
rotate_angle_y_dir = cw / ccw
rotate_angle_z_dir = cw / ccw

This defines the shortest rotation direction to the next home (angle). It is needed for OKUMA (M15, M16).

..> x_angle_const_z:0.000T y_angle_const_z:0.000T dev_angle_z:0.000T
..> x_angle_const_z_dir:cw y_angle_const_z_dir:cw dev_angle_z_dir:cw

For 5-axis machines that the controller can get 2 rotation angles A, B:

A = x_angle_const_z
B = y_angle_const_z

The angles are calculated in the following order:

- Rotation around Y

- Rotation around X

With 2 rotation angles the system can calculate only one position to get the defined plane in the correct angles. The position of X-Y in the screen of the system is not the position of the

coordinates X – Y on the machine. This was made in order to transfer the program to different type of 5_axis controllers. To compensate this error we have the parameter:

dev_angle_z

In this parameter we will find the rotation angle (G69 in fanuc G11 R in okuma) we have to set by rotation command or calculate in the GPP the new values for X and Y coordinates.

x_angle_const_z_dir = cw / ccw
y_angle_const_z_dir = cw / ccw
dev_angle_z_dir = cw / ccw

This defines the shortest rotation direction to the next home (angle). It is needed for OKUMA (M15,M16).

EXAMPLE:

HIDNHAIN 426
1020 'CYCL DEF 10.0 ROTATION
1021 'CYCL DEF 10.1 ROT+Q56 ; Q56 is the **dev_angle_z**

In machines that do not have the rotate GCODE you can use this calculation @
@calc_rotate_x_y

```
        local numeric x y s_x s_y
        local logical save_ch_x save_ch_y

;   for @line @rapid_move @arc
            ; Saving the xops and ypos value to local parameters
            s_x = xpos
            s_y = ypos

            ;rotating the poit X Y to the new position.
            x = xpos*cos(dev_angle_x) - ypos*sin(dev_angle_x)
            y = xpos*sin(dev_angle_x) + ypos*cos(dev_angle_x)

            ; setting the rotated value back to XPOS and YPOS
             xpos = x
             ypos = y

            ; set the correct change bit to xpos and ypos
            if s_x <> xpos
                 change(xpos) = true
            else
                change(xpos) = false
```

```
            endif

            if s_y <> ypos
                 change(ypos) =  true
            else
                change(ypos) =  false
            endif

;    for @arc

            ;Calculating the rotated position to xcenter and  ycenter
            x = xcenter*cos(dev_angle_x) - ycenter*sin(dev_angle_x)
            y = xcenter*sin(dev_angle_x) + ycenter*cos(dev_angle_x)

           ; setting the rotated value back to XCENTR and YCENTER
           ycenter = y
           xcenter = x

endp
```

In the @line @rapid_move @arc, the following lines have to be added:

```
   if change(xpos) eq false and change(ypos) eq false

   else
       call  @calc_rotate_x_y
   endif
```

..> x_angle_const_y:0.000T z_angle_const_y:0.000Tdev_angle_y:0.000T
..> x_angle_const_y_dir:cw z_angle_const_y_dir:cw dev_angle_y_dir:cw

Use this set of parameters for 5 axis machines that the controller can get 2 rotation angles A, C

A = x_angle_const_y
C = z_angle_const_y

The angles are calculated in the following order:
- Rotation around Z.
- Rotation around X.

All other parameters are the same as above.

..> y_angle_const_x:0.000T z_angle_const_x:0.000Tdev_angle_x:0.000T
..> y_angle_const_x_dir:cw z_angle_const_x_dir:cw dev_angle_x_dir:cw

Use this set of parameters for 5 axis machines so that the controller can get 2 rotation angles B, C:

B = y_angle_const_x
C = z_angle_const_x

The angles are calculated in the following order:
- Rotation around Z.
- Rotation around Y.
All other parameters are the same as above.

..> angle_4x_around_x:0.000T angle_4x_around_y:0.000T

Use this set of parameters for machines with 4 axis:

- If the 4th axis is along the X axis (Vertical machine), use the value of the rotation from:

angle_4x_around_x

for example: {nb,'G0 A' angle_4x_around_x}

- If the 4th axis is along the Y axis (Horizontal machine), use the value of the rotation from: **angle_4x_around_y**

for example: {nb,'G0 A' angle_4x_around_y}

..> angle_4x_around_x_dir:cw angle_4x_around_y_dir:cw

angle_4x_around_x_dir : cw / ccw
angle_4x_around_y_dir : cw / ccw

This defines the shortest rotation direction to the next home (angle). It is needed for okuma (M15 M16)

..> shift_x:0.000T shift_y:0.000T shift_z:0.000T

This is the distance from the main home to the current position of the part_home_number. The distances are measured from the rotation position of the main home position.

..> part_home_number:1

The defined number in the job dialog screen.

tool_z_level:250.000

You can use this parameter to move the Z level in order to avoid crashes during the rotation. This value is relative to the home position. Normally it is better to move to the reference point.

..> tmatrix_I_1:1.000T tmatrix_I_2:0.000T tmatrix_I_3:0.000T tmatrix_I_4:0.000T
..> tmatrix_I_5:0.000T tmatrix_I_6:1.000T tmatrix_I_7:0.000T tmatrix_I_8:0.000T
..> tmatrix_I_9:0.000T tmatrix_I_10:0.000T tmatrix_I_11:1.000T tmatrix_I_12:0.000T
..> tmatrix_I_13:0.000T tmatrix_I_14:0.000T tmatrix_I_15:0.000T tmatrix_I_16:1.000T

If the prepared rotation values are not good you can use this rotation matrix to make your own position calculations.

..> x = cosy*cosz*x - sinz*cosy*y + siny*z
..> y = (-sinx*siny*cosz + cosx*sinz)*x + (sinx*siny*sinz + cosx*cosz)*y - sinx*cosy*z
..> z = (cosx*cosz*siny + sinx*sinz)*x + (-sinz*cosx*siny + sinx*cosz)*y - cosx*cosy*z

You have to use this formula to rotate a point around the 3 rotation axis.

..> around Z
..> x = x*cos(dev_angle) - y*sin(dev_angle)
..> y = x*sin(dev_angle) + y*cos(dev_angle)

Use this formula to rotate a point around Z to get to the new X and Y coordinates.

..> around Y
..> z = z*cos(dev_angle) - x*sin(dev_angle)
..> x = z*sin(dev_angle) + x*cos(dev_angle)

Use this formula to rotate a point around Y to get to the new Z and X coordinates.

..> around X
..> y = y*cos(dev_angle) - z*sin(dev_angle)
..> z = y*sin(dev_angle) + z*cos(dev_angle)

Use this formula to rotate a point around X to get to the new Y and Z coordinates.

@tool_path_info

Parameters:

tool_path_type
approach_type.

The following value types are available for **tool_path_type:**

- start_approach
- end_approach
- start_retreat
- end_retreat
- start_finish
- end_finish

The following value types are available for **approach_type:**

- None
- vertical_approch
- diagonal_approach
- helical_approach
- linear_approach

In order to create parametric Gcode, this additional information about tool_path_type and approach_type is needed in order to eliminate some lines and to create the parametric Gcode. For example:

Example 1

Checking if the job is 2D job (not trans_surf and not 3-D model) and the tool_path_type is ‘start_approach’:

```
if  job_type <> '3-d model' and job_type <> 'trans_surf'
    if   tool_path_type eq  'start_approach'
         {nb,'G0 G80 G90 G40 G54.1P#3 B#2'}
         {nb,'S#19 M3'}
         {nb,'M8'}
         flag_zpos  = 1
         flag_g90_g91 = 0
    endif
```

Example 2

Checking if the tool_path_type is 'start_approach' and approach_type is either diagonal, helical or linear; we should then create G91 with the original movement from the Pcode.

```
if   tool_path_type eq  'start_approach'
       if approach_type eq 'diagonal_approach' or approach_type eq ‘helical_approach'
```

```
                                                    or approach_type eq 'linear_approach'
            flag_g90_g91 = 2
        endif
 endif
```

Example 3

Checking if tool_path_type is ‘end_approach’ and if we are under incremental movement; if yes we call the absolute mode G90.

```
    if   tool_path_type eq  'end_approach'
         if  flag_g90_g91 eq 7
             flag_g90_g91 = 1
             call @absolute_mode
             skipline = FALSE
          endif
             flag_g90_g91 = 1
    endif
```

Example 4

Checking if tool_path_type is ‘start_retreat’ and we are under G91; if yes, we generate G90.

```
     if   tool_path_type eq  'start_retreat'
             if flag_g90_g91 eq 91
                  flag_g90_g91 = 1
                  call @absolute_mode
                  flag_g90_g91 = 0
             endif
             flag_g90_g91 = 0
             flag_zpos  = 4
     endif
```

Example 5

Checking if tool_path_type is ‘end_retreat’, Z is already at the clearance plane and the job is not trans_surf or 3-d model; we calculate the next Z level.

```
     if   tool_path_type eq  'end_retreat'
             if flag_zpos  eq 5
                      if  job_type <> '3-d model' and job_type <> 'trans_surf'
                           {nb, '#26 = #26 - #5  '}
                      endif
                  flag_zpos  = 0
              endif
     endif
  endif
endp
```

@turn_change_tool

Parameters:

tool_number	type: integer	Number of tool to be changed to.
tool_offset_long	type: integer	Number of tool in machine tool offset table.
first_tool	type: logical	TRUE if this is the first tool in the program.
last_tool	type: logical	TRUE if this is the last tool in the program.
next_tool_number	type: integer	Number of next tool.
xnext, znext	type: numeric	Position to move to after tool change.
spin	type: numeric	Spin rate.
spin_unit	type: integer	Spin units {RPM/CSS}.
spin_direction	type: integer	Spin direction {CW, CCW}.
tool_id_number	type: integer	Identification number of the tool.
next_tool_id_number	type: integer	Identification number of the next tool.
spin_limit	type: numeric	Machine spin limit.
xtool, ztool	type: numeric	Coordinates of tool_change position (optional).
message	type: string	descriptive message for tool change.
tool_direction	type: integer	{CW/CCW}.
tool_mode	type: integer	left/right tool.
tool_origin	type: integer	Tool reference point {T_TANGENT, T_CENTER, T_DEFINE}.
tool_type	type: integer	tool family {EXT_ROUGH, TURN_DRILLING, EXT_THREAD, EXT_GROOVE, EXT_CONTOUR, INT_FACE_BACK, INT_THREAD, INT_GROOVE, INT_CONTOUR, INT_ROUGH}.
number_of_jobs_used_tool	type: integer	Number of jobs that use this tool number
next_tool_machine_type	type: integer	Machine type of next tool.

tool_A	type: numeric	tool parameter (in tool table).
tool_B	type: numeric	tool parameter (in tool table).
tool_C	type: numeric	tool parameter (in tool table).
tool_D	type: numeric	tool parameter (in tool table).
tool_D1	type: numeric	tool parameter (in tool table).
tool_D2	type: numeric	tool parameter (in tool table).
tool_E	type: numeric	tool parameter (in tool table).
tool_F	type: numeric	tool parameter (in tool table).
tool_H	type: numeric	tool parameter (in tool table).
tool_K	type: numeric	tool parameter (in tool table).
tool_ALFA	type: numeric	tool parameter (in tool table).
tool_BETA	type: numeric	tool parameter (in tool table).
tool_G	type: numeric	tool parameter (in tool table).
tool_RADIUS_ALFA	type: numeric	tool parameter (in tool table).
tool_RADIUS_BETA	type: numeric	tool parameter (in tool table).

Description:

This command generates the G-Code required to change the tool.

Examples:

```
@turn_change_tool     ; OKUMA   (simplified)
   {nb, 'GO', 'X'xtool, 'Y'ytool}
   {nb, 'T'tool_number, tool_number, tool_number, 'M8'}
   if spin_unit eq MM_MIN
      {nb, 'G97'}
   else
      {nb, 'G96'}
   endif
   {'G1', 'X'xnext, 'Y'ynext}
endp
```

@turn_drill

Parameters:

drill_type	type: integer	Drill type, as defined in [machine.mac] file.
d_drill_type	type: integer	Internal drill type {D_Drilling, D_F_Drill, D_Peck, D_Tapping, D_Boring, D_R_Boring, D_F_Boring}.
drill_upper_z	type: numeric	start position of the drill.
drill_lower_z	type: numeric	end position of the drill.
drill_depth	type: numeric	(drill_upper_z_drill_lower_z).
num_down_step	type: integer	Number of down steps (last step can be shorter than others).
safety	type: integer	distance between the tool and material before/after drilling.
down_step	type: numeric	Depth of down step.

