



G-Code Reference

2022/08/24

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

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

Q (optional) – font size

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

Usage: G06.3 H <options>

H – operation
<options> - operation dependant

Executes “operation” on current shapes.

H1 – Shift	X, Y, Z – shift value
H2 – Scale	D – scale value X, Y – scale value
H3 – Mirror	X, Y – direction and center line position
H4 – Rotate	R – angle
H5 – Reverse	
H6 – Smooth	D – smooth value
H7 – Interpolate arcs	D – curve tolerance
H8 – Offset	D – offset value

G28 - Go To Home 1 Position

Usage: G28
G28 <X..W>

Rapid move machine to Home 1 position. If intermediate move is specified then 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 then 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

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 XYZABCUVWVIJK 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
```


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.

M52 - Sets controller parameter

Usage: M52 P Q - P = parameter
- Q = value

Sets controller parameter

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

Send data to ExtOut, reads data from ExtIn.

Parameters:

M65 - Output Serial

Usage: M65 H Q

- H = Serial port (0 or 1)
- Q = data send to serial interface

M65 H Q E <R> <D>

- H = Serial port (0 or 1)
- Q = parameter number of first data location
- E = data count
- R (optional) = parameter number for returned data
- D (optional) = returned data count

Send data to serial interface.

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/M52/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	G50	- Axes Scale Cancel
G01	- Linear Feed Move	G51	- Axes Scale Enable
G02	- Clockwise Arc Feed Move	G52	- Axes Offset
G03	- Counter Clockwise Arc Feed Move	G52.1	- Axes Offset Cancel
G04	- Dwell	G53	- Machine Coordinate System
G05	- Cubic Spline	G54	- Coordinate System 1
G05.1	- Quadratic Spline	G54.1	- Coordinate System P
G05.2	- NURBS Block	G55	- Coordinate System 2
G05.3	- NURBS Block End	G56	- Coordinate System 3
G06	- Shapes Exec	G57	- Coordinate System 4
G06.1	- Shapes Clear	G58	- Coordinate System 5
G06.2	- Shapes Load	G59	- Coordinate System 6 (or P)
G06.3	- Shapes Process TODO	G59.1	- Coordinate System 7
G07	- Lathe Mode - Diameter	G59.2	- Coordinate System 8
G08	- Lathe Mode - Radius	G59.3	- Coordinate System 9
G09	- Stop, Sync & Set Position	G61	- Blend Cancel
G10	- Settings	G64	- Blend Enable
G12	- Mill: Circular Pocket CW	G65	- Call Macro
G13	- Mill: Circular Pocket CCW	G68	- Axes Rotate Enable
G15	- Polar Coordinate Cancel	G69	- Axes Rotate Cancel
G16	- Polar Coordinate Enable	G70	- Inch Units
G17	- XY Plane	G71	- Millimeter Units
G18	- ZX Plane	G72	- Mill: Facing TODO
G19	- YZ Plane	G72.1	- Mill: Profile TODO
G20	- Inch Units	G72.2	- Mill: Pocket TODO
G21	- Millimeter Units	G73	- Drill: Drill, Speed Peck, Dwell
G28	- Go To Home	G74	- Drill: Tapping Left
G28.1	- Set Home	G75	- Turn: Pattern Repeating TODO
G30	- Go To Home	G76	- Turn: Threading
G30.1	- Set Home	G77	- Turn: Roughing X TODO
G32	- Spindle Synch Motion	G78	- Turn: Roughing Z TODO
G33	- Spindle Synch Motion	G79	- Turn: Grooving TODO
G33.1	- Spindle Synch Motion With Return	G80	- Cancel Motion
G31	- Probe	G81	- Drill: Drill
G38.1	- Probe	G82	- Drill: Drill, Dwell
G38.2	- Probe	G83	- Drill: Drill, Peck, Dwell
G38.3	- Probe	G84	- Drill: Tapping Right
G38.4	- Probe	G85	- Drill: Boring, Feed Out
G38.5	- Probe	G86	- Drill: Boring, Sp Stop, Rpd Out, Sp Strt
G40	- Tool Compensation Cancel	G87	- Drill: Boring, Sp Rev, Rpd Out, Sp Rev
G41	- Tool Compensation Left	G88	- Drill: Boring, Sp Stop, Fd Out, Sp Start
G41.1	- Tool Compensation Dynamic Left	G89	- Drill: Boring, Sp Rev, Fd Out, Sp Rev
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		

G90	- Distance Mode - Absolute	G93	- Feed Mode - Inverse Time
G90.1	- Distance Mode - IJK Absolute	G94	- Feed Mode - Units per Minute
G90.2	- Distance Mode - ABC Absolute	G95	- Feed Mode - Units per Revolution
G91	- Distance Mode - Incremental		
G91.1	- Distance Mode - IJK Incremental	G96	- Spindle Mode - CSS
G91.2	- Distance Mode - ABC Incremental	G97	- Spindle Mode - RPM
G92	- Working Offset	G98	- Cycle Return - Initial Z Point
G92.1	- Working Offset Cancel	G99	- Cycle Return - R Point

List of M-Codes

M0	- Pause	M52	- Controller parameters
M1	- Pause (optional)	M53	- Enable/Disable Pause
M2	- Program End	M54	- Enable/Disable THC
M30	- Program End	M55	- Enable/Disable Transformations
		M56	- Enable/Disable Warp
M3	- Spindle CW	M57	- Enable/Disable Swap
M4	- Spindle CCW		
M5	- Spindle Stop	M59	- Wait For Input
M6	- Tool Change	M62	- Output
M61	- Tool Select	M63	- Output PWM
		M64	- Output ExtOut
M7	- Mist On	M65	- Output Serial
M17	- Mist Off/On	M66	- Output I2C
M8	- Flood On		
M18	- Flood Off/On	M70	- Modal State Store
M9	- Mist & Flood Off	M71	- Modal State Invalidate
		M72	- Modal State Restore
M10	- Motor Enable On/Off	M73	- Modal State Store & Autorestore
M11	- Limit & Probe Enable On/Off		
		M82	- Distance Mode - ABC Absolute
M48	- Enable Override Feed & Spindle	M83	- Distance Mode - ABC Incremental
M49	- Disable Override Feed & Spindle		
M50	- Enable/Disable Override Feed	M98	- Call Subprogram
M51	- Enable/Disable Override Spindle	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

Order of execution

Modal state

