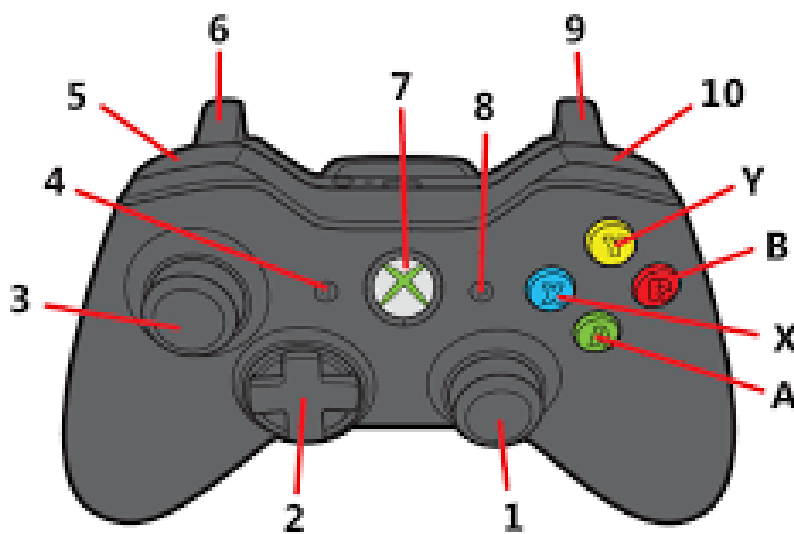# Xbox gamepad CNC pendant user manual

Computer controlled manufacturing machines are awesome, and not designed for manual cutting. This controller, for LinuxCNC, maintains the nimble feel of a manual machine while harnessing the power of a computerized machine.

Table of Contents

Illustration 1: Controller layout.

1.   Right joystick

2.   Dpad (directional pad)

3.   Left joystick

4.   Back button

5.   Left shift button

6.   Brake trigger

7.   Undo button

8.   Start button

9.   Gas trigger

10.   Right shift button

A)   Run button

B)   Stop button3

X)   Mark button

Y)   Spindle button

CONTROLLER FEATURES

RESPONSE TIME

The controller is running as a component in the 1000 Hz servo thread. Cutting operations do not rely on MDI commands, all motions intended for cutting are directly controlled by the C-language Xbox component.