In addition to the above parameters, more parameters may be defined by the user in the [machine.mac] file. These parameters define the 'turn_type' and for each type defines the parameters required for it. See the example below.

Description:

This command generates a turning drill cycle block.

Example:

```
@turn_drill     ; FANUC  (simplified)
   gcode = 74
   if drill_type eq drilling
      r = 0
      q = drill_lower_z
   endif
   if drill_type eq peck
      q = down_step
   endif
   {nb, 'G' gcode, 'R'r}
   {nb, 'G' gcode, 'Z' drill_lower_z, 'Q'q, 'F'feed}
endp
```

Note:

'r' and 'q' values are defined in the job screen.

@turn_endproc

Parameters:

label	type: integer	Name (number) of the turn subroutine.
end_of_job	type: logical	TRUE for end of job procedure.
start_line	type: function	Block number of subroutine start.
end_line	type: function	Block number of subroutine end.

Description:

This command generates G-Code for turning subroutine termination.

Examples:

```
@turn_endproc    ;   OKUMA
   gcode = 80
   {nb, 'G' gcode}
endp
```

@turn_opt_parms

Parameters:

None. Parameters may be defined by the user in the [machine.mac] file. These parameters define the 'turn_type' and for each type defines the parameters required for it.

Description:

This command gives you access to the user_defined parameters from the job screen. Usually there is no need to use this command for cycle generation.

@turn_proc

Parameters:

process_type	type: integer	Turning process type {LONG/FACE}.
label	type: integer	Name (number) of the turn subroutine.
start_line	type: function	Block number of subroutine start.
end_line	type: function	Block number of subroutine end.

Description:

This command generates the subroutine header for turning geometry description. Usage of the functions 'start_line' and 'end_line' is limited to the generation of statements only; for further information, see section 5.6.4. ('generation functions').

Examples:

```
@turn-proc    ; OKUMA
   {nl,  'NLP' label}
   if process_type eq LONG
      gcode = 81
   else
      gcode = 82
   endif
   {'G' gcode}
endp
```

@turning

Parameters:

work_type	type: integer	{ROUGH, COPY, PROFILE}.
process_type	type: integer	{LONG, FACE}.
turning_mode	type: integer	for LONG: {INTERNAL, EXTERNAL} for FACE: {BACK, FRONT}.
semi_finish	type: integer	TRUE if semi finish process is needed.
finish	type: logical	TRUE if finish process is needed.
is_line	type: logical	TRUE if geometry is a single line.
num_points	type: integer	number of points in geometry.
rough_offset_x, rough_offset_z	type: numeric	offsets for ROUGH/COPY process.
semi_offset_x, semi_offset_z	type: numeric	offsets for semi_finish process.
first_pos_x, first_pos_z	type: numeric	coordinates of first point of geometry .
last_pos_x, last_pos_z	type: numeric	coordinates of last point of geometry.
down_step	type: numeric	distance between two consecutive turning movements.
safety	type: numeric	distance to keep between the geometry and the final movement.
label	type: integer	Name (number) of geometry procedures.
start_line	type: function	Block number of geometry subroutine start.
end_line	type: function	Block number of geometry subroutine end.

In addition to the above parameters, more parameters may be defined by the user in the [machine.mac] file. These parameters define the 'turn_type' and for each type defines the parameters required for it. See the example below.

Description:

This command generates a turning cycle block.

Examples:

```
@turning    ; OKUMA (simplified)
   if work_type eq ROUGH then
      {nb, 'G85', 'NLP'label}
      {'D' (z*down_step), 'U'rough_offset_x, 'W'rough_offset_z}
      {'F' feed}
   endif
   if work_type eq COPY then
      {nb, 'G86', 'NLP'label}
      {'D' (z*down_step), 'U'rough_offset_x, 'W'rough_offset_z}
      {'F' feed}
   endif
   if semi_finish then
      {nb,'G87','NLP'label, 'U' semi_offset_x, 'W'semi_offset_z}
   endif
   if finish then
      {nb, 'G87' , 'NLP'label}
   endif
```

@wc_arc

Parameters:

xpos, ypos, zpos	type : numeric Tool-position at end of arc.
feed	type : numeric Feed-rate of movement.
xcenter, ycenter	type : numeric Absoloute center of arc.
xcenter_rel, ycenter_rel	type : numeric Center of arc relative to the start point.
radius	type : numeric Arc-radius.
start_angle, end_angle	type : numeric Start and end angles of arc (in degrees).
const_angle	type : numeric Inclination angle
arc_direction	type : integer Arc-direction {CW, CCW}
arc_plane	type : integer Arc-plain {XY, YZ, ZX}
arc_size	type : numeric Arc-size (in degrees).
next_const_angle	type : numeric next const angle (in degrees).

Description:

This command generates the arc feed-positioning G-code for EDM.

Examples:

```
@wc_arc
   if arc_direction eq CCW then
      gcode = 3
   else        ; CW
      gcode = 2
   endif
   if change(gcode) then
      {NB' G'gcode}
   else
      {NB}
   endif
   if arc_size le 360
      {[' X'xpos] [' Y'ypos],' I'xcenter_rel, ' J'ycenter_rel }
   else
      if arc_size eq 360 then
         {' I'xcenter_rel, ' J'ycenter_rel}
      endif
   endif
endp
```

@wc_chng_condition

Parameters:

chng_cond_num type : integer Number of chng_cond parameters
chng_cond type : string array
chng_cond<<1,i>> - name
chng_cond<<2,i>> - type
{INTEGER, NUMERIC, STRING}
chng_cond<<3,i>> - value

Description:

This command sets EMD conditions.

Examples:

```
@wc_chng_condition
   local integer i, a
   local numeric d
   ;
   ;1 = name
   ;2 = type (numeric , integer , string)
   ;3 = value

   i = 1
   while i <= chng_cond_num
      if change(chng_cond<<3,i>>) then
         if chng_cond<<2,i>> eq "NUMERIC"
            d = tonum(chng_cond<<3,i>>)
;           {nb, ' numeric = ' d:'5.3(*1000p)'}
         endif
         if chng_cond<<2,i>> eq "INTEGER"
            a = tonum(chng_cond<<3,i>>)
;           {nb, ' integer = ' a:'5.0(n)'}
         endif
         gcode = 10
         {nb,'G'gcode ' L10  R'i  ' P'chng_cond<<3,i>>}
      endif
      i = i + 1
   endw
endp
```

@wc_chng_e_group

Parameters:

e_group_name	type : string	Name of conditions group.
e_group_changed	type : logical	Indicates change of 'e_group_name'.

Description:

This command sets EMD group of conditions.

Examples:

```
@wc_chng_e_group
        ; e_group_name:"
    if e_group_changed then
;       {nb,'E'e_group_name ,' D'offset_radius}
        {nb,'E'e_group_name}
    endif
endp
```

@wc_cut_wire

Parameters:

None

Description:

Cut EDM wire.

Examples:

```
@wc_cut_wire
   {nb,'M7'}
endp
```

@wc_finish_info

Parameters:

tool_diameter	type : numeric	Diameter of wire.
feed	type : numeric	Feed rate.
zpos	type : numeric	Z positioning.
angle	type : numeric	Inclination angle
e_group_name	type : string	Name of conditions group.

Description:

This command defines cut conditions of finish process.

Examples:

```
@wc_finish_info
   local numeric aa1

  ; tool_diameter:0.200 feed:3.000 zpos:32.000 angle:0.000
  ; e_group_name:'727'
  {nb}
  if save_z1 <> zpos
     {nb,'Z1 = 'zpos}
     save_z1 = zpos
  endif

  if save_z2 <> program_z2
     {nb,'Z2 = 'PROGRAM_Z2}
     save_z2 = program_z2
  endif
  if save_z5 <> zero_plane
     {nb,'Z5 = 'zero_plane}
     save_z5 = zero_plane
  endif
   aa1 = tonum(e_group_name)
  {nb,'E'aa1:integer_def_f}
  {nb,'H'tool_number ' = 'tool_diameter }
  {nb 'H'tool_number ' F'feed}
  if parm_angle <> 0
     if save_angle <> angle
        {nb,'H100 = 'angle}
        save_angle = angle
     endif
  endif
endp
```

@wc_g49_arc

Parameters:

None

Description:

This command defines that the next arc will be in ISO form (not CONIC).

Examples:

```
@wc_g49_arc
   {nb, 'G49'}
 endp
```

@wc_insert_wire

Parameters:

None

Description:

Insert EDM wire.

Examples:

```
@wc_insert_wire
   {' M6'}
   {nb, 'M17'}
endp
```

@wc_line

Parameters:

xpos, ypos	type : numeric Tool-position of lower guide at end of movement.
upos, vpos	type : numeric Tool-position of upper guide at end of movement.
feed	type : numeric Feed-rate of movement.
zero_plane	type : numeric Top Z of material
upper_plane	type : numeric Bottom Z of material
const_angle	type : numeric Inclination angle
upos_inc	type : numeric For future use.
vpos_inc	type : numeric For future use.
u_angle	type : numeric Wire Inclination angle in U direction.
v_angle	type : numeric Wire Inclination angle in V direction

If appears before @wc_angle_status has new parameter next_const_angle.

Description:

This command generates the line feed-positioning G-Code for EDM.

Examples:

```
@wc_line
  {nb}
  gcode = 1
  if change(gcode) then
    {' G'gcode}
  else
    {' '}
  endif
  {[' X'xpos], [' Y'ypos], [' U'upos], [' V'vpos]}
endp
```

@wc_move

Parameters:

xpos, ypos	type : numeric Tool-position of lower guide at end of movement.
upos, vpos	type : numeric Tool-position of upper guide at end of movement.
zero_plane	type : numeric Top Z of material
upper_plane	type : numeric Bottom Z of material
upos_inc	type : numeric For future use.
vpos_inc	type : numeric For future use.
u_angle	type : numeric Wire Inclination angle in U direction.
v_angle	type : numeric Wire Inclination angle in V direction

Description:

This command generates the rapid-positioning G-Code for EDM.

Examples:

```
@wc_move
   {nb}
   gcode = 0
   if change(gcode) then
      {'G'gcode}
   else
      {'  '}
   endif
   {[' X'xpos], [' Y'ypos]}
   if job_type ne 'profile' then
      {[' U'upos],[' V'vpos]}
   endif
endp
```

@wc_program_plane

Parameters:

program_plane type : numeric Z of program plane.

Description:

This command defines Z of program plane.

7.2. User-Defined Commands

These are commands that are defined by the user and that can be activated by calls from the **SolidCAM**-generated tool-path commands. Following are 2 examples of such user-defined commands:

@start_tool1

This command starts the tool rotation. It is called from @change_tool.

Parameters

tool_direction type: integer Direction of rotation of the tool.

spin type: numeric Spin rate.

Examples:

```
@start_tool1      ; FANUC
   if direction = CCW then
      mcode = 3;
   else           ;  CW
      mcode = 4;
   endif
   {'S'spin:'5.0(p)', ' M'mcode}
endp

@start_tool1      ; MAHO-432
   ; start tool and coolant together
   if direction = CCW then
      mcode = 13
   else        ; CW
      mcode = 14
   endif
   {'S'spin:'5.0(p)', ' M'mcode}
endp
```

@stop_tool1

This command stops the tool rotation;it is called from @change_tool.