Units: G20, G21, G70, G71
Plane: G17, G18, G19
Distance Mode: G90, G90.1, G90.2, G91, G91.1, G91.2, M82, M83
Lathe Mode: G07, G08
Cycle Return: G98, G99
Polar Mode: G15, G16
Feed Mode & Speed: G93, G94, G95, F
Spindle Mode & Speed: G96, G97, S

Settings

Settings: G10
Set Home: G28.1, G30.1

Tools

ToolSelect: T
ToolChange: M6, M61

Inputs & Outputs

Spindle & Coolant: M3, M4, M5, M7, M17, M8, M18, M9
IO: M10, M11, M59, M62, M63, M64, M65, M66

Control

Overrides: M48, M49, M50, M51, M53, M54, M55, M56, M57
Pause: M0, M1
Sync & SetPosition: G09
Blend Mode: G61, G61.1, G64

Offsets

Tool: G43, G43.1, G44, G44.1, G49, G40, G41, G41.1, G42, G42.1
Work: G92, G92.1
Axis: G52, G52.1, G50, G51, G68, G69
CoordinateSystem: G54, G54.1, G55, G56, G57, G58, G59, G59.1, G59.2, G59.3

Comments

clear, print, status, msg, clipboard, mdi,
log, logcreate, logopen, logclose,
paramsclear, txt,
pointsclear, pointssave, pointsload, pointsshapes, point, pointpos,
py, pythr,
name, desc, dlgname, dlg, dlgshow,
arrclr, array, arrchr, crc16, crc32,
sw_reset, sw_print,
block_begin, block_end,
usb, expr,
color

Motion

Cancel Motion: G80
Linear Feed Move: G00, G01
Arc Move: G02, G03
Curves: G05, G05.1, G05.2, G05.3
Home: G28, G30
Probe: G31, G38.1, G38.2, G38.3, G38.4, G38.5
Sync: G32, G33, G33.1
Shapes: G06, G06.1, G06.2, G06.3
Cycles: G75, G76, G77, G78, G79, G12, G13, G72, G72.1, G72.2,
G81, G82, G83, G84, G85, G86, G87, G88, G89, G73, G74

Delay

Dwell: G04

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
TXT - stores text property

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
CRC16 - calculates and adds crc16 to parameters
CRC32 - calculates and adds crc32 to parameters

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
NE	- Relational inequality	Usage: 12 NE 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: <code>EXPR[MSG('THIS IS TEXT')]</code> (result in #<_expr> parameter)
Exists	- Checks is value exists	Usage: <code>EXISTS[#<PARAM>]</code> = 0
NotExists	- Checks is value does not exists	Usage: <code>NOTEXISTS[#<PARAM>]</code> = 1
Active	- Checks g-code is running	Usage: <code>ACTIVE[]</code> = 1
Nop	- No operation (returns zero)	Usage: <code>NOP[]</code> = 0
Nan	- NaN value	Usage: <code>NAN[]</code> = nan
Def	- Sets default value	Usage: <code>DEF[NAN[], 100]</code> = 100
Abs	- Absolute value	Usage: <code>ABS[-123]</code> = 123
Sqrt	- Square Root	Usage: <code>SQRT[9]</code> = 3
Sqr	- Square	Usage: <code>SQR[3]</code> = 9
Sin	- Sine	Usage: <code>SIN[30]</code> = 0.5
Cos	- Cosine	Usage: <code>COS[60]</code> = 0.5
Tan	- Tangent	Usage: <code>TAN[45]</code> = 1
ASin	- Inverse sine	Usage: <code>ASIN[0.5]</code> = 30
ACos	- Inverse cosine	Usage: <code>ACOS[0.5]</code> = 60
ATan	- Inverse tangent	Usage: <code>ATAN[1]</code> = 45
ATan2	- Four quadrant inverse tangent	Usage: <code>ATAN2[1,1]</code> = 45
Pi	- Pi constant value	Usage: <code>PI[]</code> = 3.141593
Rad2Deg	- Radians to degrees	Usage: <code>RAD2DEG[3.141]</code> = 179.966043
Deg2Rad	- Degrees to radians	Usage: <code>DEG2RAD[180]</code> = 3.141593
E	- e constant value	Usage: <code>E[]</code> = 2.718282
Pow	- Power	Usage: <code>POW[2,3]</code> = 8
Exp	- e raised to the given power	Usage: <code>EXP[2]</code> = 7.389056
Exp10	- 10 raised to the given power	Usage: <code>EXP10[2]</code> = 100
Exp2	- 2 raised to the given power	Usage: <code>EXP2[2]</code> = 4
Log	- Base e logarithm	Usage: <code>LOG[2]</code> = 0.693147
Log10	- Base 10 logarithm	Usage: <code>LOG10[2]</code> = 0.301030
Log2	- Base 2 logarithm	Usage: <code>LOG2[2]</code> = 1
Rand	- Random value	Usage: <code>RAND[]</code> = 0.399394
Inc	- Increases value (value,limit,default)	Usage: <code>INC[5,10,0]</code> = 6
Dec	- Decreases value (value,limit,default)	Usage: <code>DEC[5,0,10]</code> = 4
Min	- Minimum	Usage: <code>MIN[4,6]</code> = 4
Max	- Maximum	Usage: <code>MAX[4,6]</code> = 6
Min3	- Minimum of 3	Usage: <code>MIN3[4,6,3]</code> = 3
Max3	- Maximum of 3	Usage: <code>MAX3[4,6,3]</code> = 6
Round	- Round to nearest integer	Usage: <code>ROUND[0.56]</code> = 1
RoundDec	- Round to nearest value with decimals	Usage: <code>ROUNDDEC[0.56,1]</code> = 0.6
Floor	- Round down to integer	Usage: <code>FLOOR[0.56]</code> = 0
Ceil	- Round up to integer	Usage: <code>CEIL[0.56]</code> = 1
Trunc	- Truncate to integer	Usage: <code>TRUNC[0.56]</code> = 0
Not	- Bitwise complement	Usage: <code>NOT[10]</code> = 4294967285
And	- Bitwise AND	Usage: <code>AND[10,3]</code> = 2
Or	- Bitwise OR	Usage: <code>OR[10,3]</code> = 11
Xor	- Bitwise exclusive OR	Usage: <code>XOR[10,3]</code> = 9
Nand	- Bitwise NAND	Usage: <code>NAND[10,3]</code> = 4294967293
Nor	- Bitwise NOR	Usage: <code>NOR[10,3]</code> = 4294967284
Xnor	- Bitwise exclusive NOR	Usage: <code>XNOR[10,3]</code> = 4294967286
Shl	- Bitwise shift left	Usage: <code>SHL[10,2]</code> = 40
Shr	- Bitwise shift right	Usage: <code>SHR[10,2]</code> = 2
LNot	- Logic complement	Usage: <code>LNOT[1]</code> = 0
LAnd	- Logic AND	Usage: <code>LAND[1,0]</code> = 0
LOr	- Logic non-exclusive OR	Usage: <code>LOR[1,0]</code> = 1
LXor	- Logic exclusive OR	Usage: <code>LXOR[1,0]</code> = 1
LNand	- Logic NAND	Usage: <code>LNAND[1,0]</code> = 1
LNor	- Logic non-exclusive NOR	Usage: <code>LNOR[1,0]</code> = 0
LXnor	- Logic exclusive NOR	Usage: <code>LXNOR[1,0]</code> = 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
ToMachine	- Converts work coordinate to machine	Usage: TOMACHINE[90,0]	= 100