GRAPHICAL INTERFACE

The graphical interface, seen to the left in Illustration 2, is integrated into the Gmoccapy user interface and contains settings for the operations. All settings can be set either directly with the Xbox controller, or by using mouse and keyboard. Cutting operations are available only from the Xbox controller. Some settings are available as shortcuts on the Xbox controller. The shortcuts are described below in the appropriate sections. Settings are automatically saved and restored on start up.
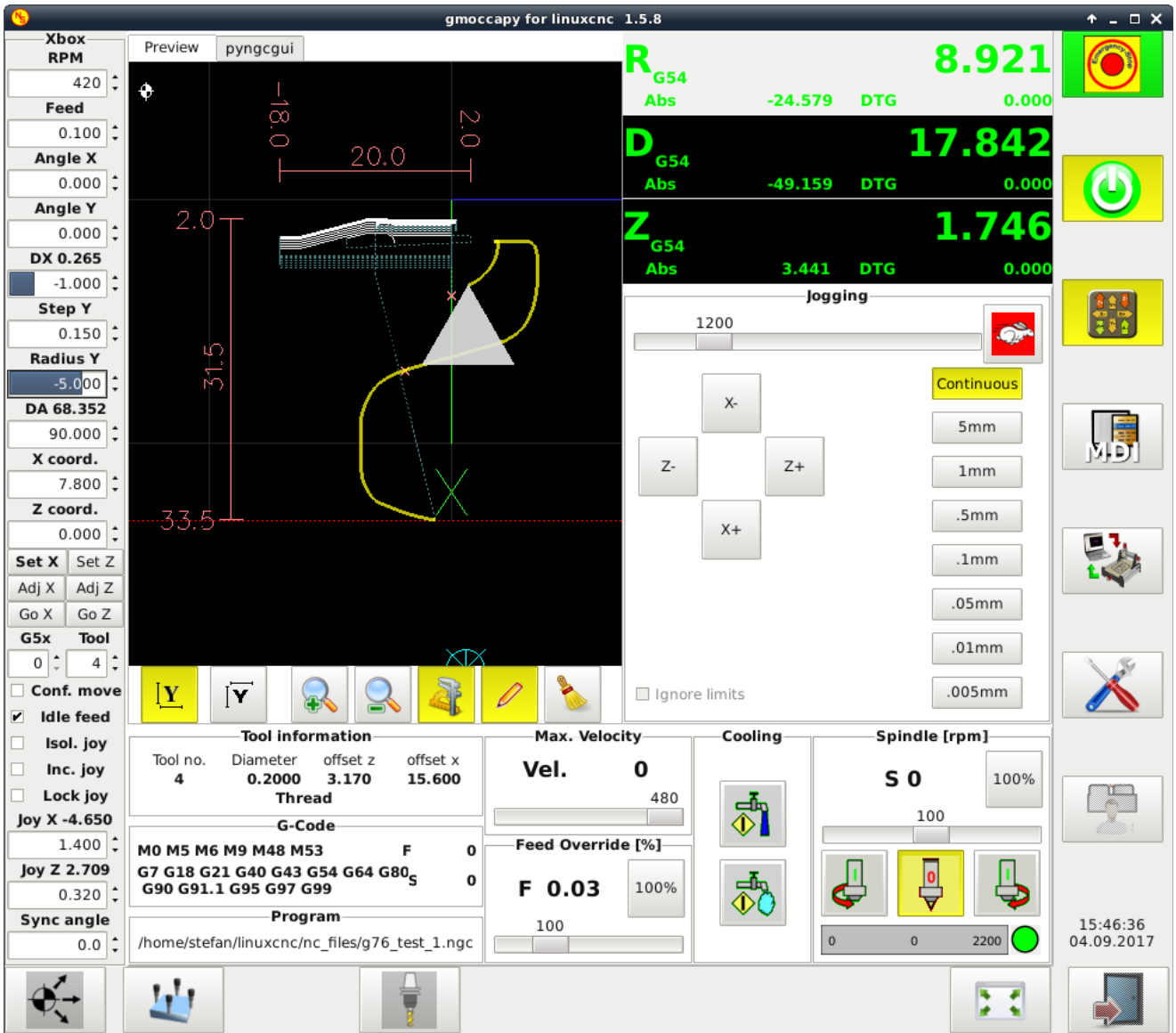
Illustration 2: The panel to the left is the Xbox pendant graphical interface.

To set the spinbox values with the Xbox controller, enter edit mode by pressing the (small black) start button. Move between the spinboxes with the left or right shift buttons. Set the values with the dpad (directional pad), left/right moves the cursor, up/down increases/decreases the value by the amount indicated by the cursor. Fast change of sign can be accomplished by pressing left while at the leftmost cursor position. The (blue) mark button rounds the least significant figure, this is also a fast way to zero the spinbox value. Exit edit mode by pressing the (small black) start button or the (red) stop button. There are blue bars progressing in the spinboxes of the active

features. The progress bar indicates the current relative position within in the pocket or radius. When a pocket or radius is active their labels will change to show a precise measurement of the distance or angle traveled from the beginning of the pocket or radius, see further details about those features in later sections. Also, watch the frame label (Xbox text), it changes to give terse information about what is going on.

