Laser Converter Plugin for CamBam

[Ver 1.0.2]

Purpose

This plugin is intended to assist with the laser engraving of images using a grey-scale mapping onto flat surfaces. The process involves converting a G-Code file created for an engraved surface (created from a surface model or an image using a heightmap generator) into a file suitable for a laser engraver. The process involves mapping Z-values in the G-Code file into varying S or F values to simulate the greyscale of the image. The process is based on the propositions that:

- The greater the laser power, the burnt paths will appear "blacker", and/or
- The slower the feed rate, the burnt paths will appear "blacker".

There are two options in the plugin for mapping the Z-values for greyscales:

- The Z-values are mapped to power values for the laser by replacing the Z-depth values with S (spindle speed) values that are used to control the laser power using the PWM control normally used for the spindle speed control (for a given feed rate).
- The Z-values are mapped to F (feed rate) values for the laser by replacing the Z-depth values with a F (feed rate) values that are used to control the feed rates in the X & Y directions (for a given speed, or laser power, level).

From Vers 1.0.2 there is a capability to specify calibration functions for both modes (Speed and Feed). These functions specify the grey-scale level for the range of Z-values to compute the required speed or feed values. This allows the user to fine tune the grey-scales to suit laser and material properties.

It is assumed that:

- The stock surface is set at Z = 0.
- The power of the laser can be controlled from the spindle speed ('Snnn' G-Code) in a range from a minimum value (usually 0) to the preset maximum value.
- The G-Code file has been prepared with a suitable post-processor that inserts the commands to turn the laser ON and OFF as required. These commands are inserted using the 'Start Cut' and 'End Cut' sections in the CamBam post-processor. The 'Start Cut' section is inserted after the first -ve valued Z move and the "End Cut" at the end of the cutting path when Z returns to a +ve valued Z.
- That only Z-values less than 0.0 are to be converted in the file (values >= 0 are taken as positioning commands with the laser OFF).

There are a number of post-processors provided with CamBam that can be adapted to suit your setup.

Preparation

Laser Setup

Setting up the laser on your CNC router is the tricky bit. This will depend on your hardware setup, in particular the type of controller board you have and how you drive it (e.g. Mach 3 or the like). In simple terms it is necessary to use:

- A signal to turn the laser ON/OFF.

- The PWM signal that sets the speed of your spindle switched to control the laser power (assuming the laser has a PWM input)

In practice there are a few catches that need to be resolved for your particular setup. In my case I am using Mach3 with a USB connection to a Leafboy (www.leafboy77.com) 4-axis controller that was supplied with my Chinese-origin machine. This controller does not seem to support M10 & M11 commands, so some other strategy was required to minimise the effects of start-up delays.

After some experimentation, the following strategies have been adopted to tune the post-processor.

- The M8/M9 (flood coolant ON/OFF) commands were used to turn the laser ON/OFF
- The M3 (Spindle ON (CW)) is used to turn on the PWM signal (with spindle power OFF).
- The PWM signal is used to control the laser power from 0 to 100% by setting the Snnn values.

All of this requires some additional electronics and a power supply to power the laser.

While this basically works it was found (as predicted) there are some delays in the laser firing after the initial move operation. In particular, the most significant delay, in my case, occurs when the laser is turned ON for the first engraving move. Subsequent moves seem to be quite OK. The effect of this initial delay has been minimised by turning the laser briefly ON, then OFF, at a point outside the work area using "M8 G4 P100 M9" (generates a small dot on the stock) in the Header section of the post-processor. I am still uncertain why this initial delay occurs, though it may be related to the inherent latency in the Mach3 software.

The G-Code File

The G-Code file may be produced in CamBam (various ways), or even from some other source. The set up for this file should be:

- Set the stock surface to Z=0
- The Z-depth should range from Zmax (say a small -ve value) down to Zmin.
- The feed rate should be set to match that required for your laser and stock material.
- The G-Code file must be created with the laser post-processor (as adapted) to insert the laser controls.

The first step is to create the G-Code file with these parameters, then run the plugin. In the plugin the Z-values are mapped to S or F values as required.

Note that previous contributors on the CamBam Forum have used a command line program that is embedded in the post-processor that runs automatically when the G-Code file is created. This may be useful if a single configuration is to be used many times. For the moment, and for evaluation purposes, I have found the plugin more useful as it is easy to try out different parameter combinations. A command line version of this plugin can be provided if required.