Examples:

```
@stop_tool1       ; FANUC, MAHO-432
  {'M5'}
endp


@change_tool
 call @start_tool1
 call @stop_tool1
endp
```

7.3. File Commands

These are commands that can be used for management of G_Code files during G_Code generation:

- Create the doc file at the beginning of the documentation generation process:
  { '!! open file = c:\\name.ext !!' }

- Close the doc file at the end of the documentation generation process:
  { '!! close file = c:\\name.ext !!' }

- Copy doc file
  { '!! copy file = c:\\copy_from_name.ext !!' }

- Delete temporary file
  { '!! delete file = c:\\temporary_file_name.ext !!' }

A P P E N D I X A

A.1. Example 1: User-defined Pre and Post-processor for a Fanuc controller

A.1.1 Pre-Processor file: [fanuc.mac]

; FANUC

@pre_processor

;Internal parms

machine_type = MILLING
post_processor = fanuc
doc_processor = fanuc
gpp_file_ext = TAP
mac_holder = holder
tool_table_name = table
max_g_name_length = 0
max_tool_numbers = 1000
default_lang = DEFAULT

;Machine Initialize

machine_plane = XY
num_axes = 4
num_simult_axes = 4
abs_coord = N
rotate = Y
mirror = Y
_4th_axes_around = X
first_rotation_angle = Z
_5th_axes_around = Z

;Program numbers

prog_num_min = 5000
prog_num_max = 8999
prog_num_dflt = 5000
get_prog_num = Y
proc_num_min = 1
proc_num_max = 8999

```
proc_num_dflt          = 1
get_proc_num           = Y

;Procedures control

full_gcode             = N
gen_procs              = N
drill_proc             = N
gen_internal_proc      = N
optimize_jobs_loop     = Y
seq_sub_number         = N
loop_exist             = Y
same_sub_numbers       = N
init_var_after_split   = Y

;Home

num_homes              = 6
dflt_home              = 1
home_data_at_start     = N

;Positioning

dflt_start             = 0.0000 200.0000 100.0000, 0.0000 7.8740 3.9370
dflt_end               = 0.0000 200.0000 0.0000, 0.0000 7.8740 0.0000
set_xy_chng            = N N
set_z_chng             = Y N
dflt_tool_chng         = 0.0000 0.0000 0.0000, 0.0000 0.0000 0.0000

;Compensation

comp_exist             = Y N
comp_arc_arc           = Y
comp_arc_line          = Y
comp_line_line         = Y
next_angle             = N
comp_x_start           = N
comp_by_arcs           = N
delta_for_TOOL_H       = 50
comp_by_zero_tool      = N

;Arc definitions

arc_exist              = Y N
arc_3d                 = Y
arc_quadrants          = N
arc_gt_180             = Y
arc_max_chord          = 30.0000, 1.1811
arc_max_angle          = 10.0000
arc_max_radius         = 2000.0000, 78.7402
arc_min_length         = 0.0000, 0.0000
arc_zx_yz              = N
```

```
;Epsilon values

eps_angle              = 0.0020
zero_value             = 0.0010, 0.0000
movement_precision     = 0.0010, 0.0000
min_delt_arc_rad       = 0.0100, 0.0004
safety_dist            = 2.0000, 0.0787

;Feed-Spin

rapid_feed             = 5000.0000, 196.8503
max_spin               = 6000.0000
max_feed               = 6000.0000, 236.2205
spin_direction         = CW

;Timing

time_factor            = 1.0000
block_time             = 0.2000
change_tool_time       = 15.0000

;Coolant_options

;Part options
   options             = G99_X NUMERIC
   options             = G99_Y NUMERIC

;Clamp options

;Job options
job_opt_type           = OPT1 Y  DELY FEAD

;Drill cycles
drill_type             = Drilling Drilling Y
drill_type             = F_Drill F_Drill Y  Delay
drill_type             = Peck Peck Y  Delay
drill_type             = Tapping Tapping Y
drill_type             = Boring Boring Y  Delay
drill_type             = R_Boring R_Boring Y  Delay
drill_type             = F_Boring F_Boring Y  Delay

;Turning cycles

;Threading cycles

;Grooving cycles

;Wire Cut cycles

;Turning definitions
```

```
   ;Fourth axis
   init_cpos              = Y
   polar_4x               = N
   cartez_4x              = N
   set_dir                = N
   fourth_axis_letter     = C

   ;Sim Five axis

   kinematic_type             = HEAD_HEAD
   spindle_direction          = 0.0000 0.0000 1.0000
   rotate_axis_dir1           = 0.0000 0.0000 -1.0000
   rotate_axis_dir2           = 0.0000 -1.0000 0.0000
   rot_axis_base_pnt1         = 0.0000 0.0000 0.0000, 0.0000 0.0000 0.0000
   rot_axis_base_pnt2         = 0.0000 0.0000 0.0000, 0.0000 0.0000 0.0000
   pivot_length               = 0.0000, 0.0000
   first_rot_axis_name        = C
   second_rot_axis_name       = B
   machine_simulation         = HeadHead
   rot_axis_min_limit0        = -100000.0000
   rot_axis_min_limit1        = -100000.0000
   rot_axis_max_limit0        = 100000.0000
   rot_axis_max_limit1        = 100000.0000
   auto_angle_pair            = Y
   other_angle_pair           = Y
   angle_change_limit         = 30.0000
   interplat_angle_step       = 3.0000
   interplat_for_dist         = N
   interplat_distance         = 5.0000, 0.1969
   retract_distance           = 100.0000, 3.9370
   center_rot_mac_num         = 20
   min_inverse_feed           = 100.0000, 3.9370
   enable_mx_edit             = N

endp
```

A.1.2. Post-Processor file: [fanuc.gpp]

```
; FANUC
; -----
;
@init_post
   global string tool_diameter_f

   num_user_procs =   1

   numeric_def_f      = '5.3'
   integer_def_f      = '5.0(p)'
   gcode_f            = '2.0(p)'
   mcode_f            = '2.0(p)'
   xpos_f             = '5.3'
   ypos_f             = '5.3'
   zpos_f             = '5.3'
   feed_f             = '4.3(p)'
   tool_diameter_f    = '5.3/1'
   blknum_f           = '5.0(p)'
   blknum_gen         = FALSE
   blknum_exist       = TRUE
   blknum             =   5
   blknum_delta       =   5
   blknum_max         = 32000
endp

;-------------------

@start_of_file
  ; before tools definition
  {'%'}
  {nl, 'O'program_number, ' (', g_file_name, ')'}
  if rotate_used then
     gcode = 69
     {nb, 'G'gcode}
   endif
  if mirror_used then
     {nb, 'G50.1 X0 Y0'}
  endif
  {nb, '(SUBROUTINES: O'first_proc_number, ' .. O'last_proc_number, ')'}
endp

;-------------------

@start_program
   ; after tools definition
   {nb, 'G80 G49 G40'}
   call @home_number
endp

;-------------------
```

```
@end_program
   {nb, 'M9'}
   call @rapid_move
   {nb, 'M30'}
endp

;-------------------

@end_of_file
   label = first_user_proc
   call @proc
   {nb, '(--------------------)'}
   {nb, '(-   CHANGE TOOL    -)'}
   {nb, '(--------------------)'}
   {nb, 'G80 G49 G40 M9'}
   {nb, 'G91 G28 Z0.'}
   call @stop_tool
   {nb, 'G90 M1'}
   {nb, 'M6'}
   call @end_proc
   {nl, '%'}
endp

;-------------------

@relative_mode
   gcode = 91
   {nb, 'G'gcode, ' '}
   skipline = FALSE
endp

;-------------------

@absolute_mode
   gcode = 90
   {nb, 'G'gcode, ' '}
   skipline = FALSE
endp

;-------------------
```

```
@machine_plane
   if machine_plane eq XY
      gcode = 17
   endif
   if machine_plane eq YZ
      gcode = 18
   endif
   if machine_plane eq ZX
      gcode = 19
   endif
   {nb, 'G'gcode}
endp

;-------------------

@call_proc
   if active(parm1) then
      gcode = 65
      {nb, 'G'gcode, ' P'label}
      {' A'parm1, [' B'parm2], [' C'parm3]}
   else
      {nb, 'M98 P'label}
   endif
   if proc_count gt 1 then
      {' L'proc_count}
   endif
   {[' ('message, ')']}
endp

;-------------------

@proc
   {nl, 'O'label}
endp

;-------------------

@end_proc
   {nb, 'M99'}
endp

;----------------

@loop
   local integer var_num

   var_num = loop_level + 20
   {nb, '#', var_num, ' = 0'}
   {nb, 'WHILE [#', var_num, ' LT ', loop_count, '] DO ', loop_level}
endp

;----------------
```

```
@end_loop
   local integer var_num

   var_num = loop_level + 20
   {nb '#', var_num, ' = #', var_num, ' + 1'}
   {nb 'END ', loop_level}
endp

;----------------

@def_tool
   {nb, '(G10 L12 P', (tool_number+50), ' R'tool_offset, ')'}
endp

;-------------------

@rapid_move
   {nb}
   gcode = 0
   if change(gcode) then
      {'G'gcode}
   else
      {'  '}
   endif
   {[' X'xpos], [' Y'ypos], [' Z'zpos]}
endp

;-------------------

@line
   {nb}
   gcode = 1
   if change(gcode) then
      {'G'gcode}
   else
      {'  '}
   endif
   {[' X'xpos], [' Y'ypos], [' Z'zpos], [' F'feed]}
endp

;-------------------
```

```
@arc

   if arc_direction eq CCW then
      gcode = 3
   else        ; CW
      gcode = 2
   endif
   if change(gcode) then
      {'G'gcode}
   else
      {'  '}
   endif
   {[' X'xpos] [' Y'ypos] [' Z'zpos]}

   if arc_size eq 360 then
   else
      if arc_size >= 180 then
         radius = -radius
      endif
      {' R'radius}
   endif

   {[' F'feed]}
endp

;-------------------

@compensation
   if side eq COMP_LEFT then
      gcode = 41
   endif
   if side eq COMP_RIGHT then
      gcode = 42
   endif
   if side eq COMP_OFF then
      gcode = 40
   endif
   {nb, 'G'gcode, ' '}
   skipline = FALSE
endp

;-------------------

@delay
   gcode = 4
   {nb 'G'gcode, ' P'delay_period:integer_def_f}
endp

;-------------------
```

```
@change_ref_point
   ; Given in absolute mode
   gcode = 92
   {nb, 'G'gcode, ' X'xhome, ' Y'yhome, ' Z'zhome}
endp

;-------------------

@home_number
   gcode = 53 + home_number
   {nb, 'G'gcode}
endp

;-------------------

@rotate
   ; Not exist in FANUC 6M
   if rotate_cancel then
      gcode = 69
      {nb, 'G'gcode}
   else
      gcode = 68
      {nb, 'G'gcode, ' X0 Y0 G91 R'angle}
      {nb, 'G90'}
   endif
endp

;-------------------

@fourth_axis
   gcode = 0
   {nb, 'G'gcode, ' A'angle}
endp

;-------------------
```

```
@change_tool
   local logical save_blknum_gen

   {nb, '(*TOOL 'tool_number, ' - DIA 'tool_diameter, '*)'}
   {nb, 'T'tool_number}
   label = first_user_proc
   call @call_simple_proc
   save_blknum_gen = blknum_gen
   blknum_gen = true       ; gen block number for next block
   gcode = 43
   {nb, 'G'gcode, ' H'tool_number, ' D'(tool_number+50), ' '}
   blknum_gen = save_blknum_gen
   xpos = xnext
   ypos = ynext
   zpos = znext
   skipline = FALSE
   call @rapid_move
   tool_direction = CCW
   call @start_tool
   {nb, 'M8'}
endp

;-------------------

@message
   {nb, '(', message, ')'}
endp

;-------------------

@drill
   call @rapid_move

   gcode = 98
   {nb, 'G'gcode, ' '}
   if drill_type eq drilling then
      gcode = 81
   endif
   if drill_type eq f_drill then
      gcode = 82
   endif
   if drill_type eq peck then
      gcode = 83
   endif
   if drill_type eq tapping then
      gcode = 84
   endif
   if drill_type eq boring then
      gcode = 85
   endif
```

```
   if drill_type eq r_boring then
      gcode = 86
   endif
   if drill_type eq f_boring then
      gcode = 89
   endif
   {'G'gcode, ' Z'drill_lower_z, ' R'drill_upper_z}
   if drill_type eq peck then
      {' Q'down_step}
   endif
   if drill_type eq f_drill or drill_type eq tapping then
      {' P'delay:integer_def_f}
   endif
   {' F'feed}

endp

;-------------------

@drill_point
   if not first_drill then
      {nb, '   ', [' X'xpos], [' Y'ypos], [' Z'zpos]}
   endif
endp

;-------------------

@mirror
   if mirror_type eq MIRROR_OFF then
      {nb, 'G50.1 X0 Y0'}
   else
      {nb, 'G51.1 '}
      if mirror_type eq MIRROR_X then
         {'X1 Y0'}
      endif
      if mirror_type eq MIRROR_Y then
         {'X0 Y1'}
      endif
      if mirror_type eq MIRROR_XY then
         {'X1 Y1'}
      endif
   endif
endp

;-------------------

@end_drill
   gcode = 80
   {nb, 'G'gcode}
endp

;-------------------
```

```
@halt_program
   {' M0'}
endp

;--------------------

@start_of_job
   ; NOP
endp

;--------------------

@end_of_job
   ; NOP
endp


;    ======================
;    USER DEFINED PROCEDURES
;    ======================

@call_simple_proc
   active(message) = FALSE
   active(parm1)   = FALSE
   active(parm2)   = FALSE
   active(parm3)   = FALSE
   proc_count      = 1
   call @call_proc
endp

;-------------------

@start_tool
   if tool_direction eq CW then
      mcode = 4
   else             ;  CCW
      mcode = 3
   endif
   {' S'spin:integer_def_f, ' M'mcode}
endp

;-------------------

@stop_tool
   {' M5'}
endp
_
```