UNDO MOVE

No one would accept a word editor or a CAD program without an undo/redo feature. Any move initiated from the wireless controller can now be undone. Material removal unfortunately cannot be undone. An arbitrary number of moves, set by[1] [JOYPAD]*MAX_UNDOES* can be undone. It is safe to try to do too many undoes or redoes, it will not move to an undefined position. Undo/redo moves are done by max velocity, or with feed velocity if a negative feed is entered in the Feed spinbox. Notice that undo/redo will move to the last/next position following a straight line, curved moves will be undone by the shortest distance to the initial position. Moves smaller than [JOYPAD]*MIN_UNDO_MOVE* will not be saved, neither will moves with too short time duration (~0.2 s). The big X-marked undo button undoes the previous move, and the previous, etc. Left shift plus the undo button redoes the latest move undone. Note that undoing a move while a pocket or radius is active will move the pocket or radius.

RUN AND STOP BUTTONS

When the machine is not on, the (green) run button will turn the machine on. If the machine is not homed, then the run button will home the machine. The run button will also change the macine mode to auto, start the program if in auto, confirm the tool change and move messages, pause a running program, and resume the program execution of a paused program.

The (red) stop button triggers an emergency stop if held down or double clicked. The stop button will also clear messages, pause a running program, stop a paused program, change the machine mode to manual, and abort step, radius, and edit mode.

GRAPHICAL PREVIEW (GREMLIN)

LinuxCNC and Gmoccapy feature a graphical preview where both the programmed and historical tool path is visualized. To pan in the preview use the left joystick. Left shift button plus left joystick zooms in and out. Left shift plus the (red) stop button will erase the historical tool path and redraw the preview.

LOGGED MOVES FILE

Any move by the wireless controller is retrievable from the undo logfile, which contains position, average feed, type of move, and time, Illustration 3. Positions are absolute in the current work coordinate system. Positions respect the radial or diametric setting given by G7/G8. A new file is started at every restart of the system, the last file is overwritten.

```
1 X, Y, Z, S (RPM), avg. feed (mm/min), Move type, 2017-03-30 01:25:27.206298.
2 max_undoes 20, min_undo_move 0.01.
3
4 Saved position 34.445, 0.000, -4.299, 0.0, 259.1, JOYSTICK, 01:27:56.071073
5 Saved position 33.790, 0.000, -4.125, 0.0, 110.9, DPAD_Y, 01:28:20.168511
6 Saved position 33.993, 0.000, -4.179, 0.0, 68.6, DPAD_Y, 01:28:34.121522
7 Saved position 34.476, 0.000, -13.047, 0.0, 121.0, DPAD_X, 01:33:05.234995
8 UNDO/REDO to 33.993, 0.000
9 Saved position 52.602, 0.000, -11.726, 0.0, 47.2, Joy to zero, 01:49:43.387605
10 Saved position 52.602, 0.000, 0.000, 0.0, 233.0, Z-home, 01:50:53.987823
11 Saved position 43.030, 0.000, -8.276, 0.0, 270.7, JOYSTICK, 01:51:11.167844
12 UNDO/REDO to 52.602 0.000
13 UNDO/REDO to 43.030 -8.276
14 Saved position 43.000, 0.000, -8.000, 0.0, 15.0, mm z snap, 01:53:02.032447
15 Saved position 42.978, 0.000, -7.998, 0.0, 0.2, JOYSTICK, 01:56:20.842384
```

Illustration 3: The manual moves are saved to file.

VIRTUAL TOP SLIDE

To make a taper, rotate the virtual top slide by entering the taper angle in the Angle X or Angle Y spinbox. The angles are degrees from the respective axis center line. The rotation of the two dpad directions can be set individually. The feed is still synchronized and the feed per revolution is measured along the rotated axes. Step lengths, see later section, are measured along the rotated axes. The angles also determine the start angle for radius cutting, see next section. The joystick still operates along the unrotated axes. The virtual top slide option is the cause of the dual X/Y and X/Z notation. The X/Y refers to the dpad directions and the X/Z refers to the machine axis.

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1) Parameters available for user customization are denoted by [INI_SECTION]*italic_text* in this document.