Interaction with Mach3

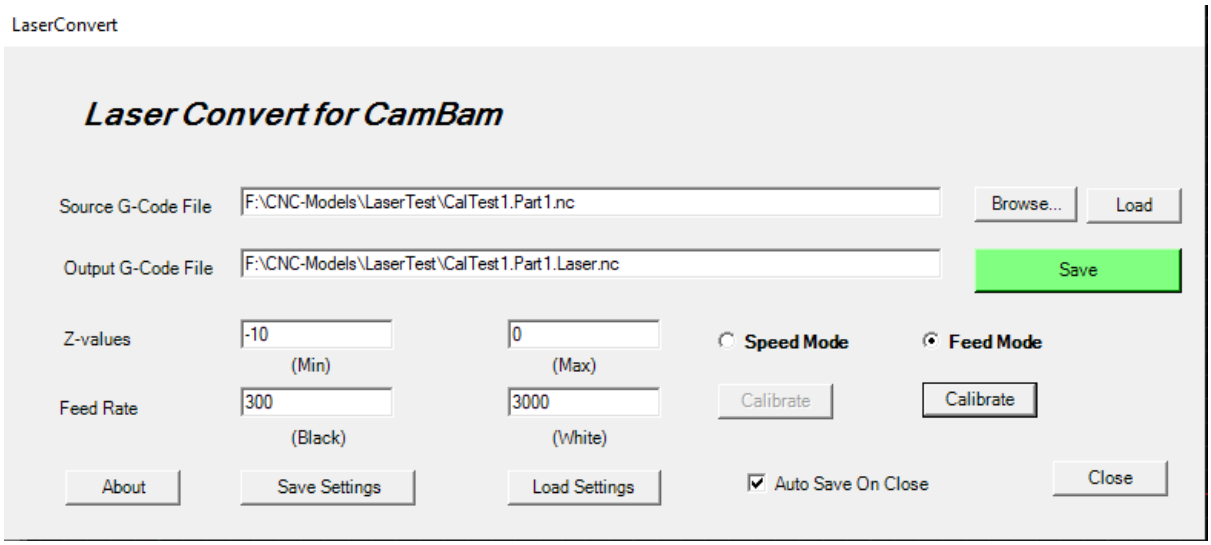
While Mach3 is purposed designed to run a CNC machine, is it probably not ideal for laser engraving. For many situations it can, however, work quite well for laser engraving and cutting where the laser settings (power and feed rate) are constant for a complete path. In such a case either Speed or Feed modes can be successfully used. For photo engraving the speed (power) or feed rate need to be adjusted along each engraved path. In these circumstances, the Feed mode seems to work reasonably well as Mach3 will adjust the feed rate "on the fly". However, in Speed mode Mach3 seems to apply a short pause whenever the "speed" is adjusted (at lease I have not figured out how

to prevent this happening). This behaviour may be natural for the CNC machine, but for the laser is it not necessary and can produce some artifacts (overburns) as well as a rather "jittery" movement.

Installation

Unzip the file provided and copy the LaserConvert.dll file into the Plugins folder of the CamBam installation folder, then restart CamBam. The plugin will then appear in the Plugins menu.

Operation



The fields are:

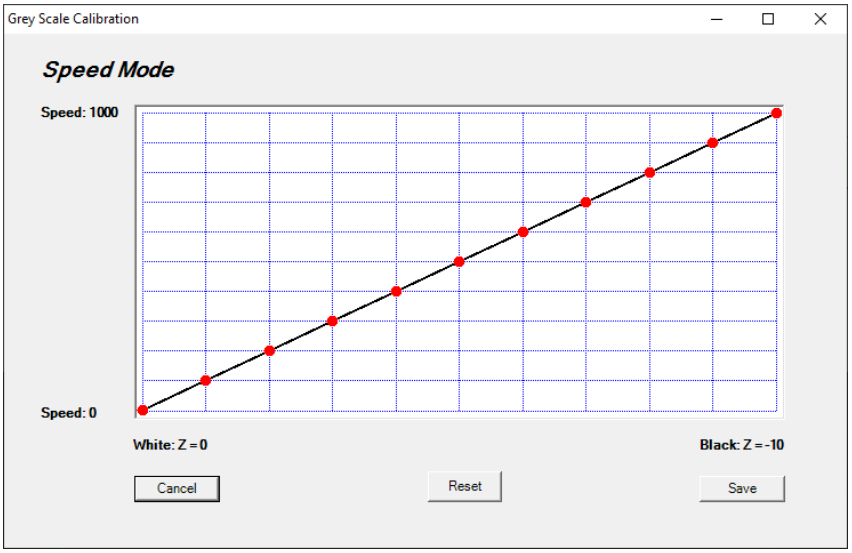
1. **Source G-Code File**: the path to the G-Code file to be converted (i.e. one created with the laser post-processor). When first loaded a "best-guess" file name is inserted, based on the name of the current CamBam file and the active MOP Part. This file can be manually edited as required.
2. **Browse**…: a button to browse to any suitable G-Code file to select it
3. **Output G-Code File**: the path for the converted G-Code file. The default is the name of the source with ".Laser" appended.
4. **Load**: a button to load the source file. When loaded the range of Z-values in the file are computed and the Zmin and Zmax values displayed.
5. **Z-Values** fields: the minimum and maximum Z values found in the source file. Normally, Zmax should be 0.0 (it might show as a +ve value, depending on the value set for stock clearance). These fields can be edited manually.
6. **Speed Mode & Feed Mode** radio buttons: Selects the required mode.
7. **Speed/Feed** fields: The user entered values for the matching the speed (power) or feed rate values to map to the required Black and White levels.
    a. **In Speed/Power mode:** the maximum power (Black) is mapped to the minimum Z value, and the minimum power (White) is mapped to the maximum Z value. The maximum power will depend on your set up; it might be 100 or 1000 or something else (depending on your controller setup). A linear relationship is presumed.

b. **In Feed rate mode:** the minimum feed rate (Black) is mapped to the minimum Z-value and the maximum feed rate (White) to the maximum Z-value. A linear relationship is presumed.

8. **Calibrate** buttons (for Speed or Feed modes): open the respective calibration form (see below) for user adjustment.
9. **Save** button: Performs the conversion and saves the output file. A confirmation dialog is provided indicating the number of lines in the G-Code file.
10. **Save Settings** button: saves the current settings to a config file, by default in the same folder as the current project with the default name "LaserConvertSettings.config".
11. **Load Settings** button: loads the settings from a saved config file.
12. **Auto Save On Close** checkbox: if checked (default) will save the current setting to the config file when the plugin is closed.

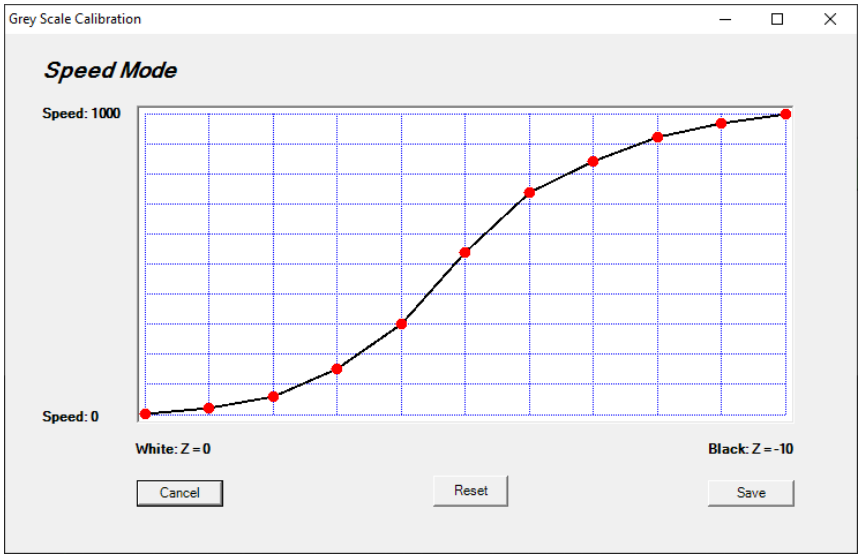
Calibration Function

The calibration function allows the user to specify the speed/feed rate relationship to the Z-values to provide the required grey-scale. The default calibration is linear like this (for speed mode):



To change the function:

- <Left-Mouse Down> on one of the red-dots.
- <Drag> the dot up or down until it is in the desired position
- <Left Mouse Up> to set position

