G-Code Reference

2021/06/17

G-Codes

Mode

G20 - Inch Units

G70 - Inch Units

Usage: G20

Set units to inches.

Parameters:

#<_units> - (RW) current units

G21 - Millimeter Units

G71 - Millimeter Units

Usage: G21

Set units to millimeters.

Parameters:

#<_units> - (RW) current units

G17 - XY Plane

Usage: G17

Set XY plane. Planes are used with arcs, circles and cycles.

#<_plane> - (RW) current plane

G18 - ZX Plane

Usage: G18

Set ZX plane. Planes are used with arcs, circles and cycles.

Parameters:

#<_plane> - (RW) current plane

G19 - YZ Plane

Usage: G19

Set YZ plane. Planes are used with arcs, circles and cycles.

Parameters:

#<_plane> - (RW) current plane

G90 - Distance Mode – Absolute

Usage: G90

Set absolute distance mode. In absolute position mode machine will move to the commanded position in the active user coordinate system.

Parameters:

#<_distancemode> - (RW) current distance mode

G91 - Distance Mode – Incremental

Usage: G91

Set incremental distance mode. In incremental position mode commanded moves are interpreted as distance and direction from the current position.

Parameters:

#<_distancemode> - (RW) current distance mode

G90.1 - Distance Mode – IJK Absolute

Usage: G90.1

Set absolute distance mode for I, J, K arc values. In absolute arc center mode the I, J, K values designate the position of the arc center in the user coordinate system.

Parameters:

#<_distancemode_ijk> - (RW) current distance mode for IJK

G91.1 - Distance Mode – IJK Incremental

Usage: G91.1

Set incremental distance mode for I, J, K arc values. In incremental arc center mode the I, J, K values designate the distance and direction to the arc center from the start point.

Parameters:

#<_distancemode_ijk> - (RW) current distance mode for IJK

G90.2 - Distance Mode – ABC Absolute

Usage: G90.2

Set absolute distance mode for A, B, C axis values. (same as M82)

Parameters:

#<_distancemode_abc> - (RW) current distance mode for ABC

G91.2 - Distance Mode – ABC Incremental

Usage: G91.2

Set incremental distance mode for A, B, C axis values. (same as M83)

#<_distancemode_abc> - (RW) current distance mode for ABC

G98 - Cycle Return - Initial Z Point

Usage: G98

Specifies that a cycle ends at the initial Z level.

Parameters:

#<_cyclereturnmode> - (RW) current cycle return mode

G99 - Cycle Return - R Point

Usage: G99

Specifies that a cycle ends at the programmed R level.

Parameters:

#<_cyclereturnmode> - (RW) current cycle return mode

G07 - Lathe Mode – Diameter

Usage: G07

Use diameter mode for axis X on a lathe. When in the diameter mode the X axis moves on a lathe will be 1/2 the distance to the center of the lathe.

Parameters:

#<_lathemode> - (RW) current lathe mode

G08 - Lathe Mode – Radius

Usage: G08

Use radius mode for axis X on a lathe. When in radius mode the X axis moves on a lathe will be the distance from the center.

Parameters:

#<_lathemode> - (RW) current lathe mode

G15 - Polar Coordinate Cancel

Usage: G15

Cancel polar mode coordinate positioning.

Parameters:

#<_polarmode> - (RW) current polar mode

G16 - Polar Coordinate Enable

Usage: G16

Enable polar mode coordinate positioning. In the polar coordinate mode movement end points are specified as a radius and angle. Origin is determined by the absolute/incremental position mode setting.

The current plane setting determines which word is radius and which is angle.

G17 – XY Plane – X is radius, Y is angle
G18 – ZX Plane – Z is radius, X is angle
G19 – YZ Plane – Y is radius, Z is angle

Parameters:

#<_polarmode> - (RW) current polar mode

Example:

```
(square with corners -30,-30 and 30,30)
G0 X0 Y0
G16
G00 X42.4264 Y225
G01 X42.4264 Y135
G01 X42.4264 Y45
G01 X42.4264 Y315
G01 X42.4264 Y225
G15
```

G61 - Blend Cancel

Usage: G61

In canceled blend mode movement is exactly as programmed. Moves will slow or stop as needed to reach every programmed point. If two sequential moves are exactly co-linear movement will not stop.

Parameters:

#<_blendmode> - (R) current blend mode

G64 - Blend Enable

Usage: G64 <P> <Q> - P (optional) = tolerance

In blend mode sharp corners will be rounded and the machine may never reach the programmed point before a direction change. Optional tolerance can be set.

Parameters:

#<_blendmode> - (R) current blend mode
#<_blend_tol> - (R) current blend tolerance

G93 - Feed Mode - Inverse Time

Usage: G93

In inverse time feed mode, an F word means the move should be completed in [one divided by the F number] minutes. When inverse time feed mode is active, an F word must appear on every motion line.

Parameters:

#<_feedmode> - (RW) current feed mode

G94 - Feed Mode - Units per Minute

Usage: G94

In units per minute feed mode, an F word is interpreted to mean the controlled point should move at a certain distance per minute.

Parameters:

#<_feedmode> - (RW) current feed mode

G95 - Feed Mode - Units per Revolution

Usage: G95

In units per revolution feed mode, an F word is interpreted to mean the controlled point should move at a certain distance per spindle revolution. This mode requires RPM feedback from the spindle.

Parameters:

#<_feedmode> - (RW) current feed mode

G96 - Spindle Mode – CSS

Usage: G96

In this mode surface speed is constant and based on cutting diameter. Surface speed is specified in units per minute. This requires special hardware and is usually not used on simple machines.

Parameters:

#<_spindlemode> - (RW) current spindle mode

G97 - Spindle Mode – RPM

Usage: G97

In this mode the spindle speed is specified in revolutions per minute.

Parameters:

#<_spindlemode> - (RW) current spindle mode

Tools

G40 - Tool Compensation Cancel

Usage: G40

Cancel tool compensation.

Parameters:

#<_toolcomp> - (R) tool compensation side
#<_toolcomp_dia> - (R) tool compensation diameter

G41 - Tool Compensation Left

G42 - Tool Compensation Right

Usage: G41 <D> - D (optional) = tool number

Start tool compensation with diameter from tool table.

If D word is not specified then current tool number is used.

Parameters:

#<_toolcomp> - (R) tool compensation side
#<_toolcomp_dia> - (R) tool compensation diameter

G41.1 - Tool Compensation Dynamic Left

G42.1 - Tool Compensation Dynamic Right

Usage: G41.1 D - D = tool diameter

Start tool compensation.

D word specifies tool diameter.

Parameters:

#<_toolcomp> - (R) tool compensation side
#<_toolcomp_dia> - (R) tool compensation diameter

G43 - Tool Offset+ Enable

G44 - Tool Offset- Enable

Usage: G43 <H> - H (optional) = tool number

Set tool offset to value from tool table.

If H word is not specified then current tool number is used.

Parameters:

#<_tooloff> - (RW) true if tool offset is currently enabled
#<_tooloff_x..w> - (RW) current tool offset

G43.1 - Tool Offset+ Enable

G44.1 - Tool Offset- Enable

Usage: G43.1 X..W - X..W = tool offset

Set tool offset to value from axis words.

Parameters:

#<_tooloff> - (RW) true if tool offset is currently enabled
#<_tooloff_x..w> - (RW) current tool offset

G49 - Tool Offset Cancel

Usage: G49

Cancel tool offset

Coordinate Systems

G54 - Coordinate System 1

G55 - Coordinate System 2

G56 - Coordinate System 3

G57 - Coordinate System 4

G58 - Coordinate System 5

G59 - Coordinate System 6

G59.1 - Coordinate System 7

G59.2 - Coordinate System 8

G59.3 - Coordinate System 9

Usage:	G54	- select coordinate system 1
	G55	- select coordinate system 2
	G56	- select coordinate system 3
	G57	- select coordinate system 4
	G58	- select coordinate system 5
	G59	- select coordinate system 6
	G59.1	- select coordinate system 7
	G59.2	- select coordinate system 8
	G59.3	- select coordinate system 9

Select coordinate system.

G54.1 - Coordinate System P

G59 P - Coordinate System P

Usage:	G54.1 P	- P = select coordinate system P+6
	G59 P	- P = select coordinate system P

Select coordinate system.

Coordinate system can be set with G10 L2 code.

1000 different coordinate systems are available.

Parameters:

#<_coordsys>	- (RW) current coordinate system number
#<_coordsys_x..w>	- (RW) current coordinate system offset
#<_coordsys_rot>	- (RW) current coordinate system rotation

Offsets

G92 - Working Offset

Usage: G92 X..W - X..W = desired position

G92 H E - H = axis number
- E = position

Set working offset. Offset is calculated so that current position becomes desired position specified with axis words.

Parameters:

#<_workoff> - (R) true, if working offset is set
#<_workoff_x..w> - (RW) current work offset

G92.1 - Working Offset Set

Usage: G92.1

G92 X..W - X..W = offset

G92 H E - H = axis number
- E = offset

Set working offset directly. Offset is set to zero if no words are specified

G52 - Axes Offset

Usage: G52 X..W - X..W = desired offset

Set axis offset.

Parameters:

#<_axisoff> - (R) true if axis offset is enabled
#<_axisoff_x..w> - (RW) current axis offset value

G52.1 - Axes Offset Cancel

Usage: G52.1

Cancel axis offset.

G51 - Axes Scale Enable

Usage:	G51 X..Z I..K	- X..Z = scale center - I..K = scale value
	G51 X..Z P	- X..Z = scale center - P = scale value
	G51 U..W I..K	- U..W = scale center - I..K = scale value
	G51 U..W P	- U..W = scale center - P = scale value

Set axis scale.

Parameters:

#<_axisscale>	- (R) true if axis scale is enabled
#<_axisscale_i..k>	- (RW) current axis scale value
#<_axisscale_x..z>	- (RW) current axis scale center
#<_axisscale_iuvw..kuvw>	- (RW) current axis scale value
#<_axisscale_u..w>	- (RW) current axis scale center

G50 - Axes Scale Cancel

Usage: G50

Cancel axis scale.

G68 - Axes Rotate Enable

Usage:	G68 X..Z R	- X..Z – rotation center - R – rotation angle

Set axis rotation.

Parameters:

#<_axisrot>	- (R) true if axis rotation is enabled
#<_axisrot_ang>	- (RW) current axis rotation angle
#<_axisrot_x..z>	- (RW) current axis rotation center
#<_axisrot_anguvw>	- (RW) current axis rotation angle
#<_axisrot_u..w>	- (RW) current axis rotation center

G69 - Axes Rotate Cancel

Usage: G69

Cancel axis rotation.

Parameters:

#<_axisrot>	- (R) true if axis rotation is enabled

Motion

G80 - Cancel Motion

Usage: G80

Cancels all motion.

G00 - Rapid Move

Usage: G00 <X..W@^> - X..Z = axis
- @, ^ = distance and angle

G00 H E - H = axis number
- E = distance

Rapid move machine to programmed position.

G01 - Linear Feed Move

Usage: G01 <X..W@^> - X..Z = axis
- @, ^ = distance and angle

G01 H E - H = axis number
- E = distance

Move machine to programmed position with feed speed.

When distance and angle are used, position is calculated against zero position.

G02 - Clockwise Arc Feed Move

G03 - Counter Clockwise Arc Feed Move

Usage: G02 <X..W@^> <IJK> <P>

G03 <X..W@^> <IJK> <P>

G02 <X..W@^> <R> <P>

G03 <X..W@^> <R> <P>

Move machine to programmed position with feed speed in arc motion.
G02 - clockwise arc
G03 - counterclockwise arc

Arc can be in 3 different planes, depending of G17, G18 or G19 modal state.
XY plane, G17 state, Z rotation axis
ZX plane, G18 state, Y rotation axis
YZ plane, G19 state, X rotation axis

If motion in direction of rotation axis is specified then helical motion is generated.

Arc is specified in center format using IJK words or in radius format using R word.

Center format – arc center is defined with IJ (in XY plane), KI (in ZX plane) or JK (in YZ plane) words.
In incremental arc distance mode (G91.1) arc center is set as offset from start position.
In absolute arc distance mode (G90.1) arc center is set as distance from zero position.

Radius format – arc is defined with arc radius. This format is depreciated because it can in certain conditions produce cuts that are out of tolerances.

Number of rotations can be set with optional P word. If, for example, P3 is set then we have two full circles before final arc.