A.2. Example 2: User-defined Pre and Post-processor for mill-Turn Full with XZYCB axis controller

A.2.1. Pre-Processor file: [Integrex-e-410h.mac]

; Integrex-e-410h

```
@pre_processor
 ;Internal parms
   gpp_file_ext        = EIA
   machine_type        = MILL_&_TURN_FULL
   post_processor      = INTEGREX-e-410H
   doc_processor       = INTEGREX-e-410H


 ;Machine Initialize
   machine_plane       = XY
   z_with_xy           = Y
   num_axes            = 5
   num_simult_axes     = 5
   abs_coord           = N
   rotate              = Y
   mirror              = Y
   variables           = N
   loops               = N
   _4th_axes_around    = Z
   first_rotation_angle= Z
   _5th_axes_around    = Z
   _5x_rotary_axes     = ZY
   direction_4x        = CW
   tilt_axis_dir       = CCW
   pos_to_coord        = N

 ;Program numbers
   prog_num_min        = 0001
   prog_num_max        = 8999
   prog_num_dflt       = 5000
   get_prog_num        = Y
   proc_num_min        = 1
   proc_num_max        = 8999
   proc_num_dflt       = 1
   get_proc_num        = Y

 ;Procedures control
   full_gcode          = N
   gen_procs           = Y
   drill_proc          = N
   turn_proc           = N
   thread_proc         = Y
   gen_internal_proc   = N
```

```
   turn_common_proc = N
   gen_1_line_proc  = Y
   optimize_jobs_loop= Y
   seq_sub_number   = Y

;Home
   num_homes        = 6
   dflt_home        = 1
   get_job_home     = N
   abs_zero_chng    = Y
   home_data_at_start= Y

;Positioning
   dflt_start       = 200.0000 0.0000 200.0000, 7.8740 0.0000 7.8740
   dflt_end         = 200.0000 0.0000 200.0000, 7.8740 0.0000 7.8740
   set_z_chng       = Y
   dflt_tool_chng   = 100.0000 0.0000 200.0000, 3.9370 0.0000 7.8740

;Compensation
   comp_exist       = Y Y
   comp_arc_arc     = Y
   comp_arc_line    = Y
   comp_line_line   = Y
   next_angle       = N
   comp_x_start     = N
   comp_by_arcs     = N
   chng_tool_table  = N
   look_forward     = 2
   delta_for_tool_h = 50
   comp_by_zero_tool= N
   bs_tools_off_delta = 100

;Arc definitions
   arc_exist        = Y
   arc_3d           = Y
   arc_3d_4x        = Y
   arc_quadrants    = N
   arc_gt_180       = Y
   arc_max_chord    = 30.0000, 1.1811
   arc_max_angle    = 10.0000
   arc_max_radius   = 2000.0000, 78.7402

;Epsilon values
   eps_angle        = 0.0020
   eps_line         = 0.0010, 0.0001
   zero_value       = 0.1000, 0.0001
   min_delt_arc_rad = 0.0100, 0.0004
   safety_dist      = 2.0000, 0.0787

;Feed-Spin
   rapid_feed       = 5000.0000, 196.8504
   max_spin         = 12000.0000
   max_feed         = 9000.0000, 236.2205
```

```
   spin_direction       = CW

;Timing
   time_factor          = 1.0000
   block_time           = 0.2000
   change_tool_time     = 15.0000

;Part options
   Options              = Include_Sub LOGICAL
   Options              = Rotation_Feed LOGICAL

;Job options

   job_opt_type         = M00_Milling LOGICAL
   job_opt_type         = M01_Milling LOGICAL

;Clamp options

;Drill cycles
   drill_type           = Drill_G81 Drilling Y
   drill_type           = Face_G82 F_Drill Y  Delay
   drill_type           = Peck_G83 Peck Y
   drill_type           = Ream_G85 Peck Y  Delay F_Retreat
   drill_type           = Tap_G84 Tapping Y  Delay Pitch
   drill_type           = Bore_G86 F_Boring Y  Delay F_Retreat
   drill_type           = Helicoil F_Boring Y  diameter pitch d_step sem_fin s_step inn out

;Turning cycles
   turn_type            = M00_Turning LOGICAL
   turn_type            = M01_Turning LOGICAL

;Threading cycles
   thread_type          = THREAD1 Y  phase no_last_cut last_cut min_down_step spin_dir1
                                     T_angle m7_m8_3

;Grooving cycles

;Turning definitions
   turning_cycle        = Y N
   groove_cycle         = Y N
   combined_cycles      = N
   optimize_cycle       = N
   finish_retreat       = N
   semi_finish_retreat  = N
   fanuc_cycle          = Y
   turn_home_x          = 1.0 0.0 0.0
   turn_home_y          = 0.0 1.0 0.0
   orient_tool_with_b   = Y
   first_Turret_type    = B_axis_Turret

;Fourth axis
   indexial_4th_axis    = N
   indexial_increment   = 0.0000, 0.0000
```

```
   init_cpos          = Y
   polar_4x           = Y
   cartez_4x          = Y
   set_dir            = N

 ;Sim Five axis
   kinematic_type             = HEAD_TABLE
   spindle_direction          = 0.0000 0.0000 1.0000
   rotate_axis_dir1           = 0.0000 0.0000 1.0000
   rotate_axis_dir2           = 0.0000 1.0000 0.0000
   rot_axis_base_pnt1         = 0.0000 0.0000 0.0000, 0.0000 0.0000 0.0000
   rot_axis_base_pnt2         = 0.0000 0.0000 230.0000, 0.0000 0.0000 0.0000
   GCode_part_coordinate      = N
   use_tool_h_length          = N
   pivot_length               = 0.0000, 0.0000
   first_rot_axis_name        = C
   second_rot_axis_name       = B
   machine_simulation         = E410H
   rot_axis_min_limit0        = -10000.0000
   rot_axis_min_limit1        = -15.0000
   rot_axis_max_limit0        = 10000.0000
   rot_axis_max_limit1        = 195.0000
   auto_angle_pair            = N
   other_angle_pair           = N
   enable_mx_edit             = N
   angle_change_limit         = 30.0000
   retract_distance           = 100.0000, 3.9370
   interplat_angle_step       = 1.0000
   interplat_for_dist         = N
   interplat_distance         = 1.0000, 0.05
   center_rot_mac_num         = 20
   min_inverse_feed           = 0.1000
   pole_angle_tolerance       = 0.5700
   use_machine_limits         = N
   trans_axis_min_limit       = -100000.0000 -100000.0000 -100000.0000
   trans_axis_max_limit       = 100000.0000 100000.0000 100000.0000
endp
```

A.2.2. Post-Processor file: [Integrex-e-410h.gpp]