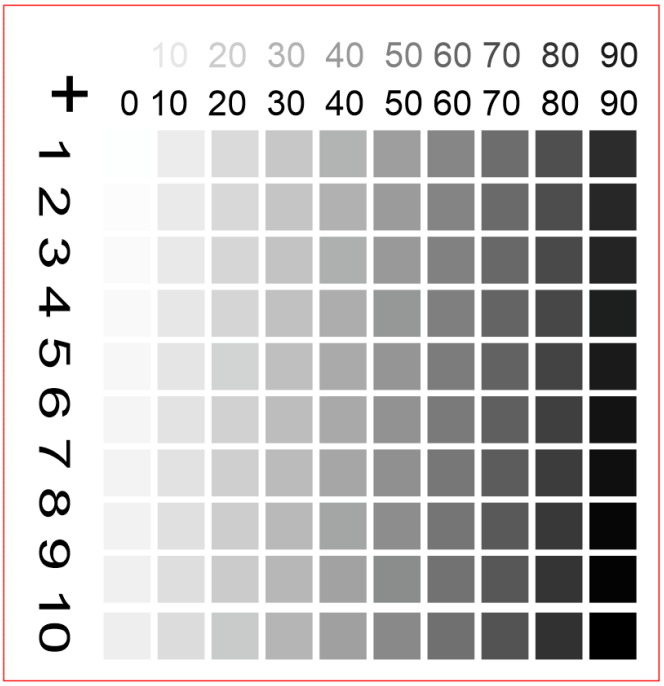


- The **Save** button, saves the function and closes the dialog
- The **Cancel** button closes the dialog without saving any changes
- The **Reset** button resets the function to a linear form.

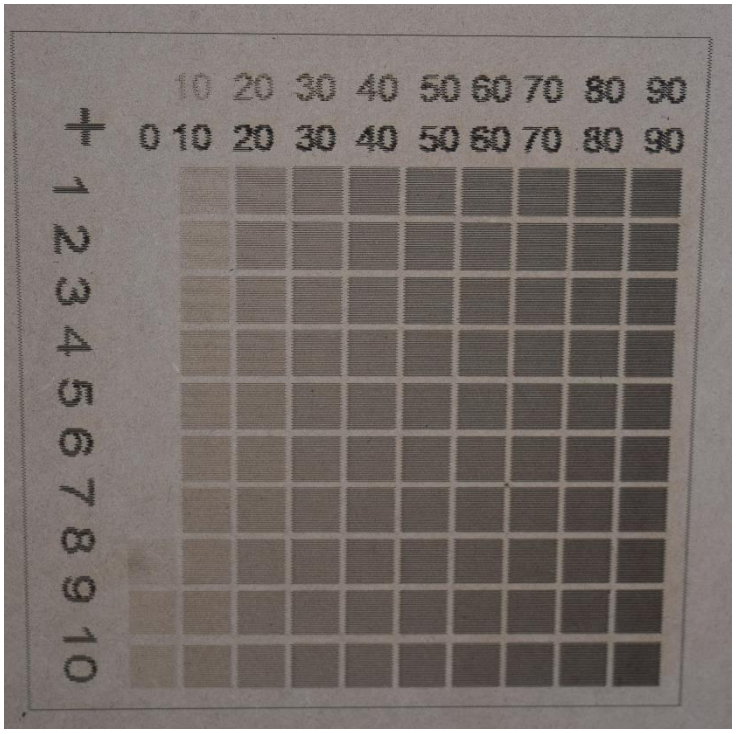
The two calibration functions are saved in the configuration file from the main dialog (see Save Settings, above)

Tests of the Greyscale Results

The following image is provided by a well know Laser machine manufacturer for calibration purposes.



Using this image as the source of data, and importing it into CamBam with the HeightMap Generator plugin I obtained the following result from my laser using the default linear calibration functions:



The image is engraved onto MDF board with a federate of 800 mm/min with scan lines at 0.5 mm spacing for (notionally) 100 possible grey levels using Speed (Power) mode. The result is not too bad. The "Black" square could be made darker by either reducing the scanline spacing, or the feed rate as required.

The following closeup photos show samples for 10%, 50% and 100% black using S-control at 800 mm/min. At 100% power the laser-cut groove is about 0.3 mm wide.