Example:

```
G17 G21 G90 G91.1 G94
F1000
G0 X0 Y0
G1 X80 Y0
G3 X100 Y20 I0 J20
G1 X100 Y80
G3 X80 Y100 I-20 J0
G1 X20 Y100
G3 X0 Y80 I0 J-20
G1 X0 Y0
```

G05 - Cubic Spline

Usage: G05 XYZ IJK PQR

X – end position X
Y – end position Y
Z – end position Z
I – incremental offset X from start point to first control point
J – incremental offset Y from start point to first control point
K – incremental offset Z from start point to first control point
P – incremental offset X from end point to second control point
Q – incremental offset Y from end point to second control point
R – incremental offset Z from end point to second control point

Cubic B-spline move.

Spline can be in 3 different planes, depending of G17, G18 or G19 modal state.
XY plane, G17 state, XY, IJ and PQ words used
ZX plane, G18 state, ZX, KI and RP words used
YZ plane, G19 state, YZ, JK and QR words used

Example:

```
G17 G21 G90 G91.1 G94
F1000
G0 X0 Y0
G1 X80 Y0
G5 X100 Y20 I20 J0 P0 Q-20
G1 X100 Y80
G5 X80 Y100 P20 Q0
G1 X20 Y100
G5 X0 Y80 P0 Q20
G1 X0 Y0
```

G05.1 - Quadratic Spline

Usage: G05.1 XYZ IJK

X – end position X
Y – end position Y
Z – end position Z
I – incremental offset X from start point to control point
J – incremental offset Y from start point to control point
K – incremental offset Z from start point to control point

Quadratic B-spline move.

Spline can be in 3 different planes, depending of G17, G18 or G19 modal state.
XY plane, G17 state, XY and IJ words used
ZX plane, G18 state, ZX and KI words used
YZ plane, G19 state, YZ and JK words used

Example:

```
G17 G21 G90 G91.1 G94
F1000
G0 X0 Y0
G1 X80 Y0
G5.1 X100 Y20 I20 J0
G1 X100 Y80
G5.1 X80 Y100 I0 J20
G1 X20 Y100
G5.1 X0 Y80 I-20 J0
G1 X0 Y0
```

G05.2- NURBS Block

G05.3- NURBS Block End

Usage:	G05.2 <L> <P> XYZ	L (optional) – curve order (default 3) P (optional) – control point weight (default 1) X – control point position X Y – control point position Y Z – control point position Z
	G05.3	end NURBS block

NURBS spline move. Block of control points is added with G05.2. At end of block use G05.3.

Spline can be in 3 different planes, depending of G17, G18 or G19 modal state.
XY plane, G17 state, XY and IJ words used
ZX plane, G18 state, ZX and KI words used
YZ plane, G19 state, YZ and JK words used

Example:

```
G17 G21 G90 G91.1 G94
F1000
G0 X0 Y0
G1 X80 Y0
G5.2 L3
G5.2 X100 Y0 P2
G5.2 X100 Y20 P2
G5.3
G1 X100 Y80
G5.2 L3
G5.2 X100 Y100 P2
G5.2 X80 Y100 P2
G5.3
G1 X20 Y100
G5.2 L3
G5.2 X0 Y100 P2
G5.2 X0 Y80 P2
G5.3
G1 X0 Y0
```

G06 - Shapes Exec

Usage: G06 <X..W> X..W – position

Executes shapes (see G06.2).

G06.1- Shapes Clear

Usage: G06.1

Clears all shapes (see G06.2).

G06.2- Shapes Load

Usage: G06.2 H1 P <X..W> H1 – type
P – program number
X..W – position

G06.2 H2 P <X..W> <R> <D> H2 – type
P – program number
X..W – position
R (optional) – font name
D (optional) – open font

Loads new shape.

H1 – shape is loaded from subprogram P
H2 – shape is loaded from ‘arrchr’

Example 1:

```
G17 G21 G90 G91.1 G94
G06.1
G06.2 H1 P1000 X15 Y5
G06 X0 Y0
G06 X-5 Y30
G06 X-10 Y60
M2

O1000
G21 G90 G91.1
G01 X0 Y0
G01 X20 Y0
G01 X20 Y20
G01 X0 Y20
G01 X0 Y0
M99
```

Example 2:

```
(arrchr,2000,Arial)
(arrchr,3000,PlanetCNC Rocks!)

G06.1
G06.2 H2 P3000 Q20 D1 Y5
G06.2 H2 P3000 Q20 D0 R2000 Y25
G06 X10
```

G06.3- Shapes Process TODO

G28 - Go To Home 1 Position

Usage: G28

G28 <X..W>

Rapid move machine to Home 1 position. If intermediate move is specified them machine will rapid move to intermediate position first and only axes specified will move to final position.

This command is often used with G91. For example: G91 G28 Z0

Parameters:

#<_home1_x..w> - (RW) home 1 position

G28.1 - Set Home 1 Position

Usage: G28.1

G28.1 <X..W>

Set current or set position as Home 1 position.

Parameters:

#<_home1_x..w> - (RW) home 1 position

G30 - Go To Home 2 Position

Usage: G30

G30 <X..W>

Rapid move machine to Home 2 position. If intermediate move is specified them machine will rapid move to intermediate position first and only axes specified will move to final position.

This command is often used with G91. For example: G91 G30 Z0

Parameters:

#<_home1_x..w> - (RW) home 1 position

G30.1 - Set Home 2 Position

Usage: G30.1

G30.1 <X..W>

Set current or set position as Home 2 position.

Parameters:

#<_home2_x..w> - (RW) home 2 position

G32 - Spindle Synchronized Motion / Threading

G33 - Spindle Synchronized Motion / Threading

Usage: G32 X..W F
- X..W – end position
- F – distance per revolution

G33 X..W K
- X..W – end position
- K – distance per revolution

Move machine with speed synchronized to spindle speed.

G33.1 - Spindle Synchronized Motion With Return / Rigid Tapping

Usage: G33.1 X..W K
- X..W – end position
- K – distance per revolution

Move machine with speed synchronized to spindle speed. When machine reaches end position, spindle reverses direction and machine moves back to start position.

G31 - Probe

G38.1 - Probe

G38.2 - Probe

G38.3 - Probe

G38.4 - Probe

G38.5 - Probe

Usage: G31 <X..W>

G38.1 <X..W>

G38.2 <X..W>

G38.3 <X..W>

G38.4 <X..W>

G38.5 <X..W>

Move machine with feed speed towards position. Immediately stop when sensor is signaled and store position to probe parameters.

G31 – axis words are position, stop on contact, error if failure

G38.1 – axis words are direction, stop on contact, error if failure

G38.2 – axis words are position, stop on contact, error if failure

G38.3 – axis words are position, stop on contact

G38.4 – axis words are position, stop on loss of contact, error if failure

G38.5 – axis words are position, stop on loss of contact

Parameters:

#<_probe> - (R) true if probe tripped
#<_probe_x..w> - (R) probe position

Settings

G10 L9 - Set Controller Position

Usage: G10 L9 <X..W>

Set controller position without move
Sends axis words to controller. Controller will set its current motor position to this value.
See also: G09

Parameters:

#<_hw_motor_x..w> - (R) motor position

G10 L3 - Transformation

Usage: G10 L3 X..W I J K
- X – Transformation A0 parameter
- Y – Transformation B0 parameter
- Z – Transformation C0 parameter
- A – Transformation A1 parameter
- B – Transformation B1 parameter
- C – Transformation C1 parameter
- U – Transformation A2 parameter
- V – Transformation B2 parameter
- W – Transformation C2 parameter
- I – Transformation A3 parameter
- J – Transformation B3 parameter
- K – Transformation C3 parameter

Set transformation parameters.

If any of XYZABCUVWIJK words are missing or values are invalid transformation is reset.

Reset state is A0=1, B0=0, C0=0, A1=0, B1=1, C1=0.

See also: M55

Parameters:

#<_trans_en> - (R) true if transformations are enabled
#<_trans_a0> - (R) transformation A0 parameter
#<_trans_b0> - (R) transformation B0 parameter
#<_trans_c0> - (R) transformation C0 parameter
#<_trans_a1> - (R) transformation A1 parameter
#<_trans_b1> - (R) transformation B1 parameter
#<_trans_c1> - (R) transformation C1 parameter
#<_trans_a2> - (R) transformation A2 parameter
#<_trans_b2> - (R) transformation B2 parameter
#<_trans_c2> - (R) transformation C2 parameter
#<_trans_a3> - (R) transformation A3 parameter
#<_trans_b3> - (R) transformation B3 parameter
#<_trans_c3> - (R) transformation C3 parameter

G10 L1, L10 - Tool Table

Usage: G10 L1 P <X..W> <D or R>
- P – tool number
- X..W (optional) – tool offset
- D (optional) – tool diameter or
- R (optional) – tool radius

G10 L10 P <X..W> <D or R>
- P – tool number
- X..W (optional) – tool offset
- D (optional) – tool diameter or
- R (optional) – tool radius

Use L1 or L10 to set tool in tool table.

L1 will set tool offset as entered. L10 will set offset so that current working position becomes entered value.

Parameters:

#<_current_tool>	- (RW) current tool number
#<_selected_tool>	- (RW) selected tool number
#<_tooloff>	- (RW) true if tool offset is currently enabled
#<_tooloff_x..w>	- (RW) current tool offset
#<_tool_exists>	- (R) true, if tool exists in tooltable
#<_tool_dia_num>	- (R) tool diameter from tooltable
#<_tool_off_x_num>..#<_tool_off_w_num>	- (R) tool offset from tooltable
#<_tool_tc_x_num>..#<_tool_tc_x_num>	- (R) tool change position from tooltable

G10 L2, L20 - Coordinate System

Usage: G10 L2 P <X..W> <R>
- P – coordinate system number
- X..W (optional) – coordinate system offset
- R (optional) – rotation in XY plane

G10 L20 P <X..W> <R>
- P – coordinate system number
- X..W (optional) – coordinate system offset
- R (optional) – rotation in XY plane

Use L2 or L20 to set coordinate system.

L2 will set coordinate system offset as entered. L20 will set offset so that current working position becomes entered value.

Optionally coordinate system rotation in XY plane is set with R word.

1000 different coordinate systems are available.

Parameters:

#<_coordsys>	- (RW) current coordinate system number
#<_coordsys_x..w>	- (RW) current coordinate system offset
#<_coordsys_rot>	- (RW) current coordinate system rotation
#<_coordsystem_exists>	- (R) true, if coordinate system exists in table
#<_coordsystem_x_num> .. #<_coordsystem_w_num>	- (R) coordinate system offset from table
#<_coordsystem_rot>	- (R) coordinate system rotation from table

Other

G04 - Dwell

Usage: G04 P

Delays execution for duration P seconds.

G09 - Stop, Sync & Set Controller Position

Usage: G09

G09 <X..W> - X..Z = axis

G09 H E - H = axis number
- E = position

Stop motion any synchronize controller and interpreter state. Usually it is used before reading inputs from controller. For example:

G00 X0
G01 X100
G09 ;wait for motion to stop before reading _hw_input parameter.
(print,Value of input is #<_hw_input>)

If axis words are present then controller will set its current motor position to this value.
For example:

G09 X10 Y20 ;controller motor position is set to X10 Y20

G53 - Machine Coordinate System

Usage: G53

Use G53 in same line with motion code to execute motion in machine coordinates.

Cycles

G12 - Mill: Circular Pocket CW
G13 - Mill: Circular Pocket CCW
G72 - Mill: Facing
G72.1 - Mill: Profile TODO
G72.2 - Mill: Pocket TODO

G75 - Turn: Pattern Repeating TODO
G76 - Turn: Threading
G77 - Turn: Roughing X TODO
G78 - Turn: Roughing Z TODO
G79 - Turn: Grooving TODO

G73 - Drill: Drill, Speed Peck, Dwell
G74 - Drill: Tapping Left
G81 - Drill: Drill
G82 - Drill: Drill, Dwell
G83 - Drill: Drill, Peck, Dwell
G84 - Drill: Tapping Right
G85 - Drill: Boring, Feed Out
G86 - Drill: Boring, Spindle Stop, Rapid Out, Spindle Start
G87 - Drill: Boring, Spindle Reverse, Rapid Out, Spindle Reverse
G88 - Drill: Boring, Spindle Stop, Feed Out, Spindle Start
G89 - Drill: Boring, Spindle Reverse, Feed Out, Spindle Reverse

Mill Cycles

G12 - Mill: Circular Pocket CW

G13 - Mill: Circular Pocket CCW

Usage:	G12 W ...	W – circle width (diameter)
	… <X> <Y> …	X (optional) – circle center X Y (optional) – circle center Y
	… <Z> <R> <K> ...	Z (optional) – pocket depth R (optional) – retract plane K (optional) – stepover Z
	… <D> <P> ...	D (optional) – tool diameter P (optional) – stepover
	… <Q> ...	Q (optional) – finish pass
	… <F> <E>	F (optional) – feed speed E (optional) – plunge speed

Cut a circular pocket with current position as circle center.
G12 – circular pocket is in clockwise direction.
G13 – circular pocket is in counter clockwise direction.