Radius cutting

To cut a radius, enter a radius value in the Radius spinbox, and an angle in the Radius angle spinbox. A positive radius value will stop and zero the Radius spinbox when the end of the radius angle is reached. A negative radius value will confine the tool to move along the radius, within the angles given.

The radius will start at the angle given for the virtual top slide and stop at an additional angle given by radius angle. A positive radius angle will produce a clockwise radius. The motion is spindle synchronized and the feed per revolution is measured along the tangent. It is OK to let go of the dpad, the radius motion will continue the next time the dpad is pressed. The Radius angle label will change to show the angle moved from the radius minimum limit. The Radius label will change to show the active dpad direction.

The radius will start in the direction intuitively expected, depending on the dpad direction and virtual top slide angle. The radius becomes active with the first dpad direction pressed after the radius value was set to a non-zero value. When active, a dpad direction reverse will cause the motion to retrace towards, but not beyond, the initial position.

It is safe to change the radius angle while a radius is active. If the radius angle changes sign while a radius is active the radius will not change the radius' curvature clockwise/anti clockwise, but will make the end angle lie beyond the start angle. If the radius angle is changed such that the tool becomes outside of the radius angle and the radius is negative, then the behavior is the same as described in the pocket section. It is safe to change the radius while a radius is active. It is also safe to change the virtual top slide angle; the radius will pivot around the tool's current position.

The radius position can be adjusted, while active, by moving the tool with the joystick, by moving to any of the teached positions, or by moving with the dpad in the other axis. To exit a radius, press the stop button or set the radius value to zero. The proportional triggers can be used to modify the feed. It is safe to change the feed while a radius is active and the shortcut for changing the feed is the same as described above in the *Spindle synchronized motion* section. Note that only dpad moves can change the relative position within the radius, undoing a move while a radius is active will move the radius.

Spindle synchronized motion

All motions initiated with the dpad, are performed with spindle synchronized feed. Feed can be either persistent or ephemeral, i.e., stop as soon as the dpad is released. For persistent feed, feed that does not stop when the dpad is released, press left and right shift buttons at the same time as the dpad. To exit persistent feed, press either the red stop button or the dpad again. Persistent feed will stop automatically at the end of the distance set by the Step X, Step Y, and Radius spinboxes, se section *Incremental/pocket motion*

The dpad feed, in mm or inch per revolution, is set by the Feed spinbox. The shortcut to set the dpad feed is the shift buttons while pressing the dpad. Left shift to decrease the feed by [JOYPAD]FEED_INCREMENT, right shift to increase. The feed can also be modified by the proportional triggers. Both the shortcut and the triggers can change the feed dynamically while cutting.

No extra effort is needed to make threads, just enter the thread pitch in the feed spinbox and press the dpad. The tool will automatically find the thread if each cut is started from the same Z-position.

For easy return to the same Z-position the mark button can be used, see the *teach position* section below. For multiple entry threads, change where the thread starts with the Sync angle spinbox.

Rigid tapping

The dpad works the same whether the spindle rotates forward or backward, but if the spindle direction is reversed while the dpad is pressed, the tool will stay synchronized and reverse its motion. Pressing and holding the (yellow) spindle button while the dpad is pressed will change the spindle direction.

PROPORTIONAL JOYSTICK

Like the dpad the joystick has fast response time and high precision. The motion is high resolution with several speed ranges, all ranges start at speed zero. The default range is up to [JOYPAD]SLOW_PERCENATGE of max velocity. Pressing the left shift button will increase the range all the way to [JOYPAD]MAX_VEL_JOY. Both ranges can also be further modified by the proportional triggers.

ISOLATE JOYSTICK AXES, INCREMENTAL JOYSTICK, DISABLE JOYSTICK

The isolate joystick option makes the joystick only move the axis which has the most joystick input. The incremental joystick option is described in a separate section below. The joystick can be disabled by the lock joystick option. The shortcut for isolate, incremental, and lock joystick is right shift plus the run button.