;Integrex-e-410h

```
@init_post

    global string tool_diameter_f spin_f tool_number_f turn_descrp spin_max tdrill_f cpos_f
    global string g_code coord_f feed_mmpm_f main_prog_path sub_prog_path delta_angle
    global integer last_part_home_number last_tool_number origin x97 trace_level
    global integer split_sub new_mill_tool cpos_rot_dir turn_rapid calc_spin rotate_count
    global numeric save_x save_z tool_dir last_rotate_angle_z
    global numeric m_feed_flag ,tool_feed_zold,tool_feed_old G97_dia last_cpos
    global numeric first_107 first_feed last_rotate_angle_y turn_drill_safety
    global logical spin_dir_us spin_dir_us1 ben2 mill_tool
    global logical gen_end_of_file new_job turn_tool first_rapid_move
    global logical main_program rapid_flag g43_flag in_cycle trans_4x g96_flag
    global string chuck_axis chuck_clamp chuck_unclamp chuck_turn_mode chuck_mill_mode
chuck_brake

    ; Non GPPL variables
    num_user_procs =    15
    line_labels    = false     ; Jump to N...

    ; GPPL variables
    pre_processor        = 'Integrex-e-410H_ELOP'
; Output formats
    numeric_def_f        = '5.3'
    integer_def_f        = '5.1(p)'
    gcode_f              = '2.0(p)'
    mcode_f              = '2.0(p)'
    ypos_f               = '5.3'
    zpos_f               = '5.3'
    cpos_f               = '5.3'
    coord_f              = '5.3'
    feed_f               = '4.3(p)'
    tdrill_f             = '4.3'
    tool_diameter_f      = '5.3/1'
    spin_f               = '5.0(n)'
    feed_mmpm_f          = '5.0(P)'
    blknum_f             = '5.0(p)'
    tool_number_f        = 'z2.0(n)'
; Sequence numbers
    blknum_gen           = true
    blknum_exist         = true
    blknum               =   5
    blknum_delta         =   5
    blknum_max           = 3200000
;    end_block_text      = ';'
; User defined parameters
    first_rapid_move     = false
    trans_4x             = false
    rotate_count         = 0
    main_program         = true
```

```
   gen_end_of_file     = true
   last_part_home_number = 0
   last_rotate_angle_y = 0
   last_rotate_angle_z = 0
   last_cpos           = 0
   new_job             = false
   mill_tool           = false
   turn_tool           = false
   g43_flag            = false
   in_cycle            = 0
;Input "Trace level : 0-None ; 5-All", trace_level
;trace "all":trace_level
;trace "@rotary_info":5
;trace "@fourth_axis":5
endp
;-------------------
@start_of_file
  main_prog_path = 'c:\\yuda\\gcode\\' + tostr(program_number)
;   main_prog_path = path_part + '\\' + part_name
     {nl,'!!open file='  main_prog_path'EIA!!'}
     {nl}
     {nl, 'O'program_number}
     {nb, '( 'upper(part_name),' - MAZAK/INTEGREX-e-410H MILL&TURN )'}
     {nb, '( SOLIDCAM FOR ELOP RECHOVOT )'}
     {nb, '( LAST UPDATE ON : 'date,'----'time,' )'}
     call @goto_ref_point_xyz_out
     {' G80 G40'}
endp
;-------------------

@end_program
   Xpos = xtool
   Zpos = ztool
 if gen_end_of_file eq true
          call @goto_ref_point_xyz_out
          {nb,'M108 M09'} ; B-AXIS UNCLAMP
          {nb,chuck_unclamp,' M05'} ;M212 M312
          {nb,'G0 C0. B0.'}
          {nb,'M107'} ; B-AXIS CLAMP
;          {nb,chuck_clamp} ;M210 M310
   if !spindle
          {nb,'M202'} ; MAIN SPINDLE UNCLAMP
   else
          {nb,'M302'} ; BACK SPINDLE UNCLAMP
   endif
;          {nb, 'M09'}
   if !spindle
          {nb, 'M205'}
   else
          {nb, 'M305'}
   endif
          {nb, 'M30'}
 endif
```

```
  if include_sub <> 1
          {nl,'!!close file='  main_prog_path'EIA!!'}
  endif
          main_program = false
endp
;-------------------

@machine_plane
  if job_machine_type eq milling
      if machine_plane eq XY
        gcode = 17
      endif
      if machine_plane eq XC
        gcode = 17
      endif
      if machine_plane eq YC
        gcode = 17
      endif
      if machine_plane eq YZ
        gcode = 19
      endif
      if machine_plane eq ZX
        gcode = 18
      endif
  else
        gcode = 18
  endif
;  {nb, 'G'gcode}
endp
;-------------------

@call_proc
        if new_mill_tool <> 1
            if rotate_angle_y <> last_rotate_angle_y or rotate_angle_z <> last_rotate_angle_z
              call @G68_home
            endif
        endif
        {nb, 'M98 P'(label+0),'('message,')'}
        new_mill_tool = 0
        turn_rapid = 0
endp
;-------------------


@call_prms
        gcode = 65
        {nb, 'G' gcode ' P'(label+0) ' L'ncalls}
        {[' ('upper(message), ')']}
endp
;-------------------

@proc
call @change_name
```

```
sub_prog_path = 'c:\\yuda\\gcode\\'+ tostr(label+0)
;sub_prog_path = path_part + '\\'+ tostr(label+0)
blknum = 10
  if include_sub <> 1
   {nl,'!!open file='  sub_prog_path'EIA!!'}
  endif
  {nl, 'O'(label+0)}
  {nb, '('part_name,')'}
  {nb}
endp
;-------------------

@end_proc
  if job_machine_type == turning
    {nb, 'G97'}
  endif
    {nb, 'M99'}
    if include_sub <> 1
    {nl,'!!close file='  sub_prog_path'EIA!!'}
    endif
endp
;----------------

@loop
   local integer var_num
;
   var_num = loop_level + 20
   {nb, '#', var_num, ' = 0'}
   {nb, 'WHILE [#', var_num, ' LT ', loop_count, '] DO ', loop_level}
endp
;----------------

@end_loop
   local integer var_num
;
   var_num = loop_level + 20
   {nb '#', var_num, ' = #', var_num, ' + 1'}
   {nb 'END ', loop_level}
endp
;----------------

@start_back
   call @goto_ref_point_xyz_out
   {nb,'M202'}
   {nb,'M0'}
   {nb, '( MOVE THE PART TO BACK SPINDLE )'}
   {nb,'M108'} ; B-AXIS UNCLAMP
   {nb,'G0 B0'}
   {nb,'M107'} ; B-AXIS CLAMP
   {nb, 'M540 ( TRANSFER MODE ON )'}
   {nb, 'M207 ( CHUCK CLOSED SPINDLE 1 )'}
   {nb, 'M306 ( CHUCK OPEN SPINDLE 2 )'}
   {nb, 'M200 ( C-AXIS CONTROL SPINDLE 1 )'}
```

```
   {nb, 'M300 ( U-AXIS CONTROL SPINDLE 2 )'}
   {nb,'#101 = 0 ( C-AXIS ANGLE VALUE SPINDLE 1 )'}
   {nb,'#102 = 0 ( U-AXIS ANGLE VALUE SPINDLE 2 )'}
   {nb,'G0 C#101 U#102'}
   {nb,'#103 = 'rapid_position:coord_f,'( W-AXIS VALUE FOR RAPID TRANSFER )'}
   {nb,'G0 W#103( START OF PRESSING )'}
   {nb,'#104 = 'clamp_position:coord_f,'( W-AXIS PRESSING POSITION )'}
   {nb,'G31  W#104F'clamp_feed:feed_mmpm_f,'(  FEED  ADVANCE  TO  PRESSING
POSITION + SIGNAL )'}
   {nb, 'M307 ( CHUCK CLOSE SPINDLE 2 )'}
   {nb, 'M206 ( CHUCK OPEN SPINDLE 1 )'}

endp
;-------------------
@end_back
   {nb,'#105 = 0 ( W-AXIS RETREAT POSITION )'}
   {nb,'G0 W#105'}
   {nb, 'M541 ( END TRANSFER MODE )'}
   {nb,'M0'}
   {nb,'M302'}
endp
;-------------------

@change_tool
   call @change_name
   if !first_tool
      {nb ,'M09'}
      call @goto_ref_point_xyz_out
      {nb,'M01'}
   endif
   if mill_tool eq false
     {nb,'( ***** MILLING ***** )'}
   endif
  {nl 'N0'tool_number ' ( ***** TOOL ' tool_number ' ***** )'}
  {nb,'T'tool_number:'z3/2.0'tool_id_number:'2/2.0(p)'}
  {' T'next_tool_number:'z3/2.0',next_tool_id_number:tool_number_f,' M06'}
  {nb,'( ' tool_user_type,' ; DIA='tool_diameter:tool_diameter_f}
    {' ; RAD='corner_radius:tool_diameter_f,' )'}
   call @goto_ref_point_xyz_in
   {nb, 'G'(53 + mac_number)}
   {nb,chuck_mill_mode} ; M200 M300
   {nb,chuck_unclamp} ; M212 M312
   call @machine_plane
   {nb, 'G'gcode}
   {nb,'G10.9 X0'}
   {nb,delta_angle,' = 0'}
   xpos_f         = '5.3'
    call @start_tool_mill
    mill_tool = true
    turn_tool = false
    last_tool_number = tool_number
    g43_flag = false
    call @G68_home
```

```
   new_mill_tool = 1
   trans_4x = false
   rotate_count = 0
endp
;-------------------

@start_tool_mill
   if tool_direction eq CW then
      mcode = 3
   else             ;  CCW
      mcode = 4
   endif

   {nb, 'G94'}
   {nb, 'S'spin:spin_f, ' M'mcode}
endp
; ----------------------

@turn_change_tool
  call @change_name
  call @turn_tool_description
  if !first_tool
      {nb ,'M09'}
      call @goto_ref_point_xyz_out
      {nb,chuck_turn_mode}
      {nb,'M01'}
  endif
if tool_used_in_main_spindle
   if tool_mode eq long
          tool_dir = 90.0
   else
          tool_dir = 0.0
   endif
else
   if tool_mode eq long
          tool_dir = 90.0
   else
          tool_dir = 180.0
   endif
endif
   if turn_tool eq false
      {nb,'( ***** TURNING ***** )'}
   endif
      {nl 'N0'tool_number ' ( ***** TOOL ' tool_number ' ***** )'}
      {nb,'T'tool_number:'z3/2.0'tool_id_number:'2/2.0(p)'}
      {' T'next_tool_number:'z3/2.0',next_tool_id_number:tool_number_f}
      {'  M06'}
      if tool_type ne Turn_Drilling
        {nb,'( 'turn_descrp,' ; RAD='tool_radius_alfa:tool_diameter_f}
        {' ; B-AXIS = '(tool_dir + tool_orientation_angle):tool_diameter_f}
        {' OFFSET POINT = 'nose_point}
      else
        {nb,'( 'turn_descrp,' ; DIA ='tool_A:tool_diameter_f}
```

```
        {' ; ANG = 'tool_ALFA:tool_diameter_f}
        endif
       {' )'}
      {nb, 'G'origin}
      {nb,chuck_turn_mode} ;M202 M302 23.02.09
      call @machine_plane
      {nb, 'G'gcode}
      {nb,'G10.9 X1'}
      xpos_f          = '5.3(*2)'
      {nb,'G92 S'spin_limit' R'spin_max}
     call @goto_ref_point_xyz_in
     {' G80 G40'}
       {nb,'M108'}
       {nb,'G0 B'(tool_dir + tool_orientation_angle)}
       {nb,'M107'}
    {nb,'M51'}
;
       gcode = 43
       if tool_type ne Turn_Drilling
          {nb, 'G0 G'gcode ' P1 Z'znext ' X'xnext:xpos_f}
          G97_dia = xnext*2
          x97 = 0
       else
          {nb, 'G0 G'gcode ' P1 Z'turn_drill_safety}
       endif
   spin_dir_us      = false
   spin_dir_us1     = true
;    xpos            = xnext
;    zpos            = znext
   mill_tool        = false
   turn_tool        = true
   last_tool_number = tool_number
endp
;-------------------

@start_tool
endp

;-------------------

@stop_tool
  if job_machine_type eq milling
      {nb ' M05'}
  else
    if !spindle
      {nb ' M205'}
    else
      {nb ' M305'}
    endif
  endif
endp
;-------------------
```

```
@tool_path_info
endp
;------------------

@rapid_move
 if job_machine_type eq milling
        call @mill_rapid_move
    else
        call @turn_rapid_move
    endif
endp
;------------------
@turn_rapid_move
        gcode = 0
        {nb}
        if change(gcode)
        {'G'gcode}
        endif
        {[' X'xpos] , [' Z'zpos]}
        rapid_flag = true
endp
;------------------

@mill_rapid_move
    rotate_angle_z = rotate_angle_z * cpos_rot_dir
    gcode = 0
  if first_rapid_move eq true
      {nb,chuck_unclamp}

      {nb,'G'gcode,' 'chuck_axis}
      if trans_4x eq false
         {rotate_angle_z:cpos_f}
      else
         {'['rotate_angle_z:cpos_f,'+'delta_angle,']'}
      endif
      {nb,chuck_clamp}
      {nb,'G'gcode,' X'xpos, ' Y'ypos}
      {nb,'   Z'zpos}
      first_rapid_move = false
  else
     if tool_path_type eq 'start_approach'
       if change(xpos) eq true or change(ypos) eq true
        {nb,['G'gcode][' X'xpos] [' Y'ypos]}
       endif
       if change(zpos) eq true
        {nb,['   Z'zpos]}
       endif
     endif
     if tool_path_type eq 'start_retreat'
       {nb,'G'gcode,' Z'zpos}
       if change(xpos) eq true or change(ypos) eq true
          {nb,'  '[' X'xpos], [' Y'ypos]}
       endif
```

```
    endif
    if tool_path_type ne 'start_approach' and tool_path_type ne 'start_retreat'
      if change(xpos) eq true or change(ypos) eq true or change(zpos) eq true
         {nb,['G'gcode],[' X'xpos],[' Y'ypos],[' Z'zpos]}
      endif
    endif
  endif
  rapid_flag = true
endp
;------------------


@mill_rapid_move_last
   rotate_angle_z = rotate_angle_z * cpos_rot_dir
   gcode = 0
  if first_rapid_move eq true
     {nb,chuck_unclamp}

     {nb,'G'gcode,' 'chuck_axis}
     if trans_4x eq false
        {rotate_angle_z:cpos_f}
     else
        {'['rotate_angle_z:cpos_f,'+'delta_angle,']'}
     endif
     {nb,chuck_clamp}
     {nb,'G'gcode,' X'xpos, ' Y'ypos}
     {nb,'   Z'zpos}
     first_rapid_move = false
  else
    if tool_path_type eq 'start_approach'
      if change(xpos) eq true or change(ypos) eq true
       {nb,['G'gcode][' X'xpos] [' Y'ypos]}
      endif
      if change(zpos) eq true
       {nb,['   Z'zpos]}
      endif
    endif
    if tool_path_type eq 'start_retreat'
      {nb,'G'gcode,' Z'zpos}
      if change(xpos) eq true or change(ypos) eq true
         {nb,'  '[' X'xpos], [' Y'ypos]}
      endif
    endif
    if tool_path_type ne 'start_approach' and tool_path_type ne 'start_retreat'
      if change(xpos) eq true or change(ypos) eq true or change(zpos) eq true
         {nb,['G'gcode],[' X'xpos],[' Y'ypos],[' Z'zpos]}
      endif
    endif
  endif
  rapid_flag = true
endp
;------------------
```

```
@line
   if job_machine_type eq milling
       call @line_mill
   else
       call @line_turn
   endif
endp
;-------------------

@compensation
   if side eq COMP_LEFT then
      gcode = 41
      {nb 'G'gcode ' ' }
   endif
   if side eq COMP_RIGHT then
      gcode = 42
      {nb 'G'gcode ' ' }
   endif
   if side eq COMP_OFF then
      gcode = 40
      {nb 'G'gcode ' ' }
   endif
      skipline = false
endp
;-------------------

@line_mill
  gcode = 1
  if change(gcode) then
      {nb,'G'gcode}
  else
      {nb,'  '}
  endif
      {[' X'xpos], [' Y'ypos],[' Z'zpos]}