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

<code>if</code>	- Conditional statement	Usage: <code>if(1, print("Yes"))</code>
<code>for</code>	- For statement	Usage: <code>for(i=0, i<10, i=i+1, print("Loop", i))</code>
<code>exec</code>	- Executes multiple expressions	Usage: <code>exec(print("One"), msg("Two"))</code>
<code>return</code>	- Returns from execution	
<code>exists</code>	- Checks if value exists	Usage: <code>exists(_param) = 0</code>
<code>notexists</code>	- Checks if value does not exists	Usage: <code>notexists(_param) = 1</code>
<code>isnum</code>	- Checks if value is valid number	
<code>nop</code>	- No operation (returns zero)	Usage: <code>nop() = 0</code>
<code>nan</code>	- NaN value	Usage: <code>nan() = nan</code>
<code>def</code>	- Sets default value	Usage: <code>def(nan(), 100) = 100</code>
<code>defnz</code>	- Sets default value not zero	Usage: <code>defnz(0, 100) = 100</code>
<code>abs</code>	- Absolute value	Usage: <code>abs(-123) = 123</code>
<code>sqrt</code>	- Square Root	Usage: <code>sqrt(9) = 3</code>
<code>sqr</code>	- Square	Usage: <code>sqr(3) = 9</code>
<code>sin</code>	- Sine	Usage: <code>sin(0.524) = 0.500347</code>
<code>cos</code>	- Cosine	Usage: <code>cos(1.047) = 0.500171</code>
<code>tan</code>	- Tangent	Usage: <code>tan(0.785) = 0.999204</code>
<code>asin</code>	- Inverse sine	Usage: <code>asin(0.5) = 0.523599</code>
<code>acos</code>	- Inverse cosine	Usage: <code>acos(0.5) = 1.047198</code>
<code>atan</code>	- Inverse tangent	Usage: <code>atan(1) = 0.785398</code>
<code>atan2</code>	- Four quadrant inverse tangent	Usage: <code>atan2(1,1) = 0.785398</code>
<code>pi</code>	- Pi constant value	Usage: <code>pi() = 3.141593</code>
<code>rad2deg</code>	- Radians to degrees	Usage: <code>rad2deg(3.141) = 179.966043</code>
<code>deg2rad</code>	- Degrees to radians	Usage: <code>deg2rad(180) = 3.141593</code>
<code>e</code>	- e constant value	Usage: <code>e() = 2.718282</code>
<code>pow</code>	- Power	Usage: <code>pow(2,3) = 8</code>
<code>exp</code>	- e raised to the given power	Usage: <code>exp(2) = 7.389056</code>
<code>exp10</code>	- 10 raised to the given power	Usage: <code>exp10(2) = 100</code>
<code>exp2</code>	- 2 raised to the given power	Usage: <code>exp2(2) = 4</code>
<code>log</code>	- Base e logarithm	Usage: <code>log(2) = 0.693147</code>
<code>log10</code>	- Base 10 logarithm	Usage: <code>log10(2) = 0.301030</code>
<code>log2</code>	- Base 2 logarithm	Usage: <code>log2(2) = 1</code>
<code>rand</code>	- random value	Usage: <code>rand() = 0.100845</code>
<code>inc</code>	- Increases value (value,limit,default)	Usage: <code>inc(5,10,0) = 6</code>
<code>dec</code>	- Decreases value (value,limit,default)	Usage: <code>dec(5,0,10) = 4</code>
<code>min</code>	- Minimum	Usage: <code>min(4,6) = 4</code> <code>min(4,6,3) = 3</code>
<code>max</code>	- Maximum	Usage: <code>max(4,6) = 6</code> <code>max(4,6,3) = 6</code>
<code>round</code>	- Round to nearest integer	Usage: <code>round(0.56) = 1</code> <code>round(0.56,1) = 0.6</code>
<code>roundup</code>	- Round up or down to nearest integer	
<code>floor</code>	- Round down to nearest value	Usage: <code>floor(0.56) = 0</code>
<code>ceil</code>	- Round up to integer	Usage: <code>ceil(0.56) = 1</code>
<code>trunc</code>	- Truncate to integer	Usage: <code>trunc(0.56) = 0</code>
<code>center</code>	- Compensate hysteresis	Usage: <code>center(0.3,0.2) = 0.2</code> <code>center(0.1,0.2) = 0.0</code>
<code>centerex</code>	- Compensate hysteresis	Usage: <code>centerex(0.3,0.2,1.0,0.8) = 0.044955</code> <code>centerex(0.1,0.2,1.0,0.8) = 0</code> <code>centerex(1,0.2,1.0,0.8) = 1</code> <code>centerex(0.9,0.2,1.0,0.8) = 0.619110</code>
<code>not</code>	- Bitwise complement	Usage: <code>not(10) = 4294967285</code>
<code>and</code>	- Bitwise AND	Usage: <code>and(10,3) = 2</code>
<code>or</code>	- Bitwise non-exclusive OR	Usage: <code>or(10,3) = 11</code>
<code>xor</code>	- Bitwise exclusive OR	Usage: <code>xor(10,3) = 9</code>
<code>nand</code>	- Bitwise NAND	Usage: <code>nand(10,3) = 4294967293</code>
<code>nor</code>	- Bitwise non-exclusive NOR	Usage: <code>nor(10,3) = 4294967284</code>
<code>xnor</code>	- Bitwise exclusive NOR	Usage: <code>xnor(10,3) = 4294967286</code>
<code>shl</code>	- Bitwise shift left	Usage: <code>shl(10,2) = 40</code>
<code>shr</code>	- Bitwise shift right	Usage: <code>shr(10,2) = 2</code>

<code>lnot</code>	- Logic complement	Usage: <code>lnot(1)</code>	= 0
<code>land</code>	- Logic AND	Usage: <code>land(1,0)</code>	= 0
<code>lor</code>	- Logic non-exclusive OR	Usage: <code>lor(1,0)</code>	= 1
<code>lxor</code>	- Logic exclusive OR	Usage: <code>lxor(1,0)</code>	= 1
<code>lnand</code>	- Logic NAND	Usage: <code>lnand(1,0)</code>	= 1
<code>lnor</code>	- Logic non-exclusive NOR	Usage: <code>lnor(1,0)</code>	= 0
<code>lxnor</code>	- Logic exclusive NOR	Usage: <code>lxnor(1,0)</code>	= 0
<code>eq</code>	- Relational equality	Usage: <code>eq(10,20)</code>	= 0
<code>ne</code>	- Relational inequality	Usage: <code>ne(10,20)</code>	= 1
<code>gt</code>	- Relational strictly greater than	Usage: <code>gt(10,20)</code>	= 0
<code>lt</code>	- Relational strictly less than	Usage: <code>lt(10,20)</code>	= 1
<code>ge</code>	- Relational greater than or equal to	Usage: <code>ge(10,20)</code>	= 0
<code>le</code>	- Relational less than or equal to	Usage: <code>le(10,20)</code>	= 1
<code>hex</code>	- Converts string to number	Usage: <code>hex("7E5")</code>	= 2021
