DMC software is designed to be a single control interface for your laser machine. You can design **your** motion path for positioning stages and galvo scanners, control laser parameters and other devices like power meters, motorised objective lens turrets, I/O's, serial port devices, and others. All this is done without you operating in g-code. Everything can be done quickly and intuitively as DMC directly interfaces with all those devices.

Main features of DMC:

- Direct hardware control.
- WYSIWYG (What You See Is What You Get) window for machining preview.
- Support for both: positioning stages and galvo scanners.
- Support for stitching, on the fly and infinite field with galvo scanners and stages.
- Import of CAD files (DXF, DWG, STL, Gerber and others).
- Unique GUI for a specific task-optimized machine.
- Ability to write plug-ins to support your hardware and application.

Contents

CONFIGURING THE HARDWARE SETTINGS

Because DMC creates a direct connection to the controlled devices, the first thing that needs to be done is the correct configuration of various hardware parameters. All the settings are saved into a single general settings file (.hrd) which can be used later or in other workstations. This way, an operator can easily change between stations with different hardware and parameters.

The settings are in File → Settings (alternatively, pressing F12).

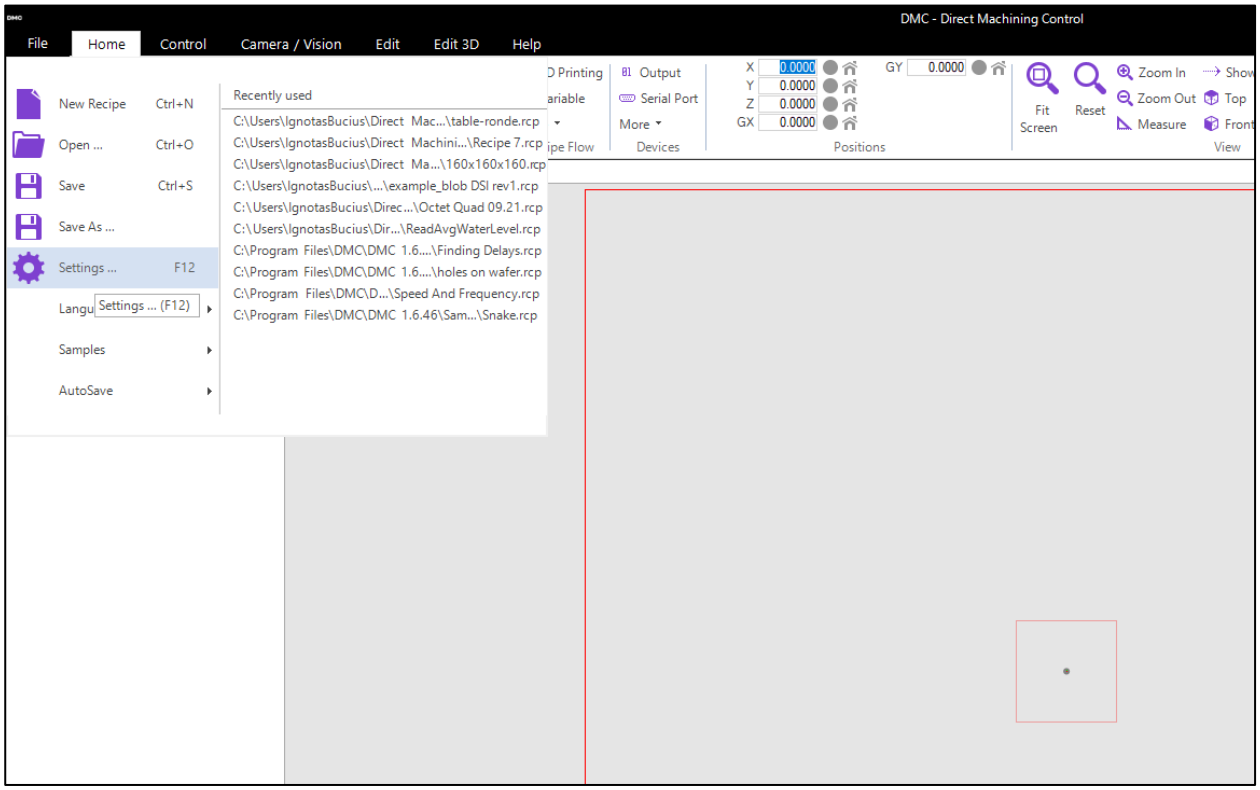


Image 1: accessing settings in DMC

Configuring general settings

The File → Settings → General settings contains User, Log, and Variable tabs, which allow you to create users and set permissions to them, enable recipe logging and manage global variables. Global variables can be used throughout the DMC and are not limited to the Recipe like a standard variable.