  if change(feed) eq true
   {[' F'feed]}
  endif
endp
;-------------------

@line_turn
local logical comp_off1
 if gcode eq 40
    comp_off1 = 1
 else
    comp_off1 = 0
 endif
 if rapid_flag == true
  if spin_unit eq css
   if g96_flag eq true
    {nb,'G96 S'spin}
    if !spindle
     {' R1'}
```

```
    else
     {' R2'}
    endif
    g96_flag = false
   endif
  endif
  rapid_flag = false
 endif
 gcode = 1
 {nb,['G'gcode]}
    if comp_off1 eq 0 or in_cycle eq 0
       if ben2 and work_type eq ROUGH
          if process_type eq LONG then
             {' X'xpos}
          else
             {' Z'zpos}
          endif
          ben2 = false
       else
          {[' X'xpos], [' Z'zpos]}
       endif
       if prev_command eq '@turn_proc' then
          change(feed) = TRUE
       endif
       {[' F'feed]}
   endif
                  G97_dia = xpos*2
endp
;--------------------

@rotary_info
endp
;--------------------

@move_4x_OLD
    cpos = cpos * cpos_rot_dir
    gcode = 0
if rot_axis_type == axis4_face
  if new_job
    {nb,chuck_unclamp} ;M212 M312

    {nb,'G'gcode,' 'chuck_axis,' ['cpos,'+'delta_angle,'] Y0.'}
    {nb, [' Y'ypos],[' Z'zpos]}
    {nb, [' X'xpos]}
    {nb,'M8 M51'}
    new_job = false
  else
    {nb, ['G'gcode],[' X'xpos],' '[ chuck_axis,cpos],[' Z'zpos]}
  endif
else
  if new_job
    {nb,chuck_unclamp} ;M212 M312
```

```
    {nb,'G'gcode,' 'chuck_axis,' ['cpos,'+'delta_angle,']'}
    {nb, [' X'xpos],[' Y'ypos]}
    {nb, [' Z'zpos]}
    {nb,'M8 M51'}
    new_job = false
  else
    {nb, ['G'gcode],[' X'xpos],[' Y'ypos],[' Z'zpos],[' 'chuck_axis' ['cpos'+'delta_angle,']']}
  endif
endif
tool_feed_zold = 0
tool_feed_old = 0
   rapid_flag = true
endp
;-------------------

@line_4x_OLD
        if spindle
        endif
    cpos = cpos * cpos_rot_dir
    gcode = 1
    {nb, ['G'gcode],[' X'xpos],[ ' Y'ypos]}
    {[' Z'zpos],[' 'chuck_axis' ['cpos'+'delta_angle,']']}
      if rotation_feed == 0
       if change(zpos) eq true
         if tool_feed_zold <> tool_feed_z
           {[' F'tool_feed_z:feed_mmpm_f]}
           tool_feed_zold = tool_feed_z
         endif
       else
         if tool_feed_old <> tool_feed
          {[' F'tool_feed:feed_mmpm_f]}
           tool_feed_old = tool_feed
         endif
       endif
      else
        {[' F'feed:feed_mmpm_f]}
      endif
endp
;-------------------

@move_4x
    cpos = cpos * cpos_rot_dir
    gcode = 0
if rot_axis_type == axis4_face
  if new_job
    {nb,chuck_unclamp} ;M212 M312

    {nb,'G'gcode,' 'chuck_axis}
      if trans_4x eq false
         {cpos}
      else
         {['cpos,'+'delta_angle,'] Y0.'}
      endif
```

```
    {nb, [' Y'ypos],[' Z'zpos]}
    {nb, [' X'xpos]}
    {nb,'M8 M51'}
    new_job = false
  else
    {nb, ['G'gcode],[' X'xpos],[' Y'ypos],[' Z'zpos]' 'chuck_axis}
      if trans_4x eq false
        {cpos}
      else
        {'['cpos,'+'delta_angle,'] Y0.'}
      endif
  endif
else
  if new_job
    {nb,chuck_unclamp} ;M212 M312

    {nb,'G'gcode,' 'chuck_axis}
      if trans_4x eq false
        {cpos}
      else
        {'['cpos,'+'delta_angle,'] Y0.'}
      endif
    {nb, [' X'xpos],[' Y'ypos]}
    {nb, [' Z'zpos]}
    {nb,'M8 M51'}
    new_job = false
  else
    {nb, ['G'gcode],[' X'xpos],[' Y'ypos],[' Z'zpos]' 'chuck_axis}
      if trans_4x eq false
        {cpos}
      else
        {'['cpos,'+'delta_angle,'] Y0.'}
      endif
  endif
endif
tool_feed_zold = 0
tool_feed_old = 0
   rapid_flag = true
endp
;------------------

@line_4x
        if spindle
        endif
    cpos = cpos * cpos_rot_dir
    gcode = 1
    {nb, ['G'gcode],[' X'xpos],[ ' Y'ypos]}
    {[' Z'zpos],' 'chuck_axis}
      if trans_4x eq false
        {cpos}
      else
        {'['cpos,'+'delta_angle,'] Y0.'}
      endif
```

```
     if rotation_feed == 0
      if change(zpos) eq true
        if tool_feed_zold <> tool_feed_z
          {[' F'tool_feed_z:feed_mmpm_f]}
          tool_feed_zold = tool_feed_z
        endif
      else
        if tool_feed_old <> tool_feed
         {[' F'tool_feed:feed_mmpm_f]}
          tool_feed_old = tool_feed
        endif
      endif
     else
       {[' F'feed:feed_mmpm_f]}
     endif
endp
;-------------------

@arc
   if job_machine_type eq milling
       call @arc_mill
   else
       call @arc_turn
   endif
endp
;-------------------

@arc_turn
       if arc_direction eq CCW then
          gcode = 3
       else        ; CW
          gcode = 2
       endif
       {nb, ['G'gcode] ' X'xend:xpos_f ' Z'zend:zpos_f}
       if arc_size >= 180 then
          radius = -radius
       endif
       {' R'radius, [' F'feed]}
endp
;-------------------

@arc_mill
   if change(arc_plane)
       if arc_plane eq XY then
          gcode = 17
       endif
       if arc_plane eq YZ then
          gcode = 18
       endif
       if arc_plane eq ZX then
          gcode = 19
       endif
       {nb,'G'gcode, ' '}
```

```
      skipline=true
   endif
   if arc_direction eq CCW then
      gcode = 3
   else        ; CW
      gcode = 2
   endif
   if change(gcode)
      {nb,'G'gcode}
   else
      {nb,'  '}
   endif
   if m_feed_flag eq 1
      {' F'feed}
      m_feed_flag = 0
    else
       {[' F'feed]}
    endif
   {[' X'xpos] [' Y'ypos] [' Z'zpos]}
   if arc_size eq 360 then
      if arc_plane eq XY then
         {' I'xcenter_rel, ' J'ycenter_rel}
      endif
      if arc_plane eq YZ then
         {' J'xcenter_rel, ' K'ycenter_rel}
      endif
      if arc_plane eq ZX then
         {' K'xcenter_rel, ' I'ycenter_rel}
      endif
   else
      if arc_size >= 180 then
         radius = -radius
      endif
      {' R'radius}
   endif
endp
;-------------------

@delay
   gcode = 4
   {nb 'G'gcode, ' P'delay_period:integer_def_f}
endp

;-------------------

@change_ref_point
   {nb,'G10 L10 P'home_number ' U'(-(xhome)), ' V'(-(yhome)), ' W'zhome}
   {nb 'G90'}
endp
;-------------------

@home_number
endp
```

```
;------------------

@rotate
;Transform Rotate
        rotate_count = rotate_count + 1
        {nb,chuck_unclamp}
        gcode = 0
        if rotate_cancel eq false
          {nb, 'G'gcode,' 'chuck_axis((rotate_angle_z * cpos_rot_dir)+(angle*rotate_count))}
        else
          {nb, 'G'gcode,' 'chuck_axis(rotate_angle_z * cpos_rot_dir)}
        endif
        {nb,chuck_clamp}
endp
;------------------

@fourth_axis
;Transform 4x
    trans_4x = true
    gcode = 0
    if rot_axis_type eq axis4_none
        {nb,chuck_unclamp}
        {nb, 'G'gcode,' 'chuck_axis((rotate_angle_z * cpos_rot_dir)+angle)}
        {nb,chuck_clamp}
    endif
;    if position eq 1
;        {nb,delta_angle' = '((rotate_angle_z * cpos_rot_dir)+angle)}
        {nb,delta_angle' = 'angle}
;    endif
first_rapid_move = true
endp
;------------------

@message
endp
;---------------

@turn_drill
    if drill_type eq Drill_G81 then     ;(G274)
    g_code = '274'
    {nb,'G',g_code, ' Z'drill_lower_z,' Q'(drill_depth)}
    endif
    if drill_type eq Peck_G83 then     ;(G274)
    g_code = '274'
    {nb,'G',g_code, ' Z'drill_lower_z,' Q'(down_step)}
    endif
    {' F'(feed*spin):tdrill_f}
    {nb,'G0 Z'zpos}
endp
;---------------

@drill_milling
```

```
   if drill_type eq Drill_G81  ;(G81)
      g_code = '81'
   endif
   if drill_type eq Face_G82   ;(G82)
      g_code = '82'
   endif
   if drill_type eq Peck_G83   ;(G83)
      g_code = '83'
   endif
   if drill_type eq Tap_G84    ;(G84)
      g_code = '84'
   endif
   if drill_type eq Ream_G85   ;(G85)
      g_code = '85'
   endif
   if drill_type eq Bore_G86   ;(G86)
       g_code = '86'
   endif
;
      {nb,'G',g_code, ' Z'drill_lower_z, ' R'drill_upper_z}
   if drill_type eq Face_G82 then
      {' P'delay:integer_def_f}
   endif
   if drill_type eq Peck_G83 then
      if  down_step == 0
            down_step = drill_depth
      endif
      {' Q'down_step}
   endif
   if drill_type eq Tap_G84 then
      {' F'pitch:feed_f}
   else
      {' F'feed:feed_f}
   endif
endp
;--------------------

@drill
   if position ne 1
     cpos = rotate_angle_z*cpos_rot_dir
   else
     cpos = cpos * cpos_rot_dir
   endif
   gcode = 0
   if position eq 1
    if rotate_count eq 0
     {nb,chuck_unclamp} ;M212 M312

     {nb,'G'gcode,' 'chuck_axis}
     if trans_4x eq false
       {cpos}
     else
       {'['cpos,'+'delta_angle,']'}
```

```
        {'Y0.'}
      endif
      {nb,chuck_clamp} ;M210 M310
    endif
   endif
   if rot_axis_type == axis4_radial
   {nb,' X'zpos,' Y0.'}
   {nb,' Z'xpos}
   else
   {nb,' X'xpos,' Y'ypos}
   {nb,' Z'zpos}
   endif
   last_cpos = cpos
   if drill_type eq helicoil
     call @helicoil
   endif
endp
;-------------------

@drill_point

            if not first_drill then
              if drill_type eq helicoil
                   call @helicoil
              else
                 {nb, '   ', [' X'xpos], [' Y'ypos], [' Z'zpos]}
              endif
            else
      call @drill_milling
            endif
endp
;-------------------

@drill4x_pnt
      cpos = cpos * cpos_rot_dir
    if cpos <> last_cpos
      {nb,chuck_unclamp} ;M212 M312

      {nb,'G'gcode,[' X'xpos], [' Y'ypos],' 'chuck_axis}
      if trans_4x eq false
        {cpos}
      else
        {'['cpos,'+'delta_angle,']'}
      endif
      {nb,chuck_clamp} ;M210 M310
    endif
            if first_drill then
                 call @drill_milling
            endif
endp
;-------------------
```

```
@mirror
    if mirror_type eq MIRROR_OFF then
        {nb, 'G50.1 X0 Y0'}
    else
        {nb, 'G51.1 '}
    if mirror_type eq MIRROR_X then
        {'X1 Y0'}
    endif
    if mirror_type eq MIRROR_Y then
        {'X0 Y1'}
    endif
    if mirror_type eq MIRROR_XY then
        {'X1 Y1'}
     endif
  endif
endp
;-------------------

@end_drill
   gcode = 80
   {nb, 'G'gcode}
   gcode = 0
   if rot_axis_type == axis4_radial
     {nb,'G'gcode,' Z'drill_clearance_z:xpos_f}
   else
     {nb,'G'gcode,' Z'drill_clearance_z:zpos_f}
   endif
endp
;-------------------

@halt_program
   {' M0'}
endp
;--------------------

@round_comp
   ; NOP
endp
;--------------------

@start_of_job
   skipline = false
   {' ( 'job_name,' )'}
   skipline= true
   new_job  = true
   first_rapid_move  = true
   if job_machine_type eq turning
   g96_flag = true
   xpos_f         = '5.3(*2)'
   else
   xpos_f         = '5.3'
   endif
endp
```

```
;--------------------

@end_of_job
 if left(job_name,2) eq '5X'
 {nb,'G49'}
 endif
 if M00_Milling or M00_Turning
 {nb,'M00'}
 {nb, '( 'msg,' )'}
 endif
 if M01_Milling or M01_Turning
 {nb,'M01'}
 {nb, '( 'msg,' )'}
 endif
 x97              = 0
 turn_rapid       = 0
 trans_4x         = false
 first_rapid_move  = false
 rotate_count      = 0
endp
;--------------------

@assign_axis
endp

;-------------------

@turning
   local numeric ww uu rr aa bb
   local logical ben1

   if semi_finish then
      rough_offset_x = semi_offset_x
      rough_offset_z = semi_offset_z
      work_type = rough
      if process_type eq long
        if turning_mode <> internal
           uu = save_x - first_pos_x
        else
           uu = first_pos_x - save_x
        endif
        down_step = (uu+10)
      else
         ww = save_z - first_pos_z
         down_step = (ww+10)
      endif
      ben1 = true
   endif

   if work_type eq ROUGH then
      if process_type eq LONG then
         gcode =271
```

```
        {nb, 'G'gcode}
        {' U'down_step, ' R'(down_step/2) }
        {nb, 'G'gcode ' P'start_line ' Q'end_line}
        {' U'rough_offset_x ' W'rough_offset_z}
    else
        gcode = 272
        {nb, 'G'gcode }
        {' W'down_step, ' R'(down_step/2) }
        {nb 'G'gcode ' P'start_line ' Q'end_line}
        {' U'rough_offset_x ' W'rough_offset_z}
    endif
    if feed_unit eq css
        {' F'feed }
    else
        {' F'feed:'5.0(p)' }
    endif
    ben2 = true
endif

if work_type eq COPY then

    ww = save_z - first_pos_z
    uu = save_x - first_pos_x

    aa = (uu - rough_offset_x)
    bb = (ww - rough_offset_z)
    rr = sqrt(aa * aa + bb * bb)

    gcode = 273
    if ben1 eq false
      num_down_steps = rr / down_step + 1
    else
      num_down_steps = 1
    endif

    {nb, 'G'gcode,' U'uu, ' W'ww, ' R'num_down_steps}
    {nb, 'G'gcode ' P'start_line ' Q'end_line }
    {' U'rough_offset_x ' W'rough_offset_z}

    if feed_unit eq css
        {' F'feed }
    else
        {' F'feed:'5.0(p)' }
    endif

endif

if semi_finish then
    gcode = 150
endif

if finish then
    gcode = 151
```

```
   endif

endp

@turn_proc
in_cycle = 1
endp

@turn_endproc
in_cycle = 0
endp

@end_job_procs
endp

@m_feed_spin
endp

@feed_spin
 if job_machine_type == turning
   if g96_flag eq true
     if tool_number ne 99
       {nb}
        if feed_unit eq mm_min
           feed_f = '5.0(p)'
           {'G94'}
        else         ; mm_rev
           {'G95'}
           feed_f = '4.3(p)'
        endif
        if spin_unit eq rpm
           gcode = 97
           {' G'gcode' S'spin}
        else ; css
           gcode = 97  ; 96
           {' G'gcode}
            if x97 == 0
              calc_spin = (spin*1000)/(3.14*G97_dia)
              {' S'calc_spin}