<code>bin</code>	- Converts string to number	Usage: <code>bin("11111100101")</code>	= 2021
<code>chr</code>	- Converts string to number	Usage: <code>chr("A")</code>	= 65
<code>sleep</code>	- Sleeps n milliseconds	Usage: <code>sleep(100)</code>	
<code>datetime</code>	- Current time (seconds since 1970)	Usage: <code>datetime()</code>	= 1616502112.792
<code>year</code>	- Year from DateTime value	Usage: <code>year(1616502112.792)</code>	= 2021
<code>month</code>	- Month from DateTime value	Usage: <code>month(1616502112.792)</code>	= 3
<code>day</code>	- Day from DateTime value	Usage: <code>day(1616502112.792)</code>	= 23
<code>hour</code>	- Hour from DateTime value	Usage: <code>hour(1616502112.792)</code>	= 13
<code>minute</code>	- Minute from DateTime value	Usage: <code>minute(1616502112.792)</code>	= 21
<code>second</code>	- Second from DateTime value	Usage: <code>second(1616502112.792)</code>	= 52
<code>millisec</code>	- Millisecond from DateTime value	Usage: <code>millisec(1616502112.792)</code>	= 792
<code>rgb2hue</code>	- Converts RGB color to hue	Usage: <code>rgb2hue(11484891)</code>	= 283.18470955
<code>rgb2sat</code>	- Converts RGB color to saturation	Usage: <code>rgb2sat(11484891)</code>	= 71.68949842
<code>rgb2lum</code>	- Converts RGB color to luminence	Usage: <code>rgb2lum(11484891)</code>	= 85.88235378
<code>rubik</code>	- Solves Rubik Cube	Usage: <code>rubik("GYORWWWWW GGGBGGYGY ROWRRRRWB BOBBGRBB YY00000BR GYBWYRYYW") =</code> <code>R' D2 R2 F D' F2 U' F D' R U' L2 B2 R2 U F2 D' B2 L2 F2</code>	
<code>url</code>	- Downloads from internet	Usage: <code>url("http://www.planet-cnc.com/")</code>	
<code>sha256</code>	- Calculates SHA256 from string	Usage: <code>sha256("PlanetCNC")</code>	
<code>sha256_f</code>	- Calculates SHA256 from file	Usage: <code>sha256_f("c:\myfile.txt")</code>	
<code>md5</code>	- Calculates MD5 from string	Usage: <code>md5("PlanetCNC")</code>	
<code>md5_f</code>	- Calculates MD5 from file	Usage: <code>md5_f("c:\myfile.txt")</code>	
<code>crc16</code>	- Calculates CRC16 from string	Usage: <code>crc16("PlanetCNC")</code>	
<code>crc32</code>	- Calculates CRC32 from string	Usage: <code>crc32("PlanetCNC")</code>	
<code>debug</code>	- Prints to output window if debug==true	Usage: <code>debug("This is text")</code>	
<code>print</code>	- Prints to output window	Usage: <code>print("This is text")</code>	
<code>clear</code>	- Clears output window	Usage: <code>clear()</code>	
<code>status</code>	- Prints to status window	Usage: <code>status("This is text")</code>	
<code>msg</code>	- Shows dialog	Usage: <code>msg("This is text")</code>	
<code>beep</code>	- Plays beep sound	Usage: <code>beep(440, 0.5, 1)</code>	
<code>siren</code>	- Plays siren sound	Usage: <code>siren(440, 10, 1)</code>	
<code>sound_load</code>	- Loads mp3/wav to sound player	Usage: <code>sound_load(0, "c:\mysound.mp3")</code>	
<code>sound_unload</code>	- Unloads mp3/wav from sound player	Usage: <code>sound_unload(0)</code>	
<code>sound_play</code>	- Starts sound player	Usage: <code>sound_play(0)</code>	
<code>sound_stop</code>	- Stops sound player	Usage: <code>sound_stop(0)</code>	
<code>sound_isplaying</code>	- Checks if sound player is playing	Usage: <code>sound_isplaying(0)</code>	

towork	- Converts machine coordinate to work	Usage: towork(100,0)	= 90
toworkxy	- Converts machine coordinate to work	Usage: towork(100,50,0)	
toworkuv	- Converts machine coordinate to work	Usage: towork(100,50,0)	
tomachine	- Converts work coordinate to machine	Usage: tomachine(90,0)	= 100
tomachinexy	- Converts work coordinate to machine	Usage: tomachine(90,45,0)	
tomachineuv	- Converts work coordinate to machine	Usage: tomachine(90,45,0)	
mmtounit	- Converts MM to g-code units	Usage: mmtounit(1)	= 0.03937
unittomm	- Converts g-code units to MM	Usage: unittomm(1)	= 25.4
mmtoasetunit	- Converts MM to settings units	Usage: mmtoasetunit(1)	= 0.03937
setunittomm	- Converts settings units to MM	Usage: setunittomm(1)	= 25.4
setunit	- Chooses value based on settings units	Usage: setunit(25.4,1)	= 25.4
getparam	- Gets parameter	Usage: getparam('_machine_x')	= 123
setparam	- Sets parameter	Usage: setparam('_param', 123)	= 123
remparam	- Removes parameter		
cmd	- Executes 'cmd' command		
cmdlist	- Prints all 'cmd' commands		
startfn	- no description		
startcode	- no description		
py	- no description		
pythr	- no description		
estop	- E-Stops machine		
start	- Starts machine		
stop	- Stops machine		
pause	- Pause machine		
out	- Turns output pin on/off		
outpwm	- Turns pwm pin on/off		
extout1	- Turns ext1 pin on/off		
extout2	- Turns ext2 pin on/off		
jog	- Jog machine		
usb	- Send USB comand		
midi_noteOn	- no description		
midi_noteOff	- no description		
midi_ctrl	- no description		
midi_prog	- no description		
midiin_channel	- no description		
midiin_prog	- no description		
midiin_note	- no description		
midiin_ctrl	- no description		
pk_digital	- no description		
pk_analog	- no description		
cam_grab	- no description		
cam_color	- no description		
cam_rect	- no description		
buffer_new	- no description		
buffer_delete	- no description		
buffer_printstring	- no description		
buffer_printdata	- no description		
buffer_setstring	- no description		
buffer_setdata	- no description		
buffer_setdata16	- no description		
buffer_setdata32	- no description		
buffer_crc16	- no description		
buffer_crc32	- no description		