W word defines circle/spiral width (diameter).

If optional P word is used then series of circles/spirals will be generated with P distance between them. If optional Q word is used then finish pass will be added.

D word is used for tool diameter compensation.

X and Y words define circle/spiral center. Z word defines end depth, K is used to set stepover in Z (plunge) direction and E word defines plunge feed speed.

R word is used to define retract plane.

This code is only valid in XY plane and with no tool compensation.

Example 1:

G00 Z15
G98 G12 X0 Y0 R0 Z-5 K2 W30 D8 P4 Q0.3 F2100 E210

G72 - Mill: Facing

Usage:	G12 W H …	W – width (size X) H – height (size Y)
	… <X> <Y> …	X (optional) – center X Y (optional) – center Y
	… <Z> <R> <K> ...	Z (optional) – pocket depth R (optional) – retract plane K (optional) – stepover Z
	… <D> <P> ...	D (optional) – tool diameter P (optional) – stepover
	… <Q> ...	Q (optional) – finish pass
	… <F>	F (optional) – feed speed

Facing operation with current position as center.

W and H word define size to be faced.

This code is only valid in XY plane and with no tool compensation.

Example 1:

G00 Z15
G98 G72 X0 Y0 R0 Z-5 K2 W125 H75 D40 P16 Q0.3 F2100

G72.1 - Mill: Profile TODO

G72.2 - Mill: Pocket TODO

Turn Cycles

G75 - Turn: Pattern Repeating TODO

G76 - Turn: Threading

Usage: G76 Z P <X> I J K
<R> <Q> <H>
<E> <A> <L>

- Z – final position of threads
- P – thread pitch in distance per revolution
- X – final X position
- I – thread peak offset from the drive line
- J – positive value specifying the initial cut depth
- K – positive value specifying the full thread depth
- R – depth degression
- Q – compound slide angle
- H – number of spring passes
- E – distance along the drive line used for the taper
- A – angle of taper
- L – which ends of the thread get the taper

Negative I values are external threads, and positive I values are internal threads.

R1.0 selects constant depth on successive threading passes. R2.0 selects constant area. Values between 1.0 and 2.0 select decreasing depth but increasing area. Values above 2.0 select decreasing area. Beware that unnecessarily high degression values will cause a large number of passes to be used.

The compound slide angle is the angle (in degrees) describing to what extent successive passes should be offset along the drive line. This is used to cause one side of the tool to remove more material than the other. A positive Q value causes the leading edge of the tool to cut more heavily. Typical values are 29, 29.5 or 30.

Spring passes are additional passes at full thread depth. If no additional passes are desired, program H0.

The angle of the taper will be so the last pass tapers to the thread crest over the distance specified with E. E10 will give a taper for the first/last 10 length units along the thread. For a 45 degree taper program E the same as K. Alternatively you can use A to set angle of the taper.

L specifies which ends of the thread get the taper. Program L0 for no taper (the default), L1 for entry taper, L2 for exit taper, or L3 for both entry and exit tapers. Entry tapers will pause at the drive line to synchronize with the index pulse then move at the feed rate in to the beginning of the taper. No entry taper and the tool will rapid to the cut depth then synchronize and begin the cut.

G77 - Turn: Roughing X TODO

G78 - Turn: Roughing Z TODO

G79 - Turn: Grooving TODO

Drill Cycles

G81 - Drill - Drill

Usage: G81 X Y Z R <L>

- X, Y – coordinate of drill center
- Z – end drill position
- R – retract plane
- L – repetition

Example 1:

```
G00 Z15
G99 G81 X0 Y0 R5 Z-3
```

Pseudocode:

```
G00 Z15
G00 X0 Y0
G00 H2 E5        (initial - rapid down to R5)
G01 H2 E-3       (drill - feed down to Z-3)
G00 H2 E5        (final - rapid up to R plane R5)
```

G82 - Drill: Drill, Dwell

Usage: G82 X Y Z R <P> <L>

- X, Y – coordinate of drill center
- Z – drill position
- R – retract plane
- P – dwell time
- L – repetition

Example 1:

```
G00 Z15
G99 G82 X0 Y0 R5 Z-3 P0.5
```

Pseudocode:

```
G00 Z15
G00 X0 Y0
G00 H2 E5        (initial - rapid down to R5)
G01 H2 E-3       (drill - feed down to Z-3)
G04 P0.5         (dwell for 0.5s)
G00 H2 E5        (final - rapid up to R plane R5)
```

G83 - Drill: Drill, Peck, Dwell

Usage: G83 X Y Z R P Q <L>

- X, Y – coordinate of drill center
- Z – drill position
- R – retract plane
- P – dwell time
- Q – delta increment
- H – initial delta
- D – chip break distance (default 0.2)
- L – repetition

Example 1:

```
G00 Z15
G98 G83 X0 Y0 R5 Z-3 Q1
```

Pseudocode:

```
G00 Z15
G00 X0 Y0
G00 H2 E5       (initial - rapid down to R5)
G01 H2 E4       (drill - feed down for Q1)
G00 H2 E5       (clear - rapid up to R5)
G00 H2 E4.2     (clear - rapid back down -0.2)
G01 H2 E3       (drill - feed down for Q1)
G00 H2 E5       (clear - rapid up to R5)
G00 H2 E3.2     (clear - rapid back down -0.2)
G01 H2 E2       (drill - feed down for Q1)
G00 H2 E5       (clear - rapid up to R5)
G00 H2 E2.2     (clear - rapid back down -0.2)
G01 H2 E1       (drill - feed down for Q1)
G00 H2 E5       (clear - rapid up to R5)
G00 H2 E1.2     (clear - rapid back down -0.2)
G01 H2 E0       (drill - feed down for Q1)
G00 H2 E5       (clear - rapid up to R5)
G00 H2 E0.2     (clear - rapid back down -0.2)
G01 H2 E-1      (drill - feed down for Q1)
G00 H2 E5       (clear - rapid up to R5)
G00 H2 E-0.8    (clear - rapid back down -0.2)
G01 H2 E-2      (drill - feed down for Q1)
G00 H2 E5       (clear - rapid up to R5)
G00 H2 E-1.8    (clear - rapid back down -0.2)
G01 H2 E-3      (drill - feed down to Z-3)
G00 H2 E15      (final - rapid up to Z level Z15)
```

Example 2:

G00 Z15
G98 G83 X0 Y0 R5 Z-3 Q1 H1.5 D0.1

Pseudocode:

```
G00 Z15
G00 X0 Y0
G00 H2 E5          (initial - rapid down to R5)
G01 H2 E2.5        (initial drill - feed down for Q1+H1.5)
G00 H2 E5          (clear - rapid up to R5)
G00 H2 E2.6        (clear - rapid back down -D0.1)
G01 H2 E1.5        (drill - feed down for Q1)
G00 H2 E5          (clear - rapid up to R5)
G00 H2 E1.6        (clear - rapid back down -D0.1)
G01 H2 E0.5        (drill - feed down for Q1)
G00 H2 E5          (clear - rapid up to R5)
G00 H2 E0.6        (clear - rapid back down -D0.1)
G01 H2 E-0.5       (drill - feed down for Q1)
G00 H2 E5          (clear - rapid up to R5)
G00 H2 E-0.4       (clear - rapid back down -D0.1)
G01 H2 E-1.5       (drill - feed down for Q1)
G00 H2 E5          (clear - rapid up to R5)
G00 H2 E-1.4       (clear - rapid back down -D0.1)
G01 H2 E-2.5       (drill - feed down for Q1)
G00 H2 E5          (clear - rapid up to R5)
G00 H2 E-2.4       (clear - rapid back down -D0.1)
G01 H2 E-3         (drill - feed down to Z-3)
G00 H2 E15         (final - rapid up to Z level Z15)
```

G73 - Drill: Drill, Speed Peck, Dwell

Usage: G73 X Y Z R <P> Q <L>

- X, Y – coordinate of drill center
- Z – drill position
- R – retract plane
- P – dwell time
- Q – delta increment
- H – initial delta
- D – chip break distance (default 0.2)
- E – chip clear
- L – repetition

Example 1:

```
G00 Z15
G98 G73 X0 Y0 R5 Z-3 Q1
```

Pseudocode:

```
G00 Z15
G00 X0 Y0
G00 H2 E5       (initial - rapid down to R5)
G01 H2 E4       (drill - feed down for Q1)
G00 H2 E4.2     (chip break - rapid up for 0.2)
G01 H2 E3       (drill - feed down for Q1)
G00 H2 E3.2     (chip break - rapid up for 0.2)
G01 H2 E2       (drill - feed down for Q1)
G00 H2 E2.2     (chip break - rapid up for 0.2)
G01 H2 E1       (drill - feed down for Q1)
G00 H2 E1.2     (chip break - rapid up for 0.2)
G01 H2 E0       (drill - feed down for Q1)
G00 H2 E0.2     (chip break - rapid up for 0.2)
G01 H2 E-1      (drill - feed down for Q1)
G00 H2 E-0.8    (chip break - rapid up for 0.2)
G01 H2 E-2      (drill - feed down for Q1)
G00 H2 E-1.8    (chip break - rapid up for 0.2)
G01 H2 E-3      (drill - feed down to Z-3)
G00 H2 E15      (final - rapid up to Z level Z15)
```

Example 2:

G00 Z15
G98 G73 X0 Y0 R5 Z-4 Q1 H1.5 D0.1 E3

Pseudocode:

```
G00 Z15
G00 X0 Y0
G00 H2 E5          (initial - rapid down to R5)
G01 H2 E2.5        (initial drill - feed down for Q1+H1.5)
G00 H2 E2.6        (chip break - rapid up for D0.1)
G01 H2 E1.5        (drill - feed down for Q1)
G00 H2 E1.6        (chip break - rapid up for D0.1)
G01 H2 E0.5        (drill - feed down for Q1)
G00 H2 E5          (clear - rapid up to R5)
G00 H2 E0.6        (clear - rapid back down -D0.1)
G01 H2 E-0.5       (drill - feed down for Q1)
G00 H2 E-0.4       (chip break - rapid up for D0.1)
G01 H2 E-1.5       (drill - feed down for Q1)
G00 H2 E-1.4       (chip break - rapid up for D0.1)
G01 H2 E-2.5       (drill - feed down for Q1)
G00 H2 E5          (clear - rapid up to R5)
G00 H2 E-2.4       (clear - rapid back down -D0.1)
G01 H2 E-3.5       (drill - feed down for Q1)
G00 H2 E-3.4       (chip break - rapid up for D0.1)
G01 H2 E-4         (drill - feed down to Z-4)
G00 H2 E15         (final - rapid up to Z level Z15)
```

G84 - Drill: Tapping Right

Usage: G84 X Y Z R K <L>

- X, Y – coordinate of drill center
- Z – drill position
- R – retract plane
- K – thread pitch
- L – repetition

Example 1:

```
G00 Z15
G98 G84 X0 Y0 R0 Z-15 K1
```

Pseudocode:

```
G00 Z15
G00 X0 Y0
G00 H2 E0
M3
G33.1 H2 E-15 K1
G01 H2 E15.000000
M5
```

G74 - Drill: Tapping Left

Usage: G74 X Y Z R K <L>

- X, Y – coordinate of drill center
- Z – drill position
- R – retract plane
- K – thread pitch
- L – repetition

Example 1:

```
G00 Z15
G98 G74 X0 Y0 R0 Z-15 K1
```

Pseudocode:

```
G00 Z15
G00 X0 Y0
G00 H2 E0
M4
G33.1 H2 E-15 K1
G01 H2 E15.000000
M5
```

G85 - Drill: Boring, Feed Out

Usage: G85 X Y Z R <P> <L>

- X, Y – coordinate of boring center
- Z – bore position
- R – retract plane
- P – dwell time
- L – repetition