JOYSTICK CALIBRATION

The joystick calibration makes the joystick engage exactly when the spring resistance starts, and reach exactly max output at the end of the stroke.   Illustration 4 shows an example. The soft curvature is adjustable by [JOYPAD]JOYSTICK_EXPONENT. The parameters are avalable for each individual joystick axis in the ini-file. To find the calibration values use the built-in LinuxCNC halshow program. Watch the pins input.0.abs-(r)x-position and input.0.abs-(r)y-position.
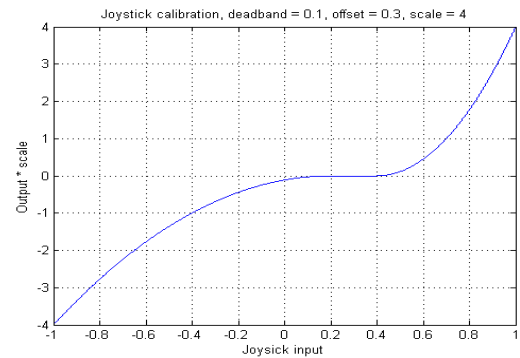

Illustration 4: Example of joystick function.

JOYSTICK COORDINATE SYSTEM AND INCREMENTAL MOTION

The joy X and joy Z labels show a separate coordinate system for the joystick and other non-pocket motions. Dpad moves within a pocket does not change these coordinates. This way the pocket position is clearly visible regardless of where you are in the pocket. The shortcut for zeroing the joystick coordinate system is both shift buttons and double clicking the mark button. To return to coordinate zero, press both shifts and the mark button. To return in the Z-axis only, press both shifts plus press and hold the mark button.

The Joy spinboxes are values for joystick incremental motion. If set to a non-zero value, the joystick will not move farther than the value in the spinboxes. A new increment is started whenever the joystick is brought to its central position. Joystick increments and coordinates are radial tool movement regardless of G7/G8.

RETURN TO HOME

Right shift and mark button returns the machine to its home position. Right shift plus press and hold the mark button homes the Z-axis only. Right shift plus double clicking the mark button unhomes all axes.

TOOL TOUCH OFF, DIGITAL DISPLAY

By pressing the Set X or Set Z button in the graphical interface the current coordinate system is set such that the tool's current position becomes the value in the X coord or Z coord spinbox. This is comparable to a digital display for a manual machine. The Adj X and Adj Z buttons will adjust the digital display by the values in the spinboxes. The Go X and Go Z buttons moves the machine to the coordinates specified in the spinboxes, respecting G7/G8. Movement velocity is max velocity, unless the Feed spinbox value is negative, in which case the movement is with the spinbox feed. As with all movements the motion can be paused, resumed, or stopped with the stop and run buttons, and the velocity can be modified with the triggers (exception is the homing motion).

The shortcut to set the digital display, or go to an absolute position, is to toggle to one of the set buttons by pressing left and right shift buttons simultaneously, the chosen button will have bold text. Left shift plus double clicking the mark button will press the chosen button. Left shift plus mark button will move the tool to position X0 Z0. Left shift plus press and hold the mark button will move the tool to Z0 without moving the X-axis. After an adjustment, the preview can be updated by pressing left shift and the stop button.

Teach position

Double clicking the (blue) mark button saves the current position. A single press on the mark button returns the tool to the teached position. Pressing and holding the mark button will return the tool in the Z-axis only. This, combined with the incremental feed option, significantly simplifies and speeds up multi pass operations.

Snap to whole millimeters

Many times, a cut is desired at a whole millimeter. To speed up arriving at the nearest mm in the X-axis, press left shift and the (green) run button, for the Z-axis press and hold, and for both axes double click.

Cheat sheet for the predefined positions

All in all, the previous sections mean up to four custom, absolute positions, plus the home positions, can be easily teached, and moved to. In addition, the next section describes how to perform an incremental motion from the current position. An additional eight positions are stored in the other work coordinate systems, G54-G59.3.