```
serial_list      - no description
serial_info      - no description
serial_open      - no description
serial_config    - no description
serial_close     - no description

serial_write     - no description
serial_writedata - no description
serial_writebuffer - no description

serial_read      - no description
serial_readdata  - no description
serial_readbuffer - no description
```

Expression unary operators

```
-      - Negation
!      - Logic NOT
~      - Bitwise
```

Expression binary operators

```
+      - Addition
-      - Subtraction
*      - Multiplication
/      - Division
%      - Modulo
^      - Power
=      - Assignment
>      - Greater than
>=     - Greater or equal than
<      - Less than
<=     - Less or equal than
==     - Equal
!=     - Not equal
&&     - Logic AND
||     - Logic OR
^^     - Logic XOR
&      - Bitwise AND
|      - Bitwise OR
^      - Bitwise XOR
<<     - Shift left
>>     - Shift right
```

Expression events

```
#Loop
#Loop5
#Loop15
#Loop60
#Loop300
#OnInit
#OnShutdown
#OnStart
#OnEnd
#OnStop
#OnEStop
#OnJog
#OnWheel
#OnCmd
```


Pipe commands

exit
isrunning

version
profname
profpath
description

isvisible
show
hide
setprogress
setstatus
msg
print

param
evaluate

islicensevalid
isuiready
iscontrollerready
iscontrollerrunning
isprogramloaded
isidle
isestop
isstop
ispause
isprog
iscmd
isjog

isestopenabled
isstopenabled
ispauseenabled
isstartenabled
isoutputenabled
iscodeenabled
iscodeexenabled
isopenenabled
iscloseenabled

estop
estop_enable
estop_disable
stop
pause
pause_enable
pause_disable
start
open
close

getcmdcount
getcmdid
getcmdidmdi
iscmdenabled
iscmdchecked
getcmdname
getcmddisname
getcmddisnamepath
cmdexec
cmdexecstr
cmdexecval
cmdexecintval

openfile
opencode
testfile
testcode
startfile
startcode

filename
linecount
line
linenum

isinitialized
serial
hwversion
swversion
versionvalid

poswork
posworkx
posworky
posworkz
posworka
posworkb
posworkc
posworku
posworkv
posworkw

posmotor
posmotorx
posmotory
posmotorz
posmotora
posmotorb
posmotorc
posmotoru
posmotorv
posmotorw

posworkunits
posworkunitsx
posworkunitsy
posworkunitsz
posworkunitsa
posworkunitsb
posworkunitsc
posworkunitsu
posworkunitsv
posworkunitsw

posmotorunits
posmotorunitsx
posmotorunitsy
posmotorunitsz
posmotorunitsa
posmotorunitsb
posmotorunitsc
posmotorunitsu
posmotorunitsv
posmotorunitsw

speed
accel
spindle
spindle_idx
spindle_enc
spindle_set
speed_ovrden

spindle_ovrden

inputhex

input
input1
input2
input3
input4
input5
input6
input7
input8

joghex

jog
jog1
jog2
jog3
jog4
jog5
jog6
jog7
jog8
joga1
joga2
jogs
jogpot

limithex

limit
limit1
limit2
limit3
limit4
limit5
limit6
limit7
limit8
limit9

outputhex

output
output1
output2
output3
output4
output5
output6
output7
output8

outputfreq1

outputfreq2
outputfreq3
outputfreq4
outputfreq5
outputfreq6
outputfreq7
outputfreq8

outputduty1

outputduty2
outputduty3
outputduty4
outputduty5
outputduty6
outputduty7
outputduty8

aux1

aux2
aux3
aux4

buffer
bufferutil

Python methods

Module: planetcnc

print
msg
msgerr
dlgFileOpen

result

Paths

getPath
getPathProfile
getPathTemp
getPathWorking

Run status

getVer
isRunning
isInitialized

Version & Profile Info

getVersionString
getProfileNameString
getProfilePathString
getDescriptionString

Screen

isVisible
show
hide
setProgress
setStatus

Parameters & Eval

getParam
setParam
evaluate

State

isLicenseValid
isUIReady
isControllerReady
isControllerRunning
isProgramLoaded
isIdle
isEStop
isStop
isPause
isProg
isCmd
isJog

Machine Command status

isEStopEnabled
isStopEnabled"
isPauseEnabled
isStartEnabled
isOutputEnabled
isCodeEnabled
isCodeExEnabled
isOpenEnabled
isCloseEnabled

Machine Commands

estop
estopToggle
stop
pause
pauseToggle
start
open
close

points_clear
points_count
points_add

Machine Commands Generic

getCmdId
getCmdIdFromMdi
isCmdEnabled
isCmdChecked

getCmdName
getCmdDisplayName

cmdExec
cmdExecStr"
cmdExecVal
cmdExecIntVal

Helpers

openFn
openCode

startFn
startCode

testFn
testCode

cmd
mdi

Info

infoIsInitialized
infoSerial
infoHWVersion
infoSWVersion
infoIsVersionValid
infoWorkPos
infoWorkPosList
infoMotorPos
infoMotorPosList
infoSpeed
infoAcceleration
infoSpindle
infoSpindleIdx,
infoSpindleEnc
infoSpindleSet
infoInput
infoJog
infoJogPot
infoLimit
infoOutput
infoOutputFreq
infoOutputDuty
infoAux
infoBufferAvailable
infoBufferUtilization

Dlg

dlgNew
dlgShow
dlgClose
dlgAddLabel
dlgAddCheckbox
dlgAddInput
dlgAddImage
dlgGetValue

Image

imageOpen
imageClose
imageSize
imageGetPixel
imageGetPixelGray

Module: gcode

isReady
isOpening
isRunning
close
open
load
lineAddAllowed
lineAdd

List of string parameters

Usage: \$<parametername>

toolchangenname
current_toolname
selected_toolname
tool_name|num
name
desc
axis|num
date
time
datetime
profilepath
profilename
filepath
filename
fileext

List of parameters

Usage: #<parametername>

		<code>_blendmode</code>	(R)
		<code>_blend_tol</code>	(R)
Work position:			
<code>_x</code>	(R)		
<code>_y</code>	(R)		
<code>_z</code>	(R)		
<code>_a</code>	(R)		
<code>_b</code>	(R)		
<code>_c</code>	(R)		
<code>_u</code>	(R)		
<code>_v</code>	(R)		
<code>_w</code>	(R)		
<code>_work_axis</code>	(R)		
		Feed:	
		<code>_feedmode</code>	(R)
		<code>_feedspeed</code>	(R)
		<code>_feedspeed_upm</code>	(R)
		<code>_feedspeed_upr</code>	(R)
		Spindle:	
		<code>_spindlemode</code>	(R)
		<code>_spindlespeed</code>	(R)
		<code>_spindlespeed_rpm</code>	(R)
		<code>_spindlespeed_css</code>	(R)
		Tools:	
		<code>_selected_tool</code>	(RW)
		<code>_current_tool</code>	(RW)
		<code>_tooloff_isset</code>	(R)