Example 1:

```
G00 Z15
G98 G85 X0 Y0 R0 Z-15 P1
```

Pseudocode:

```
G00 Z15
G00 X0 Y0
G00 H2 E0
G01 H2 E-15
G04 P1
G01 H2 E15
```

G86 - Drill: Boring, Spindle Stop, Rapid Out, Spindle Start

Usage: G86 X Y Z R <P> <L>

- X, Y – coordinate of boring center
- Z – bore position
- R – retract plane
- P – dwell time
- L – repetition

Example 1:

```
G00 Z15
M3
G98 G86 X0 Y0 R0 Z-15 P1
```

Pseudocode:

```
G00 Z15
G00 X0 Y0
G00 H2 E0
G01 H2 E-15
G04 P1
M5
G00 H2 E15
M3
```

G87 - Drill: Boring, Spindle Reverse, Rapid Out, Spindle Reverse

Usage: G87 X Y Z R <P> <L>

- X, Y – coordinate of boring center
- Z – bore position
- R – retract plane
- P – dwell time
- L – repetition

Example 1:

```
G00 Z15
M3
G98 G87 X0 Y0 R0 Z-15 P1
```

Pseudocode:

```
G00 Z15
G00 X0 Y0
G00 H2 E0
G01 H2 E-15
G04 P1
M4
G00 H2 E15
M3
```

G88 - Drill: Boring, Spindle Stop, Feed Out, Spindle Start

Usage: G88 X Y Z R <P> <L>

- X, Y – coordinate of boring center
- Z – bore position
- R – retract plane
- P – dwell time
- L – repetition

Example 1:

```
G00 Z15
M3
G98 G88 X0 Y0 R0 Z-15 P1
```

Pseudocode:

```
G00 Z15
G00 X0 Y0
G00 H2 E0
G01 H2 E-15
G04 P1
M5
G01 H2 E15
M3
```

G89 - Drill: Boring, Spindle Reverse, Feed Out, Spindle Reverse

Usage: G89 X Y Z R <P> <L>

- X, Y – coordinate of boring center
- Z – bore position
- R – retract plane
- P – dwell time
- L – repetition

Example 1:

```
G00 Z15
M3
G98 G89 X0 Y0 R0 Z-15 P1
```

Pseudocode:

```
G00 Z15
G00 X0 Y0
G00 H2 E0
G01 H2 E-15
G04 P1
M4
G01 H2 E15
M3
```

M-Codes

Program

M0 - Pause

Usage: M0

Pause a running program.

M1 - Optional pause

Usage: M1

Pause a running program if „Optional Pause“ is enabled.

M2 - Program End

M30 - Program End

Usage: M2

M30

End the program. Code after M2 will not be executed. Wrapping G-Code between % does the same thing.

Customization is possible by modifying M2.gcode script file (for example, to turn spindle off and restore modal state at end of g-code execution).

Spindle

M3 - Spindle CW

Usage: M3

Start spindle clockwise with S speed. Customization is possible by modifying M3.gcode script file.

Parameters:

#<_spindle>	- (R) spindle state
#<_spindle_on>	- (R) true if spindle is running
#<_spindle_cw>	- (R) true if spindle is running clockwise
#<_spindle_ccw>	- (R) true if spindle is running counterclockwise

M4 - Spindle CCW

Usage: M4

Start spindle counterclockwise with S speed. Customization is possible by modifying M4.gcode script file.

Parameters:

#<_spindle>	- (R) spindle state
#<_spindle_on>	- (R) true if spindle is running
#<_spindle_cw>	- (R) true if spindle is running clockwise
#<_spindle_ccw>	- (R) true if spindle is running counterclockwise

M5 - Spindle Stop

Usage: M5

Stop spindle. Customization is possible by modifying M5.gcode script file.

Parameters:

#<_spindle>	- (R) spindle state
#<_spindle_on>	- (R) true if spindle is running
#<_spindle_cw>	- (R) true if spindle is running clockwise
#<_spindle_ccw>	- (R) true if spindle is running counterclockwise

Tools

M6 - Tool Change

Usage: M6

Change tool with change procedure. Tool change will set tool selected with T as current tool. Tool change customization is possible by modifying M6.gcode script file.

Parameters:

#<_selected_tool> - (RW) selected tool number
#<_current_tool> - (RW) current tool number

M61 - Tool Select

Usage: M61 Q - Q = tool number

Select current tool number without tool change procedure.

Parameters:

#<_selected_tool> - (RW) selected tool number
#<_current_tool> - (RW) current tool number

Coolant

M7 - Mist On

Usage: M7
Turn mist output On.

Parameters:

#<_mist> - (R) mist state
#<_mist_on> - (R) true if mist is on

M17 - Mist Off/On

Usage: M17
M17 P - P = zero for Off, otherwise On

Turn mist output Off or On.

Parameters:

#<_mist> - (R) mist state
#<_mist_on> - (R) true if mist is on

M8 - Flood On

Usage: M8
Turn flood output On.

Parameters:

#<_flood> - (R) flood state
#<_flood_on> - (R) true if flood is on

M18 - Flood Off/On

Usage: M18
M18 P - P = zero for Off, otherwise On

Turn flood output Off or On.

Parameters:

#<_flood> - (R) flood state
#<_flood_on> - (R) true if flood is on

M9 - Mist & Flood Off

Usage: M9

Turn mist and flood output Off

Parameters:

#<_mist> - (R) mist state
#<_mist_on> - (R) true if mist is on
#<_flood> - (R) flood state
#<_flood_on> - (R) true if flood is on

Overrides and options

M48 - Enable Override Feed & Spindle

Usage: M48

Enables feed and spindle override.

M49 - Disable Override Feed & Spindle

Usage: M49

Disables feed and spindle override.

M50 - Enable/Disable Override Feed

Usage: M50 P - P = zero for Off, otherwise On

Enables or disables feed override.

M51 - Enable/Disable Override Spindle

Usage: M51 P - P = zero for Off, otherwise On

Enables or disables spindle override.

M53 - Enable/Disable Pause

Usage: M53 P - P = zero for Off, otherwise On

Enables or disables program pause command.

M54 - Enable/Disable THC

Usage: M54 P <Q> <R>
- P = zero for Off, otherwise On
- Q = speed limit
- R = constant speed

If speed limit is set then THC will not move if machine speed is below set speed.
If constant speed is enabled then THC will not move is machine is accelerating or decelerating.

Example:
M54 P1 Q1000 R1 – enable THC for constant speeds (no acceleration) above 1000.

M55 - Enable/Disable Transformations

Usage: M55 P - P = zero for Off, otherwise On

Enable or disable transformations.

See also: G10 L3

M56 - Enable/Disable Warp

Usage: M56 P - P = zero for Off, otherwise On

Enable or disable warp.

M57 - Enable/Disable Swap

Usage: M57 P - P = zero for Off, otherwise On

Enable or disable axis swapping.

Inputs & Outputs

M10 - Enable/Disable motor enable signal

Usage: M10 P - P = zero for Off, otherwise On

Enables or disables motor enable signal.

M11 - Enable/Disable limits

Usage: M11 P - P = zero for Off, otherwise On

Enables or disables limits.

M59 - Wait For Input

Usage: M59 P - P = pin number (1-8)

Waits for input pin.

Parameters:

#<_hw_input> - (R) output signals state

M62 - Output

Usage: M62 Q - Q = value for all eight outputs

M62 P Q - P = output number
- Q = zero for Off, otherwise On

Set signals on output connector.

Parameters:

#<_output> - (R) output signals state
#<_hw_output> - (R) actual output signals on controller

M63 - Output PWM

Usage:	M63 P Q <E>	- P = output number - Q = frequency - E (optional) = duty cycle (0% - 100%)
	M63 P R	- P = output number - R = RC servo motor position (0% - 100%)

Set PWM signal on output connector. It is possible to set frequency, frequency with duty cycle of RC servo motor position.

Parameters:

#<_hw_output>	- (R) actual output signals on controller
#<_hw_output_freq1>	- (R) actual PWM frequency on first PWM output
#<_hw_output_duty1>	- (R) actual PWM duty cycle on first PWM output
#<_hw_output_freq2>	- (R) actual PWM frequency on second PWM output
#<_hw_output_duty2>	- (R) actual PWM duty cycle on second PWM output
#<_hw_output_freq3>	- (R) actual PWM frequency on third PWM output
#<_hw_output_duty3>	- (R) actual PWM duty cycle on third PWM output

M64 - Output ExtOut

Usage:	M64 H Q <L>	- H = ExtOut SSEL value (1 or 2) - Q = data send to ExtOut - L (optional) = number of bytes send to ExtOut
	M64 H Q E <R> <D> <L>	- H = ExtOut SSEL value (1 or 2) - Q = parameter number of first data location - E = data count - R (optional) = parameter number for returned data - D (optional) = returned data count - L (optional) = number of bytes send to ExtOut
	M64 H P Q <L>	- H = ExtOut SSEL value (1 or 2) - P = bit position - Q = zero for Off, otherwise On - L (optional) = number of bytes send to ExtOut
	M64 H L0	- H = ExtOut SSEL value (1 or 2) - L = zero bytes send to ExtOut

Send data to OutExt.

Parameters:

#<_hw_extout1>	- (R) actual ExtOut1 value on controller
#<_hw_extout2>	- (R) actual ExtOut2 value on controller

M65 - Output TX

Usage:	M65 Q	- Q = data send to TX
	M65 Q E	- Q = parameter number of first data location - E = data count

Send data to TX.

M66 - Output I2C

Usage:	M66 H Q	- H = I2C address in 8bit mode - Q = data send to I2C
	M66 H Q E <R> <D>	- H = I2C address in 8bit mode - Q = parameter number of first data location - E = data count - R (optional) = parameter number for returned data - D (optional) = returned data count

Send and receive data from I2C.

Modal State

M70 - Modal State Store

Usage: M70

Store current modal state. Stored modal state can be restored with M72. Modal state is stored only in current call level. Storing/restoring modal state between call levels is not possible.

Stored modal state values are:

- Units (G20/G21)
- Plane (G17/G18/G19)
- DistanceMode (G90/G91)
- DistanceModeIJK (G90.1/G91.1)
- DistanceModeABC (G90.2/G91.2)
- LatheMode (G7/G8)
- CycleReturnMode (G98/G99)
- PolarMode (G15/G16)
- ToolOffset (G43/G49)
- ToolCompensation (G40/G41/G42)
- Coordinate System (G54..G59)
- BlendMode (G61/G64)
- FeedMode (G93/G94/G95)
- FeedSpeed (F)
- SpindleMode (G96/G97)
- SpindleSpeed(S)
- MotorsEnable (M10)
- LimitsEnable (M11)
- Overrides & Options (M48/M49/M50/51/M53/M54/M55/M56/M57)

M71 - Modal State Invalidate

Usage: M71

Invalidates stored modal state. Modal state can no longer be restored.

M72 - Modal State Restore

Usage: M72

Restore modal state stored with M70 or M73 in current call level.

M73 - Modal State Store & Autorestore

Usage: M73

Store current modal state and automatically restore on program or subroutine end. If stored state was invalidated with M71 it will not be restored.

Other Codes

F - Feed Speed

Usage: Fn - F = feed speed

Set feed speed. Value depends on feed mode which can be „Units Per Minute“, „Units Per Revolution“ or „Inverse Time“. In inverse time F must be specified an every motion line.

Parameters:

#<_feedspeed> - (R) feed speed value dependant on current feed mode
#<_feedspeed_upm> - (R) feed speed value in units per minute
#<_feedspeed_upr> - (R) feed speed value in units per minute per revolution

S - Spindle Speed

Usage: Sn - S = spindle speed

Set spindle speed. Value depends on spindle mode which can be „Revolution Per Minute“ or „Constant Surface Speed“.