              x97 = 1
            else
              {' S'spin}
            endif
        endif
        if !spindle
          if spin_direction eq CW then
            mcode = 203
          else             ;  CCW
            mcode = 204
          endif
        else
          if spin_direction eq CW then
            mcode = 303
```

```
            else             ;  CCW
               mcode = 304
            endif
          endif
        {' M'mcode}
       endif
    endif
 endif
endp

@elop_feed_spin
 if job_machine_type == turning
   if tool_number ne 99
         {nb}
          if spin_unit eq rpm
             gcode = 97
             {' G'gcode}
          else ; css
             gcode = 96
             {' G'gcode}
          endif
           {' S'spin}
    if !spindle
       if spin_direction eq CW then
          mcode = 203
       else             ;  CCW
          mcode = 204
       endif
    else
       if spin_direction eq CW then
          mcode = 303
       else             ;  CCW
          mcode = 304
       endif
    endif
  endif
endif
endp

@thread
       local string for for1 for2 for3 for4
       local numeric taper_angle
       for  = '6.0(n*10000)'
       for1 = '2/2.0(P)'
       for2 = '2/2.0(P*10)'
       for3 = '5.0(P*1000)'
       for4 = '5.3'
;
       taper_angle = (first_pos_x-last_pos_x)
       if last_pos_x <> first_pos_x
          if turning_mode <> internal
             xpos = (last_pos_x + depth + safety )
          else
```

```
            xpos = (last_pos_x - depth - safety )
         endif
         gcode = 0
         {nb,'G'gcode ' X'xpos }
      endif
;
      if lead_unit <> mm
        lead = (25.4/lead)
      endif
;
      if spin_dir1 eq 1
        tool_direction = cw
        if spin_dir_us eq false
           call @stop_tool
           call @start_tool
        endif
        spin_dir_us = true
      else
        tool_direction = ccw
        if spin_dir_us1 eq false
           call @stop_tool
           call @start_tool
           spin_dir_us = false
        endif
        spin_dir_us1 = true
      endif

      if work_type eq multiple
          gcode = 276
         {nb,       'G'gcode,       '       P'no_last_cut:for1,       phase:for2       ,T_angle:for1       '
Q'min_down_step:numeric_def_f ' R'last_cut:numeric_def_f}
         {nb 'G'gcode ' X'last_pos_x:xpos_f ' Z'last_pos_z }
         if taper_angle <> 0
            {' R'taper_angle}
         endif
         {' P'depth:numeric_def_f ' Q'down_step:numeric_def_f ' F'lead}
      else
         gcode = 292 ;was 92 23.02.09
         {nb ' G'gcode ' X'last_pos_x:xpos_f ' Z'last_pos_z}
         if taper_angle <> 0
            {' R'taper_angle}
         endif
         {' F'lead}
      endif
endp


@groove
   local string for for1 for2  for3 for4
   local numeric d1 d2

   for1 = '2/2.0(P)'
   for2 = '2/2.0(P*10)'
```

```
   for3 = '5.0(P*1000)'
   for4 = '5.3(P)'
   d1 = abs(side_step)
   d2 = abs(down_step)
   if process_type eq face

       gcode = 274
      {nb 'G'gcode, ' R'release_dist }
      {nb 'G'gcode,' X'last_pos_x:xpos_f ' Z'last_pos_z ' P'd1 :numeric_def_f ' Q'd2
:numeric_def_f }
   else

       gcode = 275
      {nb 'G'gcode, ' R'release_dist }
      {nb 'G'gcode,' X'last_pos_x:xpos_f ' Z'last_pos_z ' P'd2:numeric_def_f '
Q'd1:numeric_def_f}
   endif
   {' F'feed }
endp

@turn_opt_parms
endp


@chng_tool_cnext
endp

@init_cpos
endp

@move4x_dir

endp

@line4x_dir
endp

@move4x_polar
endp

@line4x_polar
endp

@arc4x_polar
endp

@start_cartesian
;        {nb,'G17 G90 G0 'chuck_axis,'0 X'xpos}
        {nb,chuck_brake} ;M211 M311
        {nb,'G12.1'}

endp
@move4x_cartesian
```

```
   {nb}
   gcode = 0
      {'G0 '}
   {[' X 'xpos],' ' [chuck_axis cpos],[' Z' zpos], ' F2000'}
endp

@end_cartesian

       {nb,'G13.1'}
endp


@line4x_cartesian
  if prev_command ne '@offset_change'
          {nb}
            gcode = 1
              if change(gcode) then
                {'G'gcode}
              else
                {'  '}
              endif
     { ' X'xpos,' ' chuck_axis cpos,[' Z'zpos],[' F'feed]}
  endif
endp

@arc4x_cartesian

   {nb}
   if arc_direction eq CCW then
      gcode = 3
   else        ; CW
      gcode = 2
   endif
   if change(gcode) then
      {'G'gcode}
   else
      {'  '}
   endif
   {[' X'xpos],' ' chuck_axis cpos }

   if arc_size eq 360 then
         {' I'xcenter_rel, ' K'ycenter_rel}
   else
      if arc_size >= 180 then
         radius = -radius
      endif
      {' R'radius}
   endif

   {[' F'feed]}
endp

@drill4x_polar
```

```
endp

@drill4x_cartesian
if first_drill eq true
      call @drill_milling
            {nb,'G0 Z'zpos }
            {nb,'X'(xpos) }
            {nb,'G98 G',g_code, ' Z'drill_lower_z, ' R'drill_upper_z}
   if drill_type eq Face_G82 then
      {' P'delay:integer_def_f}
   endif
   if drill_type eq Peck_G83 then
      if  down_step == 0
          down_step = drill_depth
      endif
      {' Q'down_step}
      {' P'delay:integer_def_f}
   endif
   if drill_type eq Tap_G84 then
      {' P'delay:integer_def_f}
      {' L0'}
      {' F'pitch:feed_f}
   endif
   if drill_type <> Tap_G84 then
      {' F'feed:feed_f}
   endif
endif
      {nb,chuck_unclamp} ; M212 M312
      {nb, ' X'(xpos),' 'chuck_axis cpos}
      {nb,chuck_clamp}   ; M210 M310
endp


@tmatrix
origin = mac_number + 53
if position eq 1
  if rot_axis_type eq axis4_radial
    rotate_angle_y = rotate_angle_y + 90
  endif
endif
endp


@home_data
turn_drill_safety = clearance_plane
endp

;    ======================
;    USER DEFINED PROCEDURES
;    ======================

@change_name
   if !spindle
```

```
      chuck_axis      = 'C'
      chuck_clamp     = 'M210'
      chuck_unclamp   = 'M212'
      chuck_brake     = 'M211'
      chuck_turn_mode = 'M202'
      chuck_mill_mode = 'M200'
      spin_max        = '1'
      cpos_rot_dir    = -1
      delta_angle     = '#101'
else
      chuck_axis      = 'U'
      chuck_clamp     = 'M310'
      chuck_unclamp   = 'M312'
      chuck_brake     = 'M311'
      chuck_turn_mode = 'M302'
      chuck_mill_mode = 'M300'
      spin_max        = '2'
      cpos_rot_dir    = -1
      delta_angle     = '#102'
   endif
endp
;-------------------

@goto_ref_point_xyz_out
           {nb, 'G69'}
           {nb, 'G91 G28 X0'}
           {nb, 'G28 Y0 Z0'}
           {nb, 'G90'}
endp
;-------------------

@goto_ref_point_xyz_in
           {nb, 'G69'}
           {nb, 'G91 G28 Y0 Z0'}
           {nb, 'G28 X0'}
           {nb, 'G28 Y0 Z0'}
           {nb, 'G90'}
endp
;-------------------

@goto_ref_point_x_out
           {nb, 'G69'}
           {nb, 'G91 G28 X0'}
           {nb, 'G90'}
endp
;-------------------
@turn_tool_description
 if tool_type eq Ext_ROUGH
   turn_descrp = 'EXT. ROUGH'
 endif
 if tool_type eq Turn_DRILLING
   turn_descrp = 'TURN DRILLING'
 endif
```

```
 if tool_type eq Ext_THREAD
   turn_descrp = 'EXT. THREAD'
 endif
 if tool_type eq Ext_GROOVE
   turn_descrp = 'EXT. GROOVE'
 endif
 if tool_type eq Ext_CONTOUR
   turn_descrp = 'EXT. CONTOUR'
 endif
 if tool_type eq Int_ROUGH
   turn_descrp = 'INT. ROUGH'
 endif
 if tool_type eq Int_THREAD
   turn_descrp = 'INT. THREAD'
 endif
 if tool_type eq Int_GROOVE
   turn_descrp = 'INT. GROOVE'
 endif
 if tool_type eq Int_CONTOUR
   turn_descrp = 'INT. CONTOUR'
 endif
 if tool_type eq Int_FACE_BACK
   turn_descrp = 'INT. FACE_BACK'
 endif
endp
;-------------------

@G68_home
                call @change_name
                call @goto_ref_point_x_out
                {nb,'M108'}
                {nb,chuck_unclamp}
                if rotate_angle_y == 180 and (rotate_angle_z * cpos_rot_dir) == -180
                   {nb,'G0 B'rotate_angle_y,' 'chuck_axis,'0.'}
                else
                   {nb,'G0 B'rotate_angle_y,' 'chuck_axis (rotate_angle_z * cpos_rot_dir)}
                endif
                {nb,'M107'}
                {nb,chuck_clamp}
                {nb,'(========== CURRENT HOME =========)'}
                {nb,'( MAC'home_number' POS'position,' B = 'rotate_angle_y:'5.3/1'}
                {' C = '(rotate_angle_z * cpos_rot_dir):'5.3/1',' )' }
                {nb,'(================================)'}
                if rotate_angle_y <> 0
                    {nb,'G68 X',shift_x, ' Y'shift_y, ' Z'shift_z, ' I0. J1. K0. R'rotate_angle_y}
                endif
;
                if new_mill_tool eq 1
                     if position eq 1
                       if rot_axis_type eq axis4_radial
                          {nb,'G0     G43     H'tool_number,'     X'znext:xpos_f,'     Y'ynext:ypos_f,'
Z'xnext:zpos_f}
                       else
```

```
                        {nb,'G0     G43     H'tool_number,'     X'xnext:xpos_f,'     Y'ynext:ypos_f,'
Z'znext:zpos_f}
                      endif
                    else
                        {nb,'G0     G43     H'tool_number,'     X'xnext:xpos_f,'     Y'ynext:ypos_f,'
Z'znext:zpos_f}
                    endif
                else
                    if position eq 1
                      if rot_axis_type eq axis4_radial
                        {nb,'G0 G43 H'tool_number,' Z'xnext:xpos_f}
                      else
                        {nb,'G0 G43 H'tool_number,' Z'znext:zpos_f}
                      endif
                    else
                        {nb,'G0 G43 H'tool_number,' Z'znext:zpos_f}
                    endif
                endif
;
                {nb, 'M08'}
                g43_flag = true
                last_rotate_angle_y = rotate_angle_y
                last_rotate_angle_z = rotate_angle_z
endp
;-------------------
@mill_drill
endp
@helicoil
    local integer num_step
    local numeric xpos1 xpos_out ypos_out s_step1 sem_fin1
    local logical flag_in
    local string comp_dir1

   ;----- checking if or out -----------
          if inn eq 1 and out eq 0 then
                flag_in = true
          endif
          if out eq 1 and inn eq 0 then
                flag_in = false
          endif
   ;----- checking if or out -----------

          {nb,'G17'}
   ;      {nb,'xpos = ' xpos ' tool_diameter = 'tool_diameter ' diameter = 'diameter}
   ;----- first moovement form in or out -------
          if flag_in eq true
              {nb,'G0'[' X'xpos],[' Y'ypos],' Z'drill_clearance_z}
          else
             {nb,'G0 X'(xpos+diameter/2+tool_diameter/2+2), ' Y'ypos, ' Z'drill_clearance_z}
          endif
   ;----- first moovement from in or out -------

          {nb,'G0 Z'drill_upper_z}
```

```
;---- avoid division by 0 --------
        if s_step == 0
            if sem_fin == 0
                sem_fin1 = 1
                s_step1 = 1
            else
                sem_fin1 = sem_fin
                s_step1 = sem_fin1 / 2
            endif
        else
            sem_fin1 = sem_fin
            s_step1 = s_step
        endif
;---- avoid division by 0 --------

;---- calculating the number of steps --------

        if frac(abs(sem_fin1 / s_step1)) > 0
            num_step = abs(sem_fin1 / s_step1 + 1)
        else
            num_step = abs(sem_fin1 / s_step1)
        endif

;---- calculating the number of steps --------

        while num_step >= 1
            {nb,'G1 Z'drill_lower_z ' F'feed}

; --- set the variables for in or out thred -----

            if flag_in eq true
                if num_step == 1
                    xpos1 = ((diameter/2) + xpos)
                else
                    xpos1 = ((diameter/2) + xpos - sem_fin1 + s_step1);
                endif
              if pitch gt 0
                        comp_dir1 = '41'
                        xpos_out = xpos
                        gcode = 3
              else
                    comp_dir1 = '42'
                        xpos_out = xpos
                        gcode = 2
              endif
            else
                if num_step == 1
                    xpos1 = ((diameter/2) + xpos)
                else
                    xpos1 = ((diameter/2) + xpos + sem_fin1 - s_step1);
                endif
                comp_dir1 = '42'
```

```
                xpos_out = (xpos+diameter/2+tool_diameter/2+2)
                gcode = 3
            endif

   ; --- set the variables for in or out thred -----

            {nb,'G43 X'xpos1:xpos_f}
            {nb,'G'comp_dir1}
            ; {nb,'G'gcode ' X'xpos1 }
          {nb,'G'gcode }
            {' I'xpos,' J'ypos,' B5='(360*d_step),' K'pitch}
            {nb,'G40'}
            {nb,'G1 X'xpos_out:xpos_f,' Y'ypos}
            s_step1 = s_step1 + s_step1
            num_step = num_step-1
          endw
         {nb,'G0 Z'drill_clearance_z}
         {nb,'(**END OF TAPING NEXT POINT**)'}
endp
;    ======================
;    PROCEDURES NOT IN USE
;    ======================
@start_program
endp
;-------------------

@end_of_file
endp
;-------------------

@relative_mode
   gcode = 91
   {nb, 'G'gcode, ' '}
   skipline = false
endp
;-------------------

@absolute_mode
   gcode = 90
    {nb, 'G'gcode, ' '}
   skipline = true
endp
;-------------------

@def_tool
endp
;-------------------

@def_turn_tool
endp
;-------------------
```