		<code>_tooloff</code>	(RW)
		<code>_tooloff_x</code>	(RW)
		<code>_tooloff_y</code>	(RW)
		<code>_tooloff_z</code>	(RW)
		<code>_tooloff_a</code>	(RW)
		<code>_tooloff_b</code>	(RW)
		<code>_tooloff_c</code>	(RW)
		<code>_tooloff_u</code>	(RW)
		<code>_tooloff_v</code>	(RW)
		<code>_tooloff_w</code>	(RW)
		<code>_tooloff_axis</code>	(RW)
		<code>_toolcomp</code>	(R)
		<code>_toolcomp_dia</code>	(R)
		<code>_toolcomp_orient</code>	(R)
		Tool Table:	
		<code>_tool_exists</code>	(R)
		<code>_tool_name</code>	(R)
		<code>_tool_ismill_num</code>	(R)
		<code>_tool_isdrill_num</code>	(R)
		<code>_tool_isturn_num</code>	(R)
		<code>_tool_isprobe_num</code>	(R)
		<code>_tool_islaser_num</code>	(R)
		<code>_tool_isother_num</code>	(R)
		<code>_tool_dia_num</code>	(RW)
		<code>_tool_off_x_num</code>	(RW)
		<code>_tool_off_y_num</code>	(RW)
		<code>_tool_off_z_num</code>	(RW)
		<code>_tool_off_a_num</code>	(RW)
		<code>_tool_off_b_num</code>	(RW)
		<code>_tool_off_c_num</code>	(RW)
		<code>_tool_off_u_num</code>	(RW)
		<code>_tool_off_v_num</code>	(RW)
		<code>_tool_off_w_num</code>	(RW)
		<code>_tool_tc_x_num</code>	(RW)
		<code>_tool_tc_y_num</code>	(RW)
		<code>_tool_tc_z_num</code>	(RW)
		<code>_tool_tc_a_num</code>	(RW)
		<code>_tool_tc_b_num</code>	(RW)
		<code>_tool_tc_c_num</code>	(RW)
Machine position:			
<code>_machine_x</code>	(R)		
<code>_machine_y</code>	(R)		
<code>_machine_z</code>	(R)		
<code>_machine_a</code>	(R)		
<code>_machine_b</code>	(R)		
<code>_machine_c</code>	(R)		
<code>_machine_u</code>	(R)		
<code>_machine_v</code>	(R)		
<code>_machine_w</code>	(R)		
<code>_machine_axis</code>	(R)		
Probe position:			
<code>_probe</code>	(R)		
<code>_probe_x</code>	(R)		
<code>_probe_y</code>	(R)		
<code>_probe_z</code>	(R)		
<code>_probe_a</code>	(R)		
<code>_probe_b</code>	(R)		
<code>_probe_c</code>	(R)		
<code>_probe_u</code>	(R)		
<code>_probe_v</code>	(R)		
<code>_probe_w</code>	(R)		
<code>_probe_axis</code>	(R)		
<code>_measure</code>	(RW)		
<code>_measure_x</code>	(RW)		
<code>_measure_y</code>	(RW)		
<code>_measure_z</code>	(RW)		
<code>_measure_axis</code>	(RW)		
<code>_measure_size_x</code>	(RW)		
<code>_measure_size_y</code>	(RW)		
<code>_measure_size_z</code>	(RW)		
<code>_measure_size_axis</code>	(RW)		
<code>_measure_rot</code>	(RW)		
THC:			
<code>_thc</code>	(R)		
<code>_thcen</code>	(R)		
Mode:			
<code>_motion</code>	(R)		
<code>_units</code>	(RW)		
<code>_plane</code>	(RW)		
<code>_distancemode</code>	(RW)		
<code>_distancemode_ijk</code>	(RW)		
<code>_distancemode_abc</code>	(RW)		
<code>_polarmode</code>	(RW)		
<code>_cyclereturnmode</code>	(RW)		
<code>_lathemode</code>	(RW)		
Blend:			

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

Input/Output:
 _input (R)
 _input_num (R)
 _output (RW)
 _output_num (RW)

_extin1 (R)
 _extin1_num (R)
 _extin2 (R)
 _extin2_num (R)

_extout1 (RW)
 _extout1_num (RW)
 _extout2 (RW)
 _extout2_num (RW)

_pk_digital (RW)
 _pk_analog (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)

_pause_optional (RW)

Settings - Measure:

_probe_pin_1 (RW)
_probe_pin_2 (RW)

_probe_speed	(RW)	_tc_pos_en	(RW)
_probe_speed_low	(RW)	_tc_pos_x	(RW)
_probe_swdist	(RW)	_tc_pos_y	(RW)
		_tc_pos_z	(RW)
		_tc_action	(RW)
_probe_sizeZ	(RW)	_tc_toolmeasure	(RW)
_probe_sizeXY	(RW)	_tc_tooloff_en	(RW)
_probe_size_axis	(RW)	_tc_autoreturn	(RW)
_probe_sizedx	(RW)		
_probe_sizedy	(RW)	_tc_atc_en	(RW)
_probe_sized_axis	(RW)	_tc_atc_speed	(RW)
_probe_use_tooltable	(RW)	_tc_atc_speed2	(RW)
_probe_safeheight	(RW)		
_probe_estop	(RW)	_tc_unload_in1_x	(RW)
		_tc_unload_in1_y	(RW)
		_tc_unload_in1_z	(RW)
Settings - Home:			
_home_speed	(RW)		
_home_speed_low	(RW)	_tc_unload_in2_x	(RW)
_home_swdist	(RW)	_tc_unload_in2_y	(RW)
		_tc_unload_in2_z	(RW)
_home_order_x	(RW)	_tc_unload_pin1	(RW)
_home_order_y	(RW)	_tc_unload_pin1set1	(RW)
_home_order_z	(RW)	_tc_unload_pin1delay1	(RW)
_home_order_a	(RW)	_tc_unload_pin1set2	(RW)
_home_order_b	(RW)	_tc_unload_pin1delay2	(RW)
_home_order_c	(RW)		
_home_order_u	(RW)		
_home_order_v	(RW)	_tc_unload_pin2	(RW)
_home_order_w	(RW)	_tc_unload_pin2set1	(RW)
_home_order_axis	(RW)	_tc_unload_pin2delay1	(RW)
		_tc_unload_pin2set2	(RW)
		_tc_unload_pin2delay2	(RW)
_home_dir_x	(RW)		
_home_dir_y	(RW)		
_home_dir_z	(RW)	_tc_unload_out1_x	(RW)
_home_dir_a	(RW)	_tc_unload_out1_y	(RW)
_home_dir_b	(RW)	_tc_unload_out1_z	(RW)
_home_dir_c	(RW)		
_home_dir_u	(RW)	_tc_unload_out2_x	(RW)
_home_dir_v	(RW)	_tc_unload_out2_y	(RW)
_home_dir_w	(RW)	_tc_unload_out2_z	(RW)
_home_dir_axis	(RW)		
		_tc_load_in1_x	(RW)
_home_swpos_x	(RW)	_tc_load_in1_y	(RW)
_home_swpos_y	(RW)	_tc_load_in1_z	(RW)
_home_swpos_z	(RW)		
_home_swpos_a	(RW)	_tc_load_in2_x	(RW)
_home_swpos_b	(RW)	_tc_load_in2_y	(RW)
_home_swpos_c	(RW)	_tc_load_in2_z	(RW)
_home_swpos_u	(RW)		
_home_swpos_v	(RW)	_tc_load_pin1	(RW)
_home_swpos_w	(RW)	_tc_load_pin1set1	(RW)
_home_swpos_axis	(RW)	_tc_load_pin1delay1	(RW)
		_tc_load_pin1set2	(RW)
		_tc_load_pin1delay2	(RW)
_home_moveto_x	(RW)		
_home_moveto_y	(RW)	_tc_load_pin2	(RW)
_home_moveto_z	(RW)	_tc_load_pin2set1	(RW)
_home_moveto_a	(RW)	_tc_load_pin2delay1	(RW)
_home_moveto_b	(RW)	_tc_load_pin2set2	(RW)
_home_moveto_c	(RW)	_tc_load_pin2delay2	(RW)
_home_moveto_u	(RW)		
_home_moveto_v	(RW)		
_home_moveto_w	(RW)	_tc_load_out1_x	(RW)
_home_moveto_axis	(RW)	_tc_load_out1_y	(RW)
		_tc_load_out1_z	(RW)
Settings - Tool Change			
_tc_enable	(RW)	_tc_load_out2_x	(RW)
_tc_skipsame	(RW)	_tc_load_out2_y	(RW)
_tc_spindlecheck	(RW)	_tc_load_out2_z	(RW)
_tc_safeheight_en	(RW)		
_tc_safeheight	(RW)	Settings - Tool Offset:	