		
10%	50%	100%

If the F-mode is used then (in theory) there is no direct limit on the number of possible greyscale levels. The following photos show samples for 10%, 50% and 100% using F-control at 50% power. The feed rate was varied between 300 mm/min (for black) to 2000 mm/min (for white)

 10%	 50%	 100%

These results seem to suggest that with appropriate calibration, and some experimentation, it should be possible to achieve a reasonable result, perhaps with adjustments to the scan-line spacings. The optimal scan spacing will depend on the stock material, the power of your laser and the size of the focussed beam. The greyscale for both methods suggests that the results are not too far from being linear. It would be possible to include a greyscale mapping function into the postprocessor if that seemed to be useful.

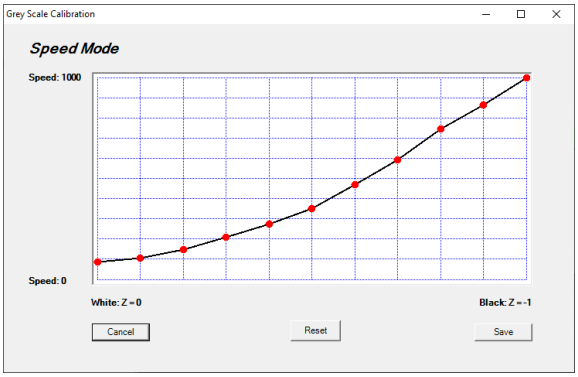
It may not be obvious which mode will produce the best results, so some experimentation is required.

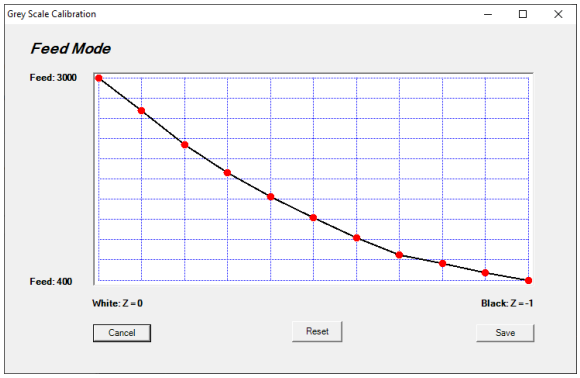
Here is one of my better results so far (the famous “Lena”): using Feed mode within the range 200 mm/min (Black) to 2000 mm/min (White) at 50% laser power for an image 150x150mm. The model was prepared using the CamBam heightmap plugin, scanline spacing is at about 0.6 mm.

Calibration Tests

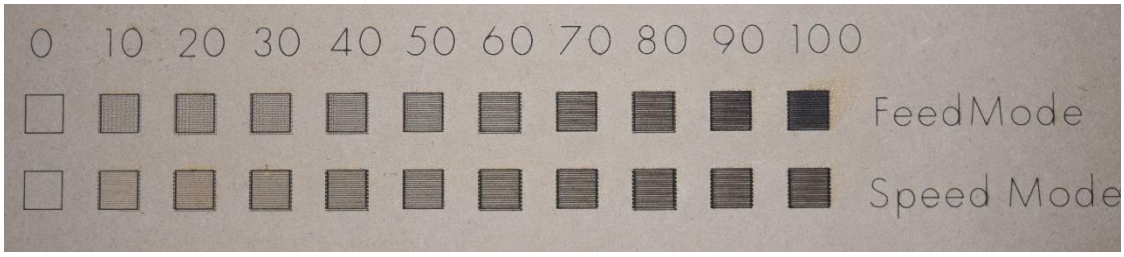
The following examples demonstrate the possibilites for varying the calibration functions. The 11 squares correspond to grey scales 0% up to 100%. The material is MDF, the squares are 10 x 10 mm and the step over is 0.5 mm. My laser is (nominal) 15 W, but running at 50% power (max power is set to 1000) using Feed mode with a range of 400 to 3000 mm/min. In the Speed mode the feed rate ins 800 mm/min.

The two calibration functions for the two modes are (after some experimentation):





And here are the results



Observations:

- Both functions can provide a reasonable grey-scale discrimination
- The Feed mode is perhaps a little better overall
- It would seem that the results are sensitive to quite small variations in the calibration functions.

History

Version	**Notes**
1.0.0	Initial release for review
1.0.1	• Added option to save and restore settings. • Some minor bug fixes.
1.0.2	• Minor bug fixes

	• Added calibration functions capabilities for both Speed and Feed models