The shortcuts to use with the predefined positions are, single click the blue mark button to move to the zero position, press and hold to move to the zero position in z-axis only. To choose which position to use:

- ✔ Left shift is the working coordinate systems, G5x. Double click presses the buttons Set X, Go X etc.

- ✔ Right shift is the machine coordinates. Double click unhomes the machine.

- ✔ Both shifts simultaneously is for the joystick coordinate system. Double click zeroes the coordinates.

- ✔ No shift is the extra teached position. Double click sets the current position as the teached position.

- ✔ Left shift and run button moves to the nearest whole mm in the digital display. Press and hold for Z-axis.
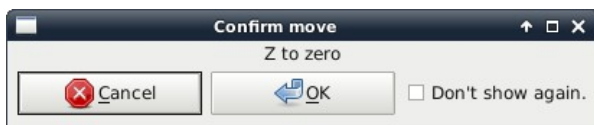
Confirm move before execution

Illustration 5: Option to force moves to be confirmed.

The confirm move option gives extra protection against mistakes. With this option, a message box will pop up when a shortcut is pressed. The pop-up, Illustration 5, shows which move the machine is about to execute and provides an opportunity to abort the move. Choose Cancel or OK either by the red and green buttons on the controller or by the mouse. This option applies to the following motions, return to teached position, return to home, return to joystick origin, return to work coordinates origin, snap to millimeters, and go to absolute position by the Go X and Go Z buttons. The last four motions may be performed with arbitrary feed by entering the desired feed rate in the Feed spinbox, with a minus sign before the value. The first two motions may be slowed down by limiting max velocity. Another way of moving safely is to hold the brake trigger while pressing the shortcut. This enables you to ease into the move by slowly releasing the brake.

Incremental / pocket motion

By setting the Step X and/or the Step Y spinboxes to a value different than zero, a pause or halt is introduced in the motion. If the value is positive the motion will pause after the distance given in the spinboxes, then continue if the dpad is still pressed. The duration of the pause is set by [JOYPAD]*step_pause_duration*. A new step is started at every dpad press, regardless if the last step was finished or not.

A negative step value will limit the motions to be within the step. The tool cannot move outside the pocket specified, the pocket is not forgotten if the dpad is released, as was the case for positive step values. The Step labels will change to show the distance moved from the step minimum limit. Both negative and positive step values will stop and exit persistent feed at both endpoints of the pocket.

The pocket position can be adjusted, while a pocket is active, by moving the tool with the joystick, by going to any of the teached positions, or by the dpad in the other axis. It is safe to adjust the pocket size while a pocket is active. If the pocket is made smaller than the current tool position the tool is prohibited to move farther outside

the pocket and will keep inside the new pocket size if moved there. It is also safe to change the virtual top slide angle; the pocket will pivot around the tool's current position. Note that only dpad moves can change the relative position within the pocket, undoing a move while a pocket is active will move the pocket.

To restart the pocket, press the stop button. To be freed from any pocket, set the step value to zero or a positive value. The motion is spindle synchronized both before and after the pause. The Y step is the step produced by the dpad up/down direction. The step length values are radial tool movement regardless of G7/G8. If the virtual top slide (see below) is rotated, step/ pocket is along the rotated axis.
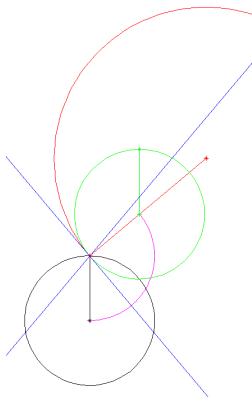
Tool radius compensation

Illustration 6: Tool radius compensation.