_tooloff_speed	(RW)	_hw_motorraw_w	(R)
_tooloff_speed_low	(RW)		
_tooloff_swdist	(RW)	_hw_motor_x	(R)
_tooloff_safeheight	(RW)	_hw_motor_y	(R)
_tooloff_sensorX	(RW)	_hw_motor_z	(R)
_tooloff_sensorY	(RW)	_hw_motor_a	(R)
_tooloff_sensorZ	(RW)	_hw_motor_b	(R)
		_hw_motor_c	(R)
Settings - Work Offset:		_hw_motor_u	(R)
_workoff_speed	(RW)	_hw_motor_v	(R)
_workoff_speed_low	(RW)	_hw_motor_w	(R)
_workoff_swdist	(RW)		
_workoff_size	(RW)	_hw_work_x	(R)
_workoff_useprobe	(RW)	_hw_work_y	(R)
		_hw_work_z	(R)
Settings - Gantry Square		_hw_work_a	(R)
_gantrysquare_speed	(RW)	_hw_work_b	(R)
_gantrysquare_axis	(RW)	_hw_work_c	(R)
_gantrysquare_dir	(RW)	_hw_work_u	(R)
_gantrysquare_move_u	(RW)	_hw_work_v	(R)
_gantrysquare_move_v	(RW)	_hw_work_w	(R)
HW:		_hw_srcidx	(R)
_hw_isinit	(R)	_hw_linenum	(R)
_hw_serial	(R)	_hw_dist_xyz	(R)
_hw_version	(R)	_hw_dist_abc	(R)
_sw_version	(R)	_hw_dist_uvw	(R)
_hw_sim	(R)	_hw_dist_x	(R)
		_hw_dist_y	(R)
_hw_buffavail	(R)	_hw_dist_z	(R)
_hw_buffempty	(R)	_hw_dist_a	(R)
_hw_buffutil	(R)	_hw_dist_b	(R)
_hw_bufflimit	(R)	_hw_dist_c	(R)
		_hw_dist_u	(R)
_hw_cmdbufffull	(R)	_hw_dist_v	(R)
_hw_cmdbufffree	(R)	_hw_dist_w	(R)
_hw_cmdbuffunread	(R)	_hw_dist_axis	(R)
_hw_cmdlevel	(R)		
		_hw_output	(R)
_hw_idle	(R)	_hw_output_num	(R)
_hw_run	(R)	_hw_output_freq1	(R)
_hw_estop	(R)	_hw_output_duty1	(R)
_hw_stop	(R)	_hw_output_freq2	(R)
_hw_pause	(R)	_hw_output_duty2	(R)
_hw_isprog	(R)	_hw_output_freq3	(R)
_hw_iscmd	(R)	_hw_output_duty3	(R)
_hw_isjog	(R)	_hw_output_freq4	(R)
		_hw_output_duty4	(R)
_hw_speed	(R)	_hw_output_freq5	(R)
_hw_accel	(R)	_hw_output_duty5	(R)
_hw_spindle	(R)	_hw_output_freq6	(R)
_hw_spindle_dir	(R)	_hw_output_duty6	(R)
_hw_spindle_idx	(R)	_hw_output_freq7	(R)
_hw_spindle_enc	(R)	_hw_output_duty7	(R)
_hw_spindle_ui	(R)	_hw_output_freq8	(R)
		_hw_output_duty8	(R)
_hw_mist	(R)		
_hw_flood	(R)	_hw_extin1_num	(R)
		_hw_extin2_num	(R)
_hw_ovrdspeed_enabled	(R)	_hw_extout1_num	(R)
_hw_ovrdspindle_enabled	(R)	_hw_extout2_num	(R)
_hw_motorraw_x	(R)	_hw_input	(R)
_hw_motorraw_y	(R)	_hw_input_num	(R)
_hw_motorraw_z	(R)		
_hw_motorraw_a	(R)	_hw_limit	(R)
_hw_motorraw_b	(R)	_hw_limit_num	(R)
_hw_motorraw_c	(R)		
_hw_motorraw_u	(R)	_hw_jog	(R)
_hw_motorraw_v	(R)	_hw_jogpot	(R)

_hw_ctrl	(R)	_prog_mintrav_z	(R)
		_prog_mintrav_a	(R)
		_prog_mintrav_b	(R)
_hw_aux1	(R)	_prog_mintrav_c	(R)
_hw_aux2	(R)	_prog_mintrav_u	(R)
_hw_aux3	(R)	_prog_mintrav_v	(R)
_hw_aux4	(R)	_prog_mintrav_w	(R)
_hw_error	(R)	_prog_maxtrav_x	(R)
_hw_motors_en	(R)	_prog_maxtrav_y	(R)
_hw_limits_en	(R)	_prog_maxtrav_z	(R)
_hw_axislock	(R)	_prog_maxtrav_a	(R)
		_prog_maxtrav_b	(R)
		_prog_maxtrav_c	(R)
_hw_ctrlspindleidx_rpm	(R)	_prog_maxtrav_u	(R)
_hw_ctrlspindleidx_val	(R)	_prog_maxtrav_v	(R)
		_prog_maxtrav_w	(R)
_hw_ctrlspindle_rpm	(R)	_prog_minfeed_x	(R)
_hw_ctrlspindle_dir	(R)	_prog_minfeed_y	(R)
_hw_ctrlspindle_val	(R)	_prog_minfeed_z	(R)
		_prog_minfeed_a	(R)
_hw_ctrlmpg_rpm	(R)	_prog_minfeed_b	(R)
_hw_ctrlmpg_dir	(R)	_prog_minfeed_c	(R)
_hw_ctrlmpg_val	(R)	_prog_minfeed_u	(R)
_hw_ctrlmpg_velocity	(R)	_prog_minfeed_v	(R)
		_prog_minfeed_w	(R)
		_prog_maxfeed_x	(R)
_hw_mpg_mode	(R)	_prog_maxfeed_y	(R)
_hw_mpg_axis	(R)	_prog_maxfeed_z	(R)
_hw_mpg_key	(R)	_prog_maxfeed_a	(R)
_hw_mpg_delta	(R)	_prog_maxfeed_b	(R)
_hw_mpg_value	(R)	_prog_maxfeed_c	(R)
_hw_mpg_axisnum	(R)	_prog_maxfeed_u	(R)
_hw_mpg_velocity	(R)	_prog_maxfeed_v	(R)
		_prog_maxfeed_w	(R)
_hw_returnparam	(R)	_prog_maxspeed	(R)
		_prog_minspeed	(R)
		_prog_maxspindle	(R)
		_prog_minspindle	(R)
Program:			
_prog_size	(R)		
_prog_linecount	(R)		
_prog_totallen	(R)		
_prog_totaltime	(R)		
_prog_linelimit	(R)	UI:	
_prog_looplimit	(R)	_isuiready	(R)
_prog_loadtime	(R)		
		_progress	(R)
		_progress_timetoend	(R)
_prog_min_x	(R)	_progress_loop	(R)
_prog_min_y	(R)	_progress_loopcnt	(R)
_prog_min_z	(R)		
_prog_min_a	(R)	_ui_width	(R)
_prog_min_b	(R)	_ui_height	(R)
_prog_min_c	(R)		
_prog_min_u	(R)	_selected_gcode_line	(R)
_prog_min_v	(R)	_selected_gcode	(R)
_prog_min_w	(R)	_selected_gcode_x	(R)
		_selected_gcode_y	(R)
		_selected_gcode_z	(R)
_prog_max_x	(R)	_selected_gcode_a	(R)
_prog_max_y	(R)	_selected_gcode_b	(R)
_prog_max_z	(R)	_selected_gcode_c	(R)
_prog_max_a	(R)	_selected_gcode_u	(R)
_prog_max_b	(R)	_selected_gcode_v	(R)
_prog_max_c	(R)	_selected_gcode_w	(R)
_prog_max_u	(R)		
_prog_max_v	(R)	Dialogs:	
_prog_max_w	(R)	_toolnumber	(R)
_prog_mintrav_x	(R)		
_prog_mintrav_y	(R)	_coord_x	(R)

<code>_coord_y</code>	(R)	<code>_coord_v_en</code>	(R)
<code>_coord_z</code>	(R)	<code>_coord_w_en</code>	(R)
<code>_coord_a</code>	(R)	<code>_coord_rot_en</code>	(R)
<code>_coord_b</code>	(R)		
<code>_coord_c</code>	(R)	Other:	
<code>_coord_u</code>	(R)	<code>_start_firstline</code>	(R)
<code>_coord_v</code>	(R)	<code>_start_lastline</code>	(R)
<code>_coord_w</code>	(R)	<code>_start_loops</code>	(R)
<code>_coord_rot</code>	(R)		
		<code>_return</code>	(R)
<code>_coord_x_en</code>	(R)		
<code>_coord_y_en</code>	(R)		
<code>_coord_z_en</code>	(R)		
<code>_coord_a_en</code>	(R)		
<code>_coord_b_en</code>	(R)		
<code>_coord_c_en</code>	(R)		
<code>_coord_u_en</code>	(R)		

Table of Contents

G-Codes	2
Mode.....	2
G20 - Inch Units.....	2
G70 - Inch Units.....	2
G21 - Millimeter Units.....	2
G71 - Millimeter Units.....	2
G17 - XY Plane.....	3
G18 - ZX Plane.....	3
G19 - YZ Plane.....	3
G90 - Distance Mode – Absolute.....	4
G91 - Distance Mode – Incremental.....	4
G90.1 - Distance Mode – IJK Absolute.....	4
G91.1 - Distance Mode – IJK Incremental.....	4
G90.2 - Distance Mode – ABC Absolute.....	4