Parameters:

#<_spindlespeed> - (R) spindle speed value dependent on current spindle mode
#<_spindlespeed_rpm> - (R) spindle speed value in units per minute mode
#<_spindlespeed_css> - (R) spindle speed value in constant surface speed mode

T - Select Tool

Usage: Tn - T = tool number

Select tool number that will be used in next tool change (M6)

Parameters:

#<_selected_tool> - (RW) selected tool number
#<_current_tool> - (RW) current tool number

List of G-Codes

G00 - Rapid Move
G01 - Linear Feed Move
G02 - Clockwise Arc Feed Move
G03 - Counter Clockwise Arc Feed Move

G04 - Dwell

G05 - Cubic Spline
G05.1 - Quadratic Spline
G05.2 - NURBS Block
G05.3 - NURBS Block End

G06 - Shapes Exec
G06.1 - Shapes Clear
G06.2 - Shapes Load
G06.3 - Shapes Process TODO

G07 - Lathe Mode - Diameter
G08 - Lathe Mode - Radius

G09 - Stop, Sync & Set Position

G10 - Settings

G12 - Mill: Circular Pocket CW
G13 - Mill: Circular Pocket CCW

G15 - Polar Coordinate Cancel
G16 - Polar Coordinate Enable

G17 - XY Plane
G18 - ZX Plane
G19 - YZ Plane

G20 - Inch Units
G21 - Millimeter Units

G28 - Go To Home
G28.1 - Set Home
G30 - Go To Home
G30.1 - Set Home

G32 - Spindle Synch Motion
G33 - Spindle Synch Motion
G33.1 - Spindle Synch Motion With Return

G31 - Probe
G38.1 - Probe
G38.2 - Probe
G38.3 - Probe
G38.4 - Probe
G38.5 - Probe

G40 - Tool Compensation Cancel
G41 - Tool Compensation Left
G41.1 - Tool Compensation Dynamic Left
G42 - Tool Compensation Right
G42.1 - Tool Compensation Dynamic Right

G43 - Tool Offset+ Enable
G43.1 - Tool Offset+ Enable
G44 - Tool Offset- Enable
G44.1 - Tool Offset- Enable
G49 - Tool Offset Cancel

G50 - Axes Scale Cancel
G51 - Axes Scale Enable

G52 - Axes Offset
G52.1 - Axes Offset Cancel

G53 - Machine Coordinate System

G54 - Coordinate System 1
G54.1 - Coordinate System P
G55 - Coordinate System 2
G56 - Coordinate System 3
G57 - Coordinate System 4
G58 - Coordinate System 5
G59 - Coordinate System 6 (or P)
G59.1 - Coordinate System 7
G59.2 - Coordinate System 8
G59.3 - Coordinate System 9

G61 - Blend Cancel
G64 - Blend Enable

G65 - Call Macro

G68 - Axes Rotate Enable
G69 - Axes Rotate Cancel

G70 - Inch Units
G71 - Millimeter Units

G71 - Millimeter Units
G71 - Millimeter Units

G72 - Mill: Facing TODO
G72.1 - Mill: Profile TODO
G72.2 - Mill: Pocket TODO

G73 - Drill: Drill, Speed Peck, Dwell
G74 - Drill: Tapping Left
G75 - Turn: Pattern Repeating TODO
G76 - Turn: Threading
G77 - Turn: Roughing X TODO
G78 - Turn: Roughing Z TODO
G79 - Turn: Grooving TODO

G80 - Cancel Motion

G81 - Drill: Drill
G82 - Drill: Drill, Dwell
G83 - Drill: Drill, Peck, Dwell
G84 - Drill: Tapping Right
G85 - Drill: Boring, Feed Out
G86 - Drill: Boring, Sp Stop, Rpd Out, Sp Strt
G87 - Drill: Boring, Sp Rev, Rpd Out, Sp Rev
G88 - Drill: Boring, Sp Stop, Fd Out, Sp Start
G89 - Drill: Boring, Sp Rev, Fd Out, Sp Rev

G90 - Distance Mode - Absolute
G90.1 - Distance Mode - IJK Absolute
G90.2 - Distance Mode - ABC Absolute
G91 - Distance Mode – Incremental
G91.1 - Distance Mode - IJK Incremental
G91.2 - Distance Mode - ABC Incremental

G92 - Working Offset
G92.1 - Working Offset Cancel

G93 - Feed Mode - Inverse Time
G94 - Feed Mode - Units per Minute
G95 - Feed Mode - Units per Revolution

G96 - Spindle Mode - CSS
G97 - Spindle Mode - RPM

G98 - Cycle Return - Initial Z Point
G99 - Cycle Return - R Point

List of M-Codes

M0 - Pause
M1 - Pause (optional)
M2 - Program End
M30 - Program End

M3 - Spindle CW
M4 - Spindle CCW
M5 - Spindle Stop

M6 - Tool Change
M61 - Tool Select

M7 - Mist On
M17 - Mist Off/On
M8 - Flood On
M18 - Flood Off/On
M9 - Mist & Flood Off

M10 - Motor Enable On/Off
M11 - Limit & Probe Enable On/Off

M48 - Enable Override Feed & Spindle
M49 - Disable Override Feed & Spindle
M50 - Enable/Disable Override Feed
M51 - Enable/Disable Override Spindle

M53 - Enable/Disable Pause
M54 - Enable/Disable THC
M55 - Enable/Disable Transformations
M56 - Enable/Disable Warp
M57 - Enable/Disable Swap

M59 - Wait For Input

M62 - Output
M63 - Output PWM
M64 - Output ExtOut
M65 - Output TX
M66 - Output I2C

M70 - Modal State Store
M71 - Modal State Invalidate
M72 - Modal State Restore
M73 - Modal State Store & Autorestore

M82 - Distance Mode - ABC Absolute
M83 - Distance Mode - ABC Incremental

M98 - Call Subprogram
M99 - Return From Subprogram

O-Words

sub..endsub subroutine block

```
Osub          - Begin subroutine
Oendsub       - End subroutine
Oreturn       - Exit subroutine
Ocall         - Call subroutine
```

do..while loop block

```
Odo           - Begin block
Owhile        - End block [condition evaluation]
Obreak        - Exit block immediately
Ocontinue     - Skip to next condition evaluation
```

while..endwhile loop block

```
Owhile        - Begin block [condition evaluation]
Oendwhile     - End block
Obreak        - Exit block immediately
Ocontinue     - Skip to next condition evaluation
```

repeat..endrepeat loop block

```
Orepeat       - Begin block [count]
Oendrepeat    - End block
```

if..endif condition block

```
Oif           - Begin block [condition evaluation]
Oendif        - End block
Oelseif       - Else [condition evaluation]
Oelse         - Else
```

Comments

```
CLEAR         - clears output window
PRINT         - prints message to output window
STATUS        - shows message in status bar
MSG           - shows dialog with message
CLIPBOARD     - stores message to clipboard
MDI           - stores message to MDI

LOG           - writes message to log
LOGCREATE     - creates new log file
LOGOPEN       - opens existing log file
LOGCLOSE      - closes log file

PARAMSCLEAR   - clears all parameters

POINTSCLEAR   - clears points collection
POINTSSAVE    - saves points collection to file
POINTSLOAD    - loads points collection from file
POINTSSHAPES  - loads points collection from shapes
POINT         - adds point from data to collection
POINT         - adds point from probe to collection
POINTPOS      - adds point from position to collection

PY            - executes python script
PYTHR         - executes python script

NAME          - sets program name
DESC          - sets program description
DLGNAME       - sets dialog name
DLG           - sets dialog property
DLGSHOW       - shows dialog

ARRAY         - creates parameters from data
ARCHR         - creates parameters from characters
TXT           - stores text property

SW_RESET      - stopwatch reset
SW_PRINT      - stopwatch print

BLOCK_BEGIN   - begin block
BLOCK_END     - end block

USB           - executes usb command
EXPR          - executes expression

COLOR=0xRRGGBB- g-code color
```

Operators

```
+           - Addition                          Usage: 12 + 34          = 46
-           - Subtraction                       Usage: 12 - 34          = -22
*           - Multiplication                    Usage: 12 * 34          = 408
/           - Division                          Usage: 34 / 12          = 2.833
MOD         - Modulus                           Usage: 34 MOD 12        = 10
DIV         - Integer Division                  Usage: 34 DIV 12        = 2
**          - Power                             Usage: 12 ** 3          = 1728

EQ          - Relational equality               Usage: 12 EQ 34         = 0
NQ          - Relational inequality             Usage: 12 NQ 34         = 1
GT          - Relational strictly greater than  Usage: 12 GT 34         = 0
LT          - Relational strictly less than     Usage: 12 LT 34         = 1
GE          - Relational greater than or equal to Usage: 12 GE 34       = 0
LE          - Relational less than or equal to  Usage: 12 LE 34         = 1

AND         - Logical AND                       Usage: 1 AND 0          = 0
OR          - Logical non-exclusive OR          Usage: 1 OR 0           = 1
XOR         - Logical exclusive OR              Usage: 1 XOR 0          = 1
NAND        - Logical NAND                      Usage: 1 NAND 0         = 1
NOR         - Logical non-exclusive NOR         Usage: 1 NOR 0          = 0
XNOR        - Logical exclusive NNOR            Usage: 1 XNOR 0         = 0
```

Operator precedence

1. **
2. * / MOD DIV
3. + -
4. GT GE LT LE
5. EQ NE
6. AND OR XOR NAND NOR XNOR

G-Code functions

```
Expr         - Executes expression                  Usage: EXPR[MSG('THIS IS TEXT')]
                                                           (result in #<_expr> parameter)

Exists       - Checks is value exists               Usage: EXISTS[#<PARAM>]    = 0
NotExists    - Checks is value does not exists      Usage: NOTEXISTS[#<PARAM>] = 1
Active       - Checks g-code is running             Usage: ACTIVE[]            = 1

Nop          - No operation (returns zero)          Usage: NOP[]           = 0
Nan          - NaN value                            Usage: NAN[]           = nan
Def          - Sets default value                   Usage: DEF[NAN[], 100] = 100.000000

Abs          - Absolute value                       Usage: ABS[-123]       = 123.000000
Sqrt         - Square Root                          Usage: SQRT[9]         = 3.000000
Sqr          - Square                               Usage: SQR[3]          = 9.000000
Sin          - Sine                                 Usage: SIN[30]         = 0.500000
Cos          - Cosine                               Usage: COS[60]         = 0.500000
Tan          - Tangent                              Usage: TAN[45]         = 1.000000
ASin         - Inverse sine                         Usage: ASIN[0.5]       = 30.000000
ACos         - Inverse cosine                       Usage: ACOS[0.5]       = 60.000000
ATan         - Inverse tangent                      Usage: ATAN[1]         = 45.000000
ATan2        - Four quadrant inverse tangent        Usage: ATAN2[1,1]      = 45.000000
Pi           - Pi constant value                    Usage: PI[]            = 3.141593
Rad2Deg      - Radians to degrees                   Usage: RAD2DEG[3.141]  = 179.966043
Deg2Rad      - Degrees to radians                   Usage: DEG2RAD[180]    = 3.141593

E            - e constant value                     Usage: E[]             = 2.718282
Pow          - Power                                Usage: POW[2,3]        = 8.000000
Exp          - e raised to the given power          Usage: EXP[2]          = 7.389056
Exp10        - 10 raised to the given power         Usage: EXP10[2]        = 100.000000
Exp2         - 2 raised to the given power          Usage: EXP2[2]         = 4.000000
Log          - Base e logarithm                     Usage: LOG[2]          = 0.693147
Log10        - Base 10 logarithm                    Usage: LOG10[2]        = 0.301030
Log2         - Base 2 logarithm                     Usage: LOG2[2]         = 1.000000

Rand         - Random value                         Usage: RAND[]          = 0.399394
Inc          - Increases value (value,limit,default) Usage: INC[5,10,0]    = 6.000000
Dec          - Decreases value (value,limit,default) Usage: DEC[5,0,10]    = 4.000000
Min          - Minimum                              Usage: MIN[4,6]        = 4.000000
Max          - Maximum                              Usage: MAX[4,6]        = 6.000000
Min3         - Minimum of 3                         Usage: MIN3[4,6,3]     = 3.000000
Max3         - Maximum of 3                         Usage: MAX3[4,6,3]     = 6.000000

Round        - Round to nearest integer             Usage: ROUND[0.56]        = 1.000000
RoundDec     - Round to nearest value with decimals Usage: ROUNDDEC[0.56,1]   = 0.600000
RoundUp      - Round up/down to integer             Usage: ROUNDUP[0.56]      = 1.000000
RoundUpDec   - Round up/down to integer             Usage: ROUNDUPDEC[0.56,1] = 0.600000
Floor        - Round down to integer                Usage: FLOOR[0.56]        = 0.000000
Ceil         - Round up to integer                  Usage: CEIL[0.56]         = 1.000000
Trunc        - Truncate to integer                  Usage: TRUNC[0.56]        = 0.000000

Not          - Bitwise complement                   Usage: NOT[10]         = 4294967285
And          - Bitwise AND                          Usage: AND[10,3]       = 2
Or           - Bitwise OR                           Usage: OR[10,3]        = 11
Xor          - Bitwise exclusive OR                 Usage: XOR[10,3]       = 9
Nand         - Bitwise NAND                         Usage: NAND[10,3]      = 4294967293
Nor          - Bitwise NOR                          Usage: NOR[10,3]       = 4294967284
Xnor         - Bitwise exclusive NOR                Usage: XNOR[10,3]      = 4294967286
Shl          - Bitwise shift left                   Usage: SHL[10,2]       = 40
Shr          - Bitwise shift right                  Usage: SHR[10,2]       = 2

LNot         - Logic complement                     Usage: LNOT[1]         = 0
LAnd         - Logic AND                            Usage: LAND[1,0]       = 0
LOr          - Logic non-exclusive OR               Usage: LOR[1,0]        = 1
LXor         - Logic exclusive OR                   Usage: LXOR[1,0]       = 1
LNand        - Logic NAND                           Usage: LNAND[1,0]      = 1
LNor         - Logic non-exclusive NOR              Usage: LNOR[1,0]       = 0
LXnor        - Logic exclusive NOR                  Usage: LXNOR[1,0]      = 0
```

```
DateTime      - Current time (seconds since 1970)      Usage: DATETIME[]                 = 1616497076.984
Year          - Year from DateTime value               Usage: YEAR[1616497076.984]       = 2021
Month         - Month from DateTime value              Usage: MONTH[1616497076.984]      = 3
Day           - Day from DateTime value                Usage: DAY[1616497076.984]        = 23
Hour          - Hour from DateTime value               Usage: HOUR[1616497076.984]       = 11
Minute        - Minute from DateTime value             Usage: MINUTE[1616497076.984]     = 57
Second        - Second from DateTime value             Usage: SECOND[1616497076.984]     = 56
MilliSec      - Millisecond from DateTime value        Usage: MILLISEC[1616497076.984]= 984

Hex           - Converts string to number              Usage: HEX[7E5]                   = 2021
Bin           - Converts string to number              Usage: BIN[11111100101]           = 2021

ToWork        - Converts machine coordinate to work    Usage: TOWORK[100,0]              = 90.000000
ToMachine     - Converts work coordinate to machine    Usage: TOMACHINE[90,0]            = 100.000000
MMToUnit      - Converts MM to g-code units            Usage: MMTOUNIT[1]                = 0.03937
UnitToMM      - Converts g-code units to MM            Usage: UNITTOMM[1]                = 25.4

U8            - Typecasts to unsigned 8 bit type       Usage: U8[2863311530]             = 170
S8            - Typecasts to signed 8 bit type         Usage: S8[2863311530]             = -86
U16           - Typecasts to unsigned 16 bit type      Usage: U16[2863311530]            = 43690
S16           - Typecasts to signed 16 bit type        Usage: S16[2863311530]            = -21846
U32           - Typecasts to unsigned 32 bit type      Usage: U32[2863311530]            = 2863311530
S32           - Typecasts to signed 32 bit type        Usage: S32[2863311530]            = -1431655766

ToU16         - Creates unsigned 16 bit value          Usage: TOU16[170,170]             = 43690
ToS16         - Creates signed 16 bit value            Usage: TOS16[170,170]             = -21846
ToU32         - Creates unsigned 32 bit value          Usage: TOU32[170,170,170,170]     = 2863311530
ToS32         - Creates signed 32 bit value            Usage: TOS32[170,170,170,170]     = -1431655766
```