Illustration 6 shows the tool radius compensation. The larger red arc is the profile to be cut. We want the arc to start at the tool's current position, as we see it in the digital display. The start angle for the arc is given by the Angle (X) spinbox, here represented by the falling blue line (Z-axis rotated +50 degrees). In the pictured example the tool is orientation six. If one were to just enter the radius value and cut, then the arc would be too low and too large, due to the size and orientation of the tool. When using the tool radius compensation, the tool's position will be moved, with feed velocity, to the position shown in green. The tool path is an arc, magenta in the figure, that gets there most effectively without damaging the arc profile. The value in the Radius spinbox is automatically adjusted to produce a tool path where the tool's edge cuts the desired arc profile. For linear cuts, e.g. tapers, the path to the compensated position is straight along the other axis, which has a direction adjustable by the Angle spinboxes. The tool's radius and orientation is read from the tool table for the currently loaded tool. The shortcut to activate the tool radius compensation is the left or right shift button, depending on desired compensation direction (here right), plus the (small black) start button. This initiates the tool compensation. For the system to know what the next move is going to be you now press the dpad in the direction you want to move (here dpad left). The tool will now first move to the compensated position. The next time the dpad is pressed the compensated move will start.

Proportional feed override

During all motions, except homing, the velocity can be overridden with the proportional triggers. The left trigger is called the brake trigger, it will slow the velocity proportionally all the way to zero. The right trigger, called the gas trigger, will speed up the motion. Maximum possible speed increase is context dependent. The feed modifications made with the triggers are reset when the triggers are released. It is possible to hold the brake trigger, start an operation, and smoothly sneak into action by slowly letting go of the brake.

Idle feed

Since all dpad motions are spindle synchronized at all time, there is no dpad motion if the spindle is stopped. To use the dpad motion features even when the spindle is stopped the idle feed option can be used. The idle feed option feeds a synthesized spindle rotation into the component with the speed given by the RPM spinbox. The shortcut for turning the idle feed option on is right shift plus the stop button. That shortcut also toggles the confirm move option. It is safe to leave the idle feed option on at all times.

Spindle button

The (yellow) spindle button will start the spindle at the speed given by the RPM spinbox. Left shift plus the spindle button will start it backward. Right shift and spindle button will orient the spindle to [JOYPAD]*SPINDLE_ORIENT_ANGLE*. For consistent spindle orientation, the first spindle rotation after start up should be forward.

When the spindle is running, or when in mode auto, the spindle override is adjustable by the shift buttons. Left shift plus spindle button decreases the spindle override by [JOYPAD]*SPINDLE_INCREMENT*. Both shifts plus the spindle button resets the override to 100 %. If, the mode is not auto, the dpad is pressed, and the spindle is running, then pressing and holding the spindle button will reverse the spindle direction.

If the program is running or paused, then the program feed and max velocity overrides can be set by the dpad buttons. Up/down changes the max velocity, left/right changes the feed override. To change the program feed or the max velocity when the program is not running you must be in auto mode and have pressed one of the shift buttons, then use the dpad as described in the previous sentence. In auto mode, both shifts plus any dpad resets the feed override to 100 % and the max velocity to [TRAJ]*MAX_VELOCITY*.

The overrides are also adjustable by the proportional triggers. The right trigger increases the feed override about [DISPLAY]*MAX_FEED_OVERRIDE* % from the current setting. The left trigger decreases max velocity, to zero if fully pressed. To make the trigger adjustments permanent, press the (small black) back button and release the trigger. The back button temporarily disables the triggers.

LOAD TOOL AND WORK COORDINATE SYSTEM

The shortcut to load a new tool or a new work coordinate system is the same as the shortcut to reload the program and redraw the preview, left shift plus the stop button. Loading tool -2 is a shortcut to execute code G49, unload tool offsets. Tool -1 means to load the tool given by the number [JOYPAD]*ZERO_OFFSET_TOOL_NUMBER*. The G5x spinbox is the index of the work coordinate system to be loaded. One for G54, to nine for G59.3. Zero spinbox entries mean there will be no change in the loaded tool offset or work coordinate system.

AUTOMATIC MODE CHOICE AND WIRELESS EMERGENCY STOP

Some operations can only be performed when the machine is in a certain mode. As far as possible the controller automatically switches to the appropriate mode, based on the user input, e.g., button presses. Operations that require a temporary mode changes will restore the previous mode after completion.