G91.2 - Distance Mode – ABC Incremental.....	4
G98 - Cycle Return - Initial Z Point.....	5
G99 - Cycle Return - R Point.....	5
G07 - Lathe Mode – Diameter.....	5
G08 - Lathe Mode – Radius.....	5
G15 - Polar Coordinate Cancel.....	6
G16 - Polar Coordinate Enable.....	6
G61 - Blend Cancel.....	7
G64 - Blend Enable.....	7
G93 - Feed Mode - Inverse Time.....	8
G94 - Feed Mode - Units per Minute.....	8
G95 - Feed Mode - Units per Revolution.....	8
G96 - Spindle Mode – CSS.....	8
G97 - Spindle Mode – RPM.....	8
Tools.....	9
G40 - Tool Compensation Cancel.....	9
G41 - Tool Compensation Left.....	9
G42 - Tool Compensation Right.....	9
G41.1 - Tool Compensation Dynamic Left.....	9
G42.1 - Tool Compensation Dynamic Right.....	9
G43 - Tool Offset+ Enable.....	10
G44 - Tool Offset- Enable.....	10
G43.1 - Tool Offset+ Enable.....	10
G44.1 - Tool Offset- Enable.....	10
G49 - Tool Offset Cancel.....	10
Coordinate Systems.....	11
G54 - Coordinate System 1.....	11
G55 - Coordinate System 2.....	11
G56 - Coordinate System 3.....	11
G57 - Coordinate System 4.....	11
G58 - Coordinate System 5.....	11
G59 - Coordinate System 6.....	11
G59.1 - Coordinate System 7.....	11
G59.2 - Coordinate System 8.....	11
G59.3 - Coordinate System 9.....	11
G54.1 - Coordinate System P.....	11
G59 P- Coordinate System P.....	11
Offsets.....	12
G92 - Working Offset.....	12
G92.1 - Working Offset Set.....	12

G52 - Axes Offset.....	12
G52.1 - Axes Offset Cancel.....	12
G51 - Axes Scale Enable.....	13
G50 - Axes Scale Cancel.....	13
G68 - Axes Rotate Enable.....	13
G69 - Axes Rotate Cancel.....	13
Motion.....	14
G80 - Cancel Motion.....	14
G00 - Rapid Move.....	14
G01 - Linear Feed Move.....	14
G02 - Clockwise Arc Feed Move.....	15
G03 - Counter Clockwise Arc Feed Move.....	15
G05 - Cubic Spline.....	16
G05.1 - Quadratic Spline.....	16
G05.2 - NURBS Block.....	17
G05.3 - NURBS Block End.....	17
G06 - Shapes Exec.....	18
G06.1 - Shapes Clear.....	18
G06.2 - Shapes Load.....	18
G06.3 - Shapes Process.....	19
G28 - Go To Home 1 Position.....	20
G28.1 - Set Home 1 Position.....	20
G30 - Go To Home 2 Position.....	20
G30.1 - Set Home 2 Position.....	20
G32 - Spindle Synchronized Motion / Threading.....	21
G33 - Spindle Synchronized Motion / Threading.....	21
G33.1 - Spindle Synchronized Motion With Return / Rigid Tapping.....	21
G31 - Probe.....	22
G38.1 - Probe.....	22
G38.2 - Probe.....	22
G38.3 - Probe.....	22
G38.4 - Probe.....	22
G38.5 - Probe.....	22
Settings.....	23
G10 L9 - Set Controller Position.....	23
G10 L3 - Transformation.....	23
G10 L1, L10 - Tool Table.....	24
G10 L2, L20 - Coordinate System.....	24
Other.....	25
G04 - Dwell.....	25
G09 - Stop, Sync & Set Controller Position.....	25
G53 - Machine Coordinate System.....	25
Cycles.....	26
Mill Cycles.....	27
G12 - Mill: Circular Pocket CW.....	27
G13 - Mill: Circular Pocket CCW.....	27
G72 - Mill: Facing.....	28
G72.1 - Mill: Profile TODO.....	29
G72.2 - Mill: Pocket TODO.....	29
Turn Cycles.....	30
G75 - Turn: Pattern Repeating TODO.....	30
G76 - Turn: Threading.....	30
G77 - Turn: Roughing X TODO.....	31
G78 - Turn: Roughing Z TODO.....	31
G79 - Turn: Grooving TODO.....	31
Drill Cycles.....	32

G81 - Drill - Drill.....	32
G82 - Drill: Drill, Dwell.....	32
G83 - Drill: Drill, Peck, Dwell.....	33
G73 - Drill: Drill, Speed Peck, Dwell.....	35
G84 - Drill: Tapping Right.....	37
G74 - Drill: Tapping Left.....	37
G85 - Drill: Boring, Feed Out.....	38
G86 - Drill: Boring, Spindle Stop, Rapid Out, Spindle Start.....	38
G87 - Drill: Boring, Spindle Reverse, Rapid Out, Spindle Reverse.....	39
G88 - Drill: Boring, Spindle Stop, Feed Out, Spindle Start.....	39
G89 - Drill: Boring, Spindle Reverse, Feed Out, Spindle Reverse.....	40
M-Codes.....	41
Program.....	41
M0 - Pause.....	41
M1 - Optional pause.....	41
M2 - Program End.....	41
M30 - Program End.....	41
Spindle.....	42
M3 - Spindle CW.....	42
M4 - Spindle CCW.....	42
M5 - Spindle Stop.....	42
Tools.....	43
M6 - Tool Change.....	43
M61 - Tool Select.....	43
Coolant.....	44
M7 - Mist On.....	44
M17 - Mist Off/On.....	44
M8 - Flood On.....	44
M18 - Flood Off/On.....	44
M9 - Mist & Flood Off.....	44
Overrides and options.....	45
M48 - Enable Override Feed & Spindle.....	45
M49 - Disable Override Feed & Spindle.....	45
M50 - Enable/Disable Override Feed.....	45
M51 - Enable/Disable Override Spindle.....	45
M52 - Sets controller parameter.....	45
M53 - Enable/Disable Pause.....	46
M54 - Enable/Disable THC.....	46
M55 - Enable/Disable Transformations.....	46
M56 - Enable/Disable Warp.....	46
M57 - Enable/Disable Swap.....	46
Inputs & Outputs.....	47
M10 - Enable/Disable motor enable signal.....	47
M11 - Enable/Disable limits.....	47
M59 - Wait For Input.....	47
M62 - Output.....	47
M63 - Output PWM.....	48
M64 - Output ExtOut.....	48
M65 - Output Serial.....	49
M66 - Output I2C.....	49
Modal State.....	50
M70 - Modal State Store.....	50
M71 - Modal State Invalidate.....	51
M72 - Modal State Restore.....	51
M73 - Modal State Store & Autorestore.....	51
Other Codes.....	52

F - Feed Speed.....	52
S - Spindle Speed.....	52
T - Select Tool.....	52
List of G-Codes.....	53
List of M-Codes.....	54
O-Words.....	55
Order of execution.....	56
Comments.....	57
Operators.....	58
Operator precedence.....	58
G-Code functions.....	59
Expression functions.....	61
Expression unary operators.....	64
Expression binary operators.....	64
Expression events.....	64
Pipe commands.....	65
Python methods.....	69
Module: planetcnc.....	69
Module: gcode.....	71
List of string parameters.....	72
List of parameters.....	73