Expression functions

```
if          - Conditional statement                 Usage: if(1, print("Yes"))
for         - For statement                         Usage: for(i=0, i<10, i=i+1, print("Loop", i))
exec        - Executes multiple expressions         Usage: exec(print("One"), msg("Two"))

exists      - Checks is value exists                Usage: exists(_param)    = 0
notexists   - Checks is value does not exists       Usage: notexists(_param) = 1

nop         - No operation (returns zero)           Usage: nop()           = 0.000000
nan         - NaN value                             Usage: nan()           = nan
def         - Sets default value                    Usage: def(nan(), 100) = 100.000000
defnz       - Sets default value not zero           Usage: defnz(0, 100)   = 100.000000

abs         - Absolute value                        Usage: abs(-123)       = 123.000000
sqrt        - Square Root                           Usage: sqrt(9)         = 3.000000
sqr         - Square                                Usage: sqr(3)          = 9.000000
sin         - Sine                                  Usage: sin(0.524)      = 0.500347
cos         - Cosine                                Usage: cos(1.047)      = 0.500171
tan         - Tangent                               Usage: tan(0.785)      = 0.999204
asin        - Inverse sine                          Usage: asin(0.5)       = 0.523599
acos        - Inverse cosine                        Usage: acos(0.5)       = 1.047198
atan        - Inverse tangent                       Usage: atan(1)         = 0.785398
atan2       - Four quadrant inverse tangent         Usage: atan2(1,1)      = 0.785398
pi          - Pi constant value                     Usage: pi()            = 3.141593
rad2deg     - Radians to degrees                    Usage: rad2deg(3.141)  = 179.966043
deg2rad     - Degrees to radians                    Usage: deg2rad(180)    = 3.141593

e           - e constant value                      Usage: e()             = 2.718282
pow         - Power                                 Usage: pow(2,3)        = 8.000000
exp         - e raised to the given power           Usage: exp(2)          = 7.389056
exp10       - 10 raised to the given power          Usage: exp10(2)        = 100.000000
exp2        - 2 raised to the given power           Usage: exp2(2)         = 4.000000
log         - Base e logarithm                      Usage: log(2)          = 0.693147
log10       - Base 10 logarithm                     Usage: log10(2)        = 0.301030
log2        - Base 2 logarithm                      Usage: log2(2)         = 1.000000

rand        - random value                          Usage: rand()          = 0.100845
inc         - Increases value (value,limit,default) Usage: inc(5,10,0)     = 6.000000
dec         - Decreases value (value,limit,default) Usage: dec(5,0,10)     = 4.000000
min         - Minimum                               Usage: min(4,6)        = 4.000000
                                                           min(4,6,3)      = 3.000000
max         - Maximum                               Usage: max(4,6)        = 6.000000
                                                           max(4,6,3)      = 6.000000

round       - Round to nearest integer              Usage: round(0.56)     = 1.000000
                                                           round(0.56,1)   = 0.600000
roundup     - Round up/down to integer              Usage: roundup(0.56)   = 1.000000
                                                           roundup(0.56,1) = 0.600000
floor       - Round to nearest value with decimals  Usage: floor(0.56)     = 0.000000
ceil        - Round up to integer                   Usage: ceil(0.56)      = 1.000000
trunc       - Truncate to integer                   Usage: trunc(0.56)     = 0.000000

center      - Compensate hysteresis                 Usage: center(0.3,0.2) = 0.2
                                                           center(0.1,0.2) = 0.0
centerex    - Compensate hysteresis                 Usage: centerex(0.3,0.2,1.0,0.8) = 0.044955
                                                           centerex(0.1,0.2,1.0,0.8) = 0.000000
                                                           centerex(1,0.2,1.0,0.8) = 1.000000
                                                           centerex(0.9,0.2,1.0,0.8) = 0.619110

not         - Bitwise complement                    Usage: not(10)         = 4294967285
and         - Bitwise AND                           Usage: and(10,3)       = 2
or          - Bitwise non-exclusive OR              Usage: or(10,3)        = 11
xor         - Bitwise exclusive OR                  Usage: xor(10,3)       = 9
nand        - Bitwise NAND                          Usage: nand(10,3)      = 4294967293
nor         - Bitwise non-exclusive NOR             Usage: nor(10,3)       = 4294967284
xnor        - Bitwise exclusive NOR                 Usage: xnor(10,3)      = 4294967286
shl         - Bitwise shift left                    Usage: shl(10,2)       = 40
shr         - Bitwise shift right                   Usage: shr(10,2)       = 2
```

```
lnot          - Logic complement                      Usage: lnot(1)          = 0
land          - Logic AND                             Usage: land(1,0)        = 0
lor           - Logic non-exclusive OR                Usage: lor(1,0)         = 1
lxor          - Logic exclusive OR                    Usage: lxor(1,0)        = 1
lnand         - Logic NAND                            Usage: lnand(1,0)       = 1
lnor          - Logic non-exclusive NOR               Usage: lnor(1,0)        = 0
lxnor         - Logic exclusive NOR                   Usage: lxnor(1,0)       = 0

eq            - Relational equality                   Usage: eq(10,20)              = 0
ne            - Relational inequality                 Usage: ne(10,20)              = 1
gt            - Relational strictly greater than      Usage: gt(10,20)              = 0
lt            - Relational strictly less than         Usage: lt(10,20)              = 1
ge            - Relational greater than or equal to   Usage: ge(10,20)              = 0
le            - Relational less than or equal to      Usage: le(10,20)              = 1

hex           - Converts string to number             Usage: hex("7E5")             = 2021
bin           - Converts string to number             Usage: bin("11111100101")     = 2021

sleep         - Sleeps n milliseconds                 Usage: sleep(100)

datetime      - Current time (seconds since 1970)     Usage: datetime()             = 1616502112.792
year          - Year from DateTime value              Usage: year(1616502112.792)   = 2021
month         - Month from DateTime value             Usage: month(1616502112.792)  = 3
day           - Day from DateTime value               Usage: day(1616502112.792)    = 23
hour          - Hour from DateTime value              Usage: hour(1616502112.792)   = 13
minute        - Minute from DateTime value            Usage: minute(1616502112.792) = 21
second        - Second from DateTime value            Usage: second(1616502112.792) = 52
millisec      - Millisecond from DateTime value       Usage: millisec(1616502112.792)= 792


mmtounit      - Converts MM to g-code units           Usage: mmtounit[1]            = 0.03937
unittomm      - Converts g-code units to MM           Usage: unittomm[1]            = 25.4
mmtosetunit   - Converts MM to settings units         Usage: mmtosetunit[1]         = 0.03937
setunittomm   - Converts settings units to MM         Usage: setunittomm[1]         = 25.4
setunit       - Shoses value based on settings units  Usage: setunit(25.4,1)        = 25.4

print         - Prints to output window               Usage: print("This is text")
clear         - Clears output window                  Usage: clear()
status        - Prints to status window               Usage: status("This is text")
msg           - Shows dialog                          Usage: msg("This is text")

getparam      - Gets parameter                        Usage: getparam('_machine_x')  = 123.000000
setparam      - Sets parameter                        Usage: setparam('_param', 123) = 123.000000

cmd
mdi

startfn
startcode

start
stop
pause
out
outpwm
jog
usb
```

List of parameters

Work position:

_x	(R)
_y	(R)
_z	(R)
_a	(R)
_b	(R)
_c	(R)
_u	(R)
_v	(R)
_w	(R)
_work_axis	(R)

Machine position:

_machine_x	(R)
_machine_y	(R)
_machine_z	(R)
_machine_a	(R)
_machine_b	(R)
_machine_c	(R)
_machine_u	(R)
_machine_v	(R)
_machine_w	(R)
_machine_axis	(R)

Probe position:

_probe	(R)
_probe_x	(R)
_probe_y	(R)
_probe_z	(R)
_probe_a	(R)
_probe_b	(R)
_probe_c	(R)
_probe_u	(R)
_probe_v	(R)
_probe_w	(R)
_probe_axis	(R)

_measure	(RW)
_measure_x	(RW)
_measure_y	(RW)
_measure_z	(RW)
_measure_axis	(RW)
_measure_sizex	(RW)
_measure_sizey	(RW)
_measure_sizez	(RW)
_measure_size_axis	(RW)
_measure_rot	(RW)

THC:

_thc	(R)
_thcen	(R)

Mode:

_motion	(R)
_units	(RW)
_plane	(RW)
_distancemode	(RW)
_distancemode_ijk	(RW)
_distancemode_abc	(RW)
_polarmode	(RW)
_cyclereturnmode	(RW)
_lathemode	(RW)

Blend:

_blendmode	(R)
_blend_tol	(R)

Feed:

_feedmode	(R)
_feedspeed	(R)
_feedspeed_upm	(R)
_feedspeed_upr	(R)

Spindle:

_spindlemode	(R)
_spindlespeed	(R)
_spindlespeed_rpm	(R)
_spindlespeed_css	(R)

Tools:

_selected_tool	(RW)
_current_tool	(RW)

_tooloff	(RW)
_tooloff_x	(RW)
_tooloff_y	(RW)
_tooloff_z	(RW)
_tooloff_a	(RW)
_tooloff_b	(RW)
_tooloff_c	(RW)
_tooloff_u	(RW)
_tooloff_v	(RW)
_tooloff_w	(RW)
_tooloff_axis	(RW)