Although not a replacement for a physically connected emergency stop, an e-stop can, in all modes, be triggered by double clicking the (red) stop button, or by pressing and holding the stop button. E-stop trigger times are separately tunable.

Complete cheat sheet

Run button (green)

- Turn the machine on.
- Home the machine.
- Change the mode to auto.
- Start the program if in auto.
- Accept a confirm move message.
- Confirm the tool change message.
- Pause a running program.
- Resume program execution.

Stop button (red)

- Trigger an emergency stop if held down or double clicked.
- Exit persistent feed.
- Clear messages.
- Pause a running program.
- Stop a paused program.
- Change mode to manual.
- Reject a confirm move message.
- Abort step, radius, persistent feed, and edit mode.

Edit mode

- Enter or exit edit mode by pressing the (small black) start button.
- Move between the spinboxes with the left or right shift buttons.
- Set the values with the dpad.
- Change sign by pressing left while at the leftmost cursor position.
- Zero the spinbox with the mark button (double check that you are in edit mode before pressing).
- Round the least significant figure with the mark button.

Predefined positions (Blue button)

- Single click to move to the position. Not in edit or auto mode.
- Press and hold to move to the position in z-axis only.
- The digital coordinate display, G5x, is left shift. Double click presses the buttons Set X, Go X etc.
- The machine coordinate system is right shift. Double click unhomes the machine.
- The joystick coordinate system is both shifts simultaneously. Double click zeroes the coordinates.
- The extra teached position is no shift. Double click sets the current position as the teached position.
- Move to the nearest whole mm in the digital display by left shift and run button. Press and hold for Z.

Graphical preview (Gremlin)

- Pan with left mouse.
- Zoom with left mouse plus left shift button.
- Clear and redraw with left shift plus the stop button.

Undo move

- The big X-marked undo button undoes the previous move.
- Left shift plus the undo button redoes the latest move undone.

✔ Isolate, incremental, and lock joystick options are toggled by right shift plus the run button.

✔ The idle feed and confirm move options are toggled by right shift plus the stop button.

TRIGGERS

✔ The left trigger will slow the feed.

✔ The right trigger will speed up the feed.

TOOL RADIUS COMPENSATION

✔ The left trigger and the (small black) start button, followed by intended dpad direction is compensation to the left.

✔ The right trigger and the (small black) start button, followed by intended dpad direction is compensation to the right.

FEED SHORTCUTS

✔ For persistent feed, press left and right shift buttons at the same time as the dpad.

✔ The dpad feed shortcut is the shift buttons and pressing the dpad.

✔ The program feed overrides are dpad left/right, when program is started.

✔ Max velocity overrides is dpad up/down, when program is started.

✔ The program feed and max velocity overrides is shift plus dpad, when mode is auto.

✔ The back button temporarily disables the triggers for the program feed and max velocity overrides.

✔ Resets the feed and the max velocity to 100 % by both shifts plus any dpad, when in mode auto.

SPINDLE SHORTCUTS (YELLOW BUTTON)

✔ The spindle override is shifts plus spindle button, when the spindle is running, or when in mode auto.

✔ Resets the spindle override to 100 % by both shifts plus the spindle button.

✔ Reverse the spindle by holding the spindle button. Dpad pressed, not mode auto, and spindle running.

LOAD TOOL AND REDRAW PREVIEW

✔ To load a new tool and redraw the preview press left shift plus the stop button.

✔ Tool zero means no change in the tool offset data.

✔ Tool -1 means load the tool given by the number [JOYPAD]*ZERO_OFFSET_TOOL_NUMBER*.

✔ Tool -2 is unload tool offsets, G49.

MISCELLANEOUS

✔ The frame label gives hints about what is going on.

✔ Confine the movement range by using negative values for steps and radius.

✔ Reduce the speed for moves to predefined positions by a negative feed value in the Feed spinbox.