A P P E N D I X B

B. GPPtool error messages

GPPtool generates error messages while translating **SolidCAM** tool-path commands into G-Code. If an error occures, GPPtool displays the line number at which the error occured, the error number and an explanatory text for that error. In this appendix you will find a complete list of GPPtool error messages together with explanations of how to recover from these errors.

♦ Not enough memory

Description: GPPtool runs out of memory.

Recovery : Quit, and re-run **SolidCAM**. Try to generate the G-Code now. If this fails, see Chapter 2 for generation of G-Code outside **SolidCAM**.

♦ ENDIF statement missing

Description: GPPLtool's 'IF' statement started, but no respective 'ENDIF' statement found.

Recovery : Check [MACHINE.GPP] file for misspelling of the 'ENDIF' keyword. Check for balanced number of 'IF' and 'ENDIF' keywords.

♦ Variable 'xxx' is not defined

Description: Variable 'xxx' was used, but it is neither system variable nor was it explicitely declared as global or local variable.

Recovery : Check for misspelling of the variable name. Declare it as global/local variable if necessary.

♦ Program too complex

Description: The GPPL program is too complicated for GPPtool.

Recovery: Try to simplify your program: use less nested 'IF' statements, or reduce procedure CALLs level. Error 384 rarely occurs;if you get this error andm you have other errors for that GPPL file, try to fix them and check the program again. In most cases this will solve the problem.

♦ Unrecognized statement

Description: GPPtool encountered a statement which could not be classified.

Recovery : Check for misspelling of line's keywords. Check also if a statement appears out of the procedure body. E.g: an 'ENDIF' keyword without an earlier 'IF' keyword. A frequent mistake is to write statements out of a procedure body (i.e: after an 'ENDP' statement, and before the start of the next procedure).

♦ Variable 'xxx' is not numeric

Description: GPPtool requires a numeric (not integer or logical) value.

Recovery : Check the expression and convert it to numeric.

♦ Argument of function out of range

Description: One of the arguments for GPPL internal functions is out of its legal range.

Recovery : Check in chapter 5.6 for legal values of functions' arguments.

♦ ENDP statement missing

Description: GPPtool found the beginning of a procedure before it found the 'ENDP' statement of the previous one.

Recovery : Correct the problem and re-run.

♦ Invalid ASSIGNMENT statement

Description: Check the syntax.

Recovery : Correct the problem and re-run.

♦ Invalid GENERATE statement

Description: Check the syntax.

Recovery : Correct the problem and re-run.

♦ Invalid CALL statement

Description: Check the syntax.

Recovery : Correct the problem and re-run.

♦ Invalid IF statement

Description: Check the syntax.

Recovery : Correct the problem and re-run.

♦ Variable 'xxx' is not string variable

Description: GPPtool requires a string variable (not an integer or numeric one).

Recovery : Check the expression and convert it to string.

♦ Literals table overflow

Description: Too many literals (string constants) are defined for that statement.

Recovery : This error rarely appears. Try to simplify the line that caused the problem (i.e: split it for two lines if possible).

♦ Proc '@xxx' already defined

Description: You declared more than one GPPL procedure with the same name '@xxx'.

Recovery : Check for misspelling and rename one procedure.

♦ Local table 'xxx' cannot be recovered

Description: GPPtool internal error.

Recovery : Try to solve other error messages (if any) and re-run the program. If the error still exists, call CADTECH for technical support.

♦ Invalid seek

Description: GPPtool could not find the proper sector of a disk file.

Recovery : Probably you ran out of disk space;free some space and re-run the program.

♦ Cannot open file 'xxx'

Description: GPPtool could not find file 'xxx'.

Recovery : Check the existance of the file in the current working directory.

♦ Invalid GLOBAL statement

Description: Check the syntax.

Recovery : Correct the problem and re-run.

♦ Invalid LOCAL statement

Description: Check the syntax.

Recovery : Correct the problem and re-run.

♦ Symbol 'xxx' cannot be modified

Description: You tried to assign a value into a non-modifiable system variable.

Recovery : It is forbidden to assign a value into a GPPL non-modifiable variable. It makes no sense to change 'pi' value for example.

♦ Symbol table is full

Description: GPPL symbol table ran out of its size.

Recovery : Try to reduce the number of global/local variables. Sometimes the problem arises because GPPtool ran out of memory. Quit and re-run **SolidCAM**.

♦ Symbol 'xxx' does not exist

Description: You used an unrecognized variable named 'xxx' in your program.

Recovery : Check for misspelling. If OK, declare that variable as global or local.

♦ Stack overflow

Description: GPPtool run-time stack ran out of memory.

Recovery : Try to reduce stack requirements: reduce the number of nested 'IF' statements or reduce the number of CALLs levels. This error rarely occures.

♦ Stack underflow

Description: GPPtool internal error.

Recovery : Try to solve other error messages (if any) and re-run the program. If the error still exists, call CADTECH for technical support.

♦ Zero divide

Description: You tried to divide by zero.

Recovery : Correct the problem.

♦ Format: without any digit

Description: A display format does not contain an <integer> part.

Recovery : See chapter 5.5.10 for proper display format and correct the problem.

♦ Format: scale factor invalid

Description: A display format scale factor is invalid.

Recovery : See chapter 5.5.10 for proper display format and correct the problem.

♦ Val: number out of range

Description: You tried to generate a number which is larger than 1.E100.

Recovery : Correct the problem.

♦ Global variable 'xxx' is multiply defined

Description: A global variable 'xxx' is multiply declared with different types.

Recovery : Check for misspelling. It is impossible to declare a variable with two different types.

♦ Local variable 'xxx' is multiply defined

Description: A local variable 'xxx' is multiply declared with different types.

Recovery : Check for misspelling. It is impossible to declare a variable with two different types.

♦ Variable 'xxx' is already declared as local

Description: You declared a local variable 'xxx' as global one.

Recovery : Check for misspelling. It is impossible to declare a variable as local and global together.

♦ Variable 'xxx' is already declared as global

Description: You declared a global variable 'xxx' as local one.

Recovery : Check for misspelling. It is impossible to declare a variable as local and global together.

♦ System variable 'xxx' cannot be declared

Description: You tried to declare system variable 'xxx' as global or local.

Recovery : Rename variable and re-run.

♦ Numeric expression is not of logical type

Description: A numeric expression does not yield a TRUE/FALSE (1/0) value.

Recovery : Correct the problem and re-run the program.

♦ Format: no decimal point

Description: A display format does not contain a decimal point.

Recovery : See chapter 5.5.10 for proper display format and correct the problem.

♦ Format: no fraction digits

Description: A display format does not contain a <fraction> part.

Recovery : See chapter 5.5.10 for proper display format and correct the problem.

♦ Format: Invalid format option

Description: A display format contains an invalid option.

Recovery : See chapter 5.5.10 for proper display format and correct the problem.

♦ Cannot initialize GPPtool environment

Description: An error occured while initializing the GPPtool environment.

Recovery : Correct other error messages. When running GPPtool outside **SolidCAM**: check if 'CONFIG.NC' file contains proper machine name, and if [MACHINE.MAC] file contains proper 'post_processor' parameter value.

♦ Cannot terminate GPPtool environment

Description: Error occured while terminating GPPtool environment.

Recovery : Internal error. Call CADTECH for technical support.

♦ Error while reading file 'xxx'

Description: I/O error occured while reading file 'xxx'.

Recovery : Probably hardware error. Try to re-run the program. If the problem still occurs, try to change the magnetic media (i.e: try to run it on another disk).

♦ Error while writing file 'xxx'

Description: I/O error occured while writing file 'xxx'.

Recovery : Probably hardware error. Try to re-run the program. If the problem still occurs, try to change the magnetic media (i.e: try to run it on another disk). If working with diskettes, check that the diskette is not a 'read-only' one.

♦ Block number field too big

Description: While sequencing G-code blocks, 'blknum_max' value was reached.

Recovery : If possible, increase 'blknum_max' value (in procedure '@init_post'). Otherwise, split the Part into smaller parts and re-generate the G-Code.