_toolcomp	(R)
_toolcomp_dia	(R)
_toolcomp_orient	(R)

Tool Table:

_tool_exists	(R)
_tool_name	(R)

_tool_ismill_num	(R)
_tool_isdrill_num	(R)
_tool_isturn_num	(R)
_tool_isprobe_num	(R)

_tool_dia_num	(RW)

_tool_off_x_num	(RW)
_tool_off_y_num	(RW)
_tool_off_z_num	(RW)
_tool_off_a_num	(RW)
_tool_off_b_num	(RW)
_tool_off_c_num	(RW)
_tool_off_u_num	(RW)
_tool_off_v_num	(RW)
_tool_off_w_num	(RW)

_tool_tc_x_num	(RW)
_tool_tc_y_num	(RW)
_tool_tc_z_num	(RW)
_tool_tc_a_num	(RW)
_tool_tc_b_num	(RW)
_tool_tc_c_num	(RW)
_tool_tc_u_num	(RW)
_tool_tc_v_num	(RW)
_tool_tc_w_num	(RW)

_tool_so_x_num	(RW)
_tool_so_y_num	(RW)
_tool_so_z_num	(RW)

_tool_skipmeasure_num	(RW)
_tool_skipchange_num	(RW)
_tool_par1_num	(RW)
_tool_par2_num	(RW)
_tool_par3_num	(RW)
_tool_par4_num	(RW)
_tool_par5_num	(RW)
_tool_par6_num	(RW)
Offset:	
_workoff	(R)
_workoff_x	(RW)
_workoff_y	(RW)
_workoff_z	(RW)
_workoff_a	(RW)
_workoff_b	(RW)
_workoff_c	(RW)
_workoff_u	(RW)
_workoff_v	(RW)
_workoff_w	(RW)
_workoff_axis	
_axisoff	(R)
_axisoff_x	(RW)
_axisoff_y	(RW)
_axisoff_z	(RW)
_axisoff_a	(RW)
_axisoff_b	(RW)
_axisoff_c	(RW)
_axisoff_u	(RW)
_axisoff_v	(RW)
_axisoff_w	(RW)
_axisoff_axis	(RW)
_axisscale	(R)
_axisscale_i	(RW)
_axisscale_j	(RW)
_axisscale_k	(RW)
_axisscale_iuvw	(RW)
_axisscale_juvw	(RW)
_axisscale_kuvw	(RW)
_axisscale_x	(RW)
_axisscale_y	(RW)
_axisscale_z	(RW)
_axisscale_u	(RW)
_axisscale_v	(RW)
_axisscale_w	(RW)
_axisrot	(R)
_axisrot_ang	(R)
_axisrot_anguvw	(R)
_axisrot_x	(R)
_axisrot_y	(R)
_axisrot_z	(R)
_axisrot_u	(R)
_axisrot_v	(R)
_axisrot_w	(R)
CoordinateSystem:	
_coordsys_num	(R)
_coordsys_x	(RW)
_coordsys_y	(RW)
_coordsys_z	(RW)
_coordsys_a	(RW)
_coordsys_b	(RW)
_coordsys_c	(RW)
_coordsys_u	(RW)
_coordsys_v	(RW)
_coordsys_w	(RW)
_coordsys_axis	(RW)
_coordsys_rot	(RW)
CoordinateSystem Table:	
_coordsystem_exists	(R)
_coordsystem_x_num	(R)
_coordsystem_y_num	(R)
_coordsystem_z_num	(R)
_coordsystem_a_num	(R)
_coordsystem_b_num	(R)
_coordsystem_c_num	(R)
_coordsystem_u_num	(R)
_coordsystem_v_num	(R)
_coordsystem_w_num	(R)
_coordsystem_rot_num	(R)
CameraOffset:	
_cam_offset_x	(R)
_cam_offset_y	(R)
Home:	
_home1_x	(RW)
_home1_y	(RW)
_home1_z	(RW)
_home1_a	(RW)
_home1_b	(RW)
_home1_c	(RW)
_home1_u	(RW)
_home1_v	(RW)
_home1_w	(RW)
_home2_x	(RW)
_home2_y	(RW)
_home2_z	(RW)
_home2_a	(RW)
_home2_b	(RW)
_home2_c	(RW)
_home2_u	(RW)
_home2_v	(RW)
_home2_w	(RW)
Transformation:	
_trans_en	(R)
_trans_a0	(R)
_trans_b0	(R)
_trans_c0	(R)
_trans_a1	(R)
_trans_b1	(R)
_trans_c1	(R)
_trans_a2	(R)
_trans_b2	(R)
_trans_c2	(R)
_trans_a3	(R)
_trans_b3	(R)
_trans_c3	(R)
_trans_shift_x	(R)
_trans_shift_y	(R)
_trans_shift_z	(R)
_trans_rot_x	(R)
_trans_rot_y	(R)
_trans_rot_z	(R)
_trans_scale_x	(R)
_trans_scale_y	(R)
_trans_scale_z	(R)
Warp:	
_warp_en	(R)

```
_warp_count                 (R)
_warp_offset                (R)

PointList:
_pointcnt                   (R)
_point_x_num                (R)
_point_y_num                (R)
_point_z_num                (R)
_point_a_num                (R)
_point_b_num                (R)
_point_c_num                (R)
_point_u_num                (R)
_point_v_num                (R)
_point_w_num                (R)

Operator:
_operator_x                 (RW)
_operator_y                 (RW)
_operator_z                 (RW)
_operator_a                 (RW)
_operator_b                 (RW)
_operator_c                 (RW)
_operator_u                 (RW)
_operator_v                 (RW)
_operator_w                 (RW)
_operator_axis              (RW)

Output:
_output                     (R)

Spindle & Coolant:
_spindle                    (R)
_spindle_on                 (R)
_spindle_cw                 (R)
_spindle_ccw                (R)
_mist                       (R)
_mist_on                    (R)
_flood                      (R)
_flood_on                   (R)


Settings:
_set_units                  (RW)


Settings – Motors:
_motoroutputorder_1         (RW)
_motoroutputorder_2         (RW)
_motoroutputorder_3         (RW)
_motoroutputorder_4         (RW)
_motoroutputorder_5         (RW)
_motoroutputorder_6         (RW)
_motoroutputorder_7         (RW)
_motoroutputorder_8         (RW)
_motoroutputorder_9         (RW)
_motoroutputorder_axis      (RW)

_motoroutputreverse_1       (RW)
_motoroutputreverse_2       (RW)
_motoroutputreverse_3       (RW)
_motoroutputreverse_4       (RW)
_motoroutputreverse_5       (RW)
_motoroutputreverse_6       (RW)
_motoroutputreverse_7       (RW)
_motoroutputreverse_8       (RW)
_motoroutputreverse_9       (RW)
_motoroutputreverse_axis    (RW)

Settings – Motors/StepsPerUnit:
_motorspu_x                 (RW)
_motorspu_y                 (RW)
_motorspu_z                 (RW)
_motorspu_a                 (RW)
_motorspu_b                 (RW)
_motorspu_c                 (RW)
_motorspu_u                 (RW)
_motorspu_v                 (RW)
_motorspu_w                 (RW)
_motorspu_axis              (RW)

Settings – Motors/Speed:
_motorspeed_x               (RW)
_motorspeed_y               (RW)
_motorspeed_z               (RW)
_motorspeed_a               (RW)
_motorspeed_b               (RW)
_motorspeed_c               (RW)
_motorspeed_u               (RW)
_motorspeed_v               (RW)
_motorspeed_w               (RW)
_motorspeed_axis            (RW)

Settings – Motors/Acceleration:
_motoracc_x                 (RW)
_motoracc_y                 (RW)
_motoracc_z                 (RW)
_motoracc_a                 (RW)
_motoracc_b                 (RW)
_motoracc_c                 (RW)
_motoracc_u                 (RW)
_motoracc_v                 (RW)
_motoracc_w                 (RW)
_motoracc_axis              (RW)

_motordec_x                 (RW)
_motordec_y                 (RW)
_motordec_z                 (RW)
_motordec_a                 (RW)
_motordec_b                 (RW)
_motordec_c                 (RW)
_motordec_u                 (RW)
_motordec_v                 (RW)
_motordec_w                 (RW)
_motordec_axis              (RW)

Settings – Motors/Limits:
_motorlimit_xn              (RW)
_motorlimit_yn              (RW)
_motorlimit_zn              (RW)
_motorlimit_an              (RW)
_motorlimit_bn              (RW)
_motorlimit_cn              (RW)
_motorlimit_un              (RW)
_motorlimit_vn              (RW)
_motorlimit_wn              (RW)

_motorlimit_xp              (RW)
_motorlimit_yp              (RW)
_motorlimit_zp              (RW)
_motorlimit_ap              (RW)
_motorlimit_bp              (RW)
_motorlimit_cp              (RW)
_motorlimit_up              (RW)
_motorlimit_vp              (RW)
_motorlimit_wp              (RW)

_motorlimit_xn_en           (RW)
_motorlimit_yn_en           (RW)
_motorlimit_zn_en           (RW)
_motorlimit_an_en           (RW)
```

_motorlimit_bn_en (RW)
_motorlimit_cn_en (RW)
_motorlimit_un_en (RW)
_motorlimit_vn_en (RW)
_motorlimit_wn_en (RW)

_motorlimit_xp_en (RW)
_motorlimit_yp_en (RW)
_motorlimit_zp_en (RW)
_motorlimit_ap_en (RW)
_motorlimit_bp_en (RW)
_motorlimit_cp_en (RW)
_motorlimit_up_en (RW)
_motorlimit_vp_en (RW)
_motorlimit_wp_en (RW)

Settings - Motors/Limit Switch:
_limitpin_xn (RW)
_limitpin_yn (RW)
_limitpin_zn (RW)
_limitpin_an (RW)
_limitpin_bn (RW)
_limitpin_cn (RW)
_limitpin_un (RW)
_limitpin_vn (RW)
_limitpin_wn (RW)
_limitpin_n_axis (RW)

_limitpin_xp (RW)
_limitpin_yp (RW)
_limitpin_zp (RW)
_limitpin_ap (RW)
_limitpin_bp (RW)
_limitpin_cp (RW)
_limitpin_up (RW)
_limitpin_vp (RW)
_limitpin_wp (RW)
_limitpin_p_axis (RW)

Settings – Motion:
_motion_maxspeed (RW)
_motion_maxacc (RW)
_motion_maxdec (RW)

Settings – Jogging:
_jog_speeddef (RW)
_jog_stepdef (RW)
_jog_rounddef (RW)

_jog_speedkbd (RW)

_jog_speed (RW)
_jog_step (RW)
_jog_round (RW)

Settings – IO/Spindle:
_spindle_pin_mode (RW)
_spindle_pin_cw (RW)
_spindle_pin_ccw (RW)
_spindle_pin_speed (RW)
_spindle_speed_min (RW)
_spindle_speed_max (RW)
_spindle_delay_start (RW)
_spindle_delay_stop (RW)

_spindle_freq_mode (RW)
_spindle_usefreq (R)
_spindle_freq_min (RW)
_spindle_freq_max (RW)
_spindle_freq_stepwidth (RW)
_spindle_usepwm (R)
_spindle_pwm_freq (RW)
_spindle_userc (R)
_spindle_rc_lo (RW)
_spindle_rc_hi (RW)

Settings – IO/Coolant:
_mist_pin (RW)
_flood_pin (RW)

Settings – THC:
_thc_axis (RW)
_thc_rangemin (RW)
_thc_rangemax (RW)
_thc_speed (RW)
_thc_pindec (RW)
_thc_pininc (RW)
_thc_pinok (RW)

Settings - Program Options:
_program_units (RW)
_program_plane (RW)
_program_distmode (RW)
_program_distmodeijk (RW)
_program_distmodeabc (RW)
_program_cyclereturn (RW)
_program_lathemode (RW)

_speed_traverse (RW)
_speed_traverseabc (RW)
_speed_feed (RW)
_speed_spindle (RW)

_ovrd_speedfeed (RW)
_ovrd_speedtraverse (RW)
_ovrd_spindle (RW)

Settings – Measure:
_probe_pin_1 (RW)
_probe_pin_2 (RW)

_probe_speed (RW)
_probe_speed_low (RW)
_probe_swdist (RW)

_probe_sizeZ (RW)
_probe_sizeXY (RW)
_probe_size_axis (RW)
_probe_sizedx (RW)
_probe_sizedy (RW)
_probe_sized_axis (RW)
_probe_use_tooltable (RW)
_probe_safeheigh (RW)
_probe_estop (RW)

Settings – Home:
_home_speed (RW)
_home_speed_low (RW)
_home_swdist (RW)

_home_order_x (RW)
_home_order_y (RW)
_home_order_z (RW)
_home_order_a (RW)
_home_order_b (RW)
_home_order_c (RW)
_home_order_u (RW)
_home_order_v (RW)
_home_order_w (RW)

_home_order_axis	(RW)
_home_dir_x	(RW)
_home_dir_y	(RW)
_home_dir_z	(RW)
_home_dir_a	(RW)
_home_dir_b	(RW)
_home_dir_c	(RW)
_home_dir_u	(RW)
_home_dir_v	(RW)
_home_dir_w	(RW)
_home_dir_axis	(RW)
_home_swpos_x	(RW)
_home_swpos_y	(RW)
_home_swpos_z	(RW)
_home_swpos_a	(RW)
_home_swpos_b	(RW)
_home_swpos_c	(RW)
_home_swpos_u	(RW)
_home_swpos_v	(RW)
_home_swpos_w	(RW)
_home_swpos_axis	(RW)
_home_moveto_x	(RW)
_home_moveto_y	(RW)
_home_moveto_z	(RW)
_home_moveto_a	(RW)
_home_moveto_b	(RW)
_home_moveto_c	(RW)
_home_moveto_u	(RW)
_home_moveto_v	(RW)
_home_moveto_w	(RW)
_home_moveto_axis	(RW)

Settings - Tool Change

_tc_enable	(RW)
_tc_skipsame	(RW)
_tc_spindlecheck	(RW)
_tc_safeheight_en	(RW)
_tc_safeheight	(RW)
_tc_pos_en	(RW)
_tc_pos_x	(RW)
_tc_pos_y	(RW)
_tc_pos_z	(RW)
_tc_action	(RW)
_tc_toolmeasure	(RW)
_tc_tooloff_en	(RW)
_tc_autoreturn	(RW)
_tc_atc_en	(RW)
_tc_atc_speed	(RW)
_tc_atc_speed2	(RW)
_tc_unload_in1_x	(RW)
_tc_unload_in1_y	(RW)
_tc_unload_in1_z	(RW)
_tc_unload_in2_x	(RW)
_tc_unload_in2_y	(RW)
_tc_unload_in2_z	(RW)
_tc_unload_pin1	(RW)
_tc_unload_pin1set1	(RW)
_tc_unload_pin1delay1	(RW)
_tc_unload_pin1set2	(RW)
_tc_unload_pin1delay2	(RW)
_tc_unload_pin2	(RW)
_tc_unload_pin2set1	(RW)
_tc_unload_pin2delay1	(RW)
_tc_unload_pin2set2	(RW)
_tc_unload_pin2delay2	(RW)
_tc_unload_out1_x	(RW)
_tc_unload_out1_y	(RW)
_tc_unload_out1_z	(RW)
_tc_unload_out2_x	(RW)
_tc_unload_out2_y	(RW)
_tc_unload_out2_z	(RW)
_tc_load_in1_x	(RW)
_tc_load_in1_y	(RW)
_tc_load_in1_z	(RW)
_tc_load_in2_x	(RW)
_tc_load_in2_y	(RW)
_tc_load_in2_z	(RW)
_tc_load_pin1	(RW)
_tc_load_pin1set1	(RW)
_tc_load_pin1delay1	(RW)
_tc_load_pin1set2	(RW)
_tc_load_pin1delay2	(RW)
_tc_load_pin2	(RW)
_tc_load_pin2set1	(RW)
_tc_load_pin2delay1	(RW)
_tc_load_pin2set2	(RW)
_tc_load_pin2delay2	(RW)
_tc_load_out1_x	(RW)
_tc_load_out1_y	(RW)
_tc_load_out1_z	(RW)
_tc_load_out2_x	(RW)
_tc_load_out2_y	(RW)
_tc_load_out2_z	(RW)

Settings - Tool Offset:

_tooloff_speed	(RW)
_tooloff_speed_low	(RW)
_tooloff_swdist	(RW)
_tooloff_safeheight	(RW)
_tooloff_sensorX	(RW)
_tooloff_sensorY	(RW)
_tooloff_sensorZ	(RW)

Settings - Work Offset:

_workoff_speed	(RW)
_workoff_speed_low	(RW)
_workoff_swdist	(RW)
_workoff_size	(RW)
_workoff_useprobe	(RW)

Settings - Gantry Square

_gantrysquare_speed	(RW)
_gantrysquare_axis	(RW)
_gantrysquare_dir	(RW)
_gantrysquare_move_u	(RW)
_gantrysquare_move_v	(RW)

HW:

_hw_isinit	(R)
_hw_serial	(R)
_hw_version	(R)
_sw_version	(R)
_hw_buffavail	(R)

_hw_buffempty	(R)
_hw_buffutil	(R)
_hw_cmdbufffull	(R)
_hw_cmdbufffree	(R)
_hw_cmdbuffunread	(R)
_hw_cmdlevel	(R)
_hw_idle	(R)
_hw_estop	(R)
_hw_stop	(R)
_hw_pause	(R)
_hw_isprog	(R)
_hw_iscmd	(R)
_hw_isjog	(R)
_hw_speed	(R)
_hw_accel	(R)
_hw_spindle	(R)
_hw_spindle_dir	(R)
_hw_spindle_idx	(R)
_hw_spindle_enc	(R)
_hw_spindle_ui	(R)
_hw_mist	(R)
_hw_flood	(R)
_hw_ovrdspeed_enabled	(R)
_hw_ovrdspindle_enabled	(R)
_hw_motor_x	(R)
_hw_motor_y	(R)
_hw_motor_z	(R)
_hw_motor_a	(R)
_hw_motor_b	(R)
_hw_motor_c	(R)
_hw_motor_u	(R)
_hw_motor_v	(R)
_hw_motor_w	(R)
_hw_work_x	(R)
_hw_work_y	(R)
_hw_work_z	(R)
_hw_work_a	(R)
_hw_work_b	(R)
_hw_work_c	(R)
_hw_work_u	(R)
_hw_work_v	(R)
_hw_work_w	(R)
_hw_srcidx	(R)
_hw_linenum	(R)
_hw_dist_xyz	(R)
_hw_dist_abc	(R)
_hw_dist_uvw	(R)
_hw_dist_x	(R)
_hw_dist_y	(R)
_hw_dist_z	(R)
_hw_dist_a	(R)
_hw_dist_b	(R)
_hw_dist_c	(R)
_hw_dist_u	(R)
_hw_dist_v	(R)
_hw_dist_w	(R)
_hw_dist_axis	(R)
_hw_output	(R)
_hw_output_num	(R)
_hw_output_freq1	(R)
_hw_output_duty1	(R)
_hw_output_freq2	(R)
_hw_output_duty2	(R)
_hw_output_freq3	(R)
_hw_output_duty3	(R)
_hw_output_freq4	(R)
_hw_output_duty4	(R)
_hw_output_freq5	(R)
_hw_output_duty5	(R)
_hw_output_freq6	(R)
_hw_output_duty6	(R)
_hw_output_freq7	(R)
_hw_output_duty7	(R)
_hw_output_freq8	(R)
_hw_output_duty8	(R)
_hw_extin1	(R)
_hw_extin1_num	(R)
_hw_extin2	(R)
_hw_extin2_num	(R)
_hw_extout1	(R)
_hw_extout1_num	(R)
_hw_extout2	(R)
_hw_extout2_num	(R)
_hw_input	(R)
_hw_input_num	(R)
_hw_limit	(R)
_hw_limit_num	(R)
_hw_jog	(R)
_hw_jogpot	(R)
_hw_ctrl	(R)
_hw_aux1	(R)
_hw_aux2	(R)
_hw_aux3	(R)
_hw_aux4	(R)
_hw_error	(R)
_hw_motors_en	(R)
_hw_limits_en	(R)
_hw_axislock	(R)
_hw_ctrlspindleidx_rpm	(R)
_hw_ctrlspindleidx_val	(R)
_hw_ctrlspindle_rpm	(R)
_hw_ctrlspindle_dir	(R)
_hw_ctrlspindle_val	(R)
_hw_ctrlmpg_rpm	(R)
_hw_ctrlmpg_dir	(R)
_hw_ctrlmpg_val	(R)
_hw_ctrlmpg_velocity	(R)
_hw_ctrlenc_rpm	(R)
_hw_ctrlenc_dir	(R)
_hw_ctrlenc_val	(R)
_hw_mpg_mode	(R)
_hw_mpg_axis	(R)
_hw_mpg_key	(R)
_hw_mpg_delta	(R)
_hw_mpg_value	(R)
_hw_mpg_axisnum	(R)
_hw_mpg_velocity	(R)
_hw_returnparam	(R)

Program:

_prog_size	(R)
_prog_linecount	(R)
_prog_totallen	(R)
_prog_totaltime	(R)
_prog_linelimit	(R)
_prog_looplimit	(R)
_prog_loadtime	(R)
_prog_min_x	(R)
_prog_min_y	(R)
_prog_min_z	(R)
_prog_min_a	(R)
_prog_min_b	(R)
_prog_min_c	(R)
_prog_min_u	(R)
_prog_min_v	(R)
_prog_min_w	(R)
_prog_max_x	(R)
_prog_max_y	(R)
_prog_max_z	(R)
_prog_max_a	(R)
_prog_max_b	(R)
_prog_max_c	(R)
_prog_max_u	(R)
_prog_max_v	(R)
_prog_max_w	(R)
_prog_mintrav_x	(R)
_prog_mintrav_y	(R)
_prog_mintrav_z	(R)
_prog_mintrav_a	(R)
_prog_mintrav_b	(R)
_prog_mintrav_c	(R)
_prog_mintrav_u	(R)
_prog_mintrav_v	(R)
_prog_mintrav_w	(R)
_prog_maxtrav_x	(R)
_prog_maxtrav_y	(R)
_prog_maxtrav_z	(R)
_prog_maxtrav_a	(R)
_prog_maxtrav_b	(R)
_prog_maxtrav_c	(R)
_prog_maxtrav_u	(R)
_prog_maxtrav_v	(R)
_prog_maxtrav_w	(R)
_prog_minfeed_x	(R)
_prog_minfeed_y	(R)
_prog_minfeed_z	(R)
_prog_minfeed_a	(R)
_prog_minfeed_b	(R)
_prog_minfeed_c	(R)
_prog_minfeed_u	(R)
_prog_minfeed_v	(R)
_prog_minfeed_w	(R)
_prog_maxfeed_x	(R)
_prog_maxfeed_y	(R)
_prog_maxfeed_z	(R)
_prog_maxfeed_a	(R)
_prog_maxfeed_b	(R)
_prog_maxfeed_c	(R)
_prog_maxfeed_u	(R)
_prog_maxfeed_v	(R)
_prog_maxfeed_w	(R)
_prog_maxspeed	(R)
_prog_minspeed	(R)
_prog_maxspindle	(R)
_prog_minspindle	(R)

UI:

_isuiready	(R)
_progress	(R)
_progress_timetoend	(R)
_progress_loop	(R)
_progress_loopcnt	(R)
_ui_width	(R)
_ui_height	(R)
_selected_gcode_line	(R)
_selected_gcode	(R)
_selected_gcode_x	(R)
_selected_gcode_y	(R)
_selected_gcode_z	(R)
_selected_gcode_a	(R)
_selected_gcode_b	(R)
_selected_gcode_c	(R)
_selected_gcode_u	(R)
_selected_gcode_v	(R)
_selected_gcode_w	(R)

Dialogs:

_toolnumber	(R)
_coord_x	(R)
_coord_y	(R)
_coord_z	(R)
_coord_a	(R)
_coord_b	(R)
_coord_c	(R)
_coord_u	(R)
_coord_v	(R)
_coord_w	(R)
_coord_rot	(R)
_coord_x_en	(R)
_coord_y_en	(R)
_coord_z_en	(R)
_coord_a_en	(R)
_coord_b_en	(R)
_coord_c_en	(R)
_coord_u_en	(R)
_coord_v_en	(R)
_coord_w_en	(R)
_coord_rot_en	(R)

Other:

_start_firstline	(R)
_start_lastline	(R)
_start_loops	(R)
_return	(R)

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