At first, you might want to skip the General tab, as there is nothing that usually needs to be adjusted there for the basic first run.

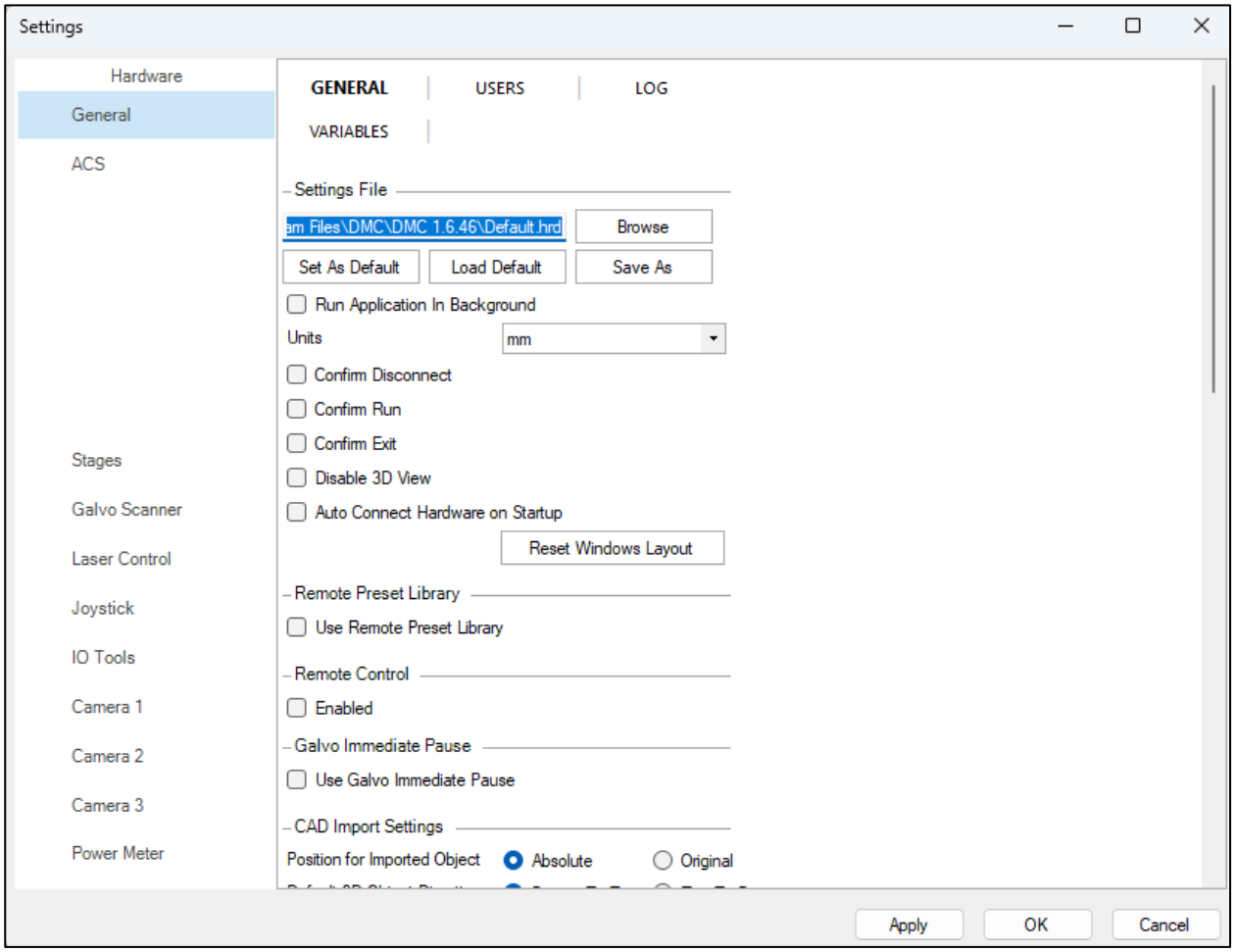


Image 2: General settings

Configuring positioning stage controllers

In Settings, there is a selection for an appropriate controller that needs to be enabled and correct communication settings configured. Several devices are available in the default version. For others, the selection appears after a separate plug-in is installed.

To configure a controller, adjust the settings for each controller individually. DMC allows using several stage controllers to control separate axes.

Each controller's setting is different, and the user should be familiar with the controller, its configuration, and its parameters. It is advisable to look at the controller manual for guidance on where to find the required parameters.

ACS controller setup instructions are available in the DMC help (Help tab in the ribbon -> Help button) "Configuration and Set Up -> Motion Controllers". For the other controller instructions, please request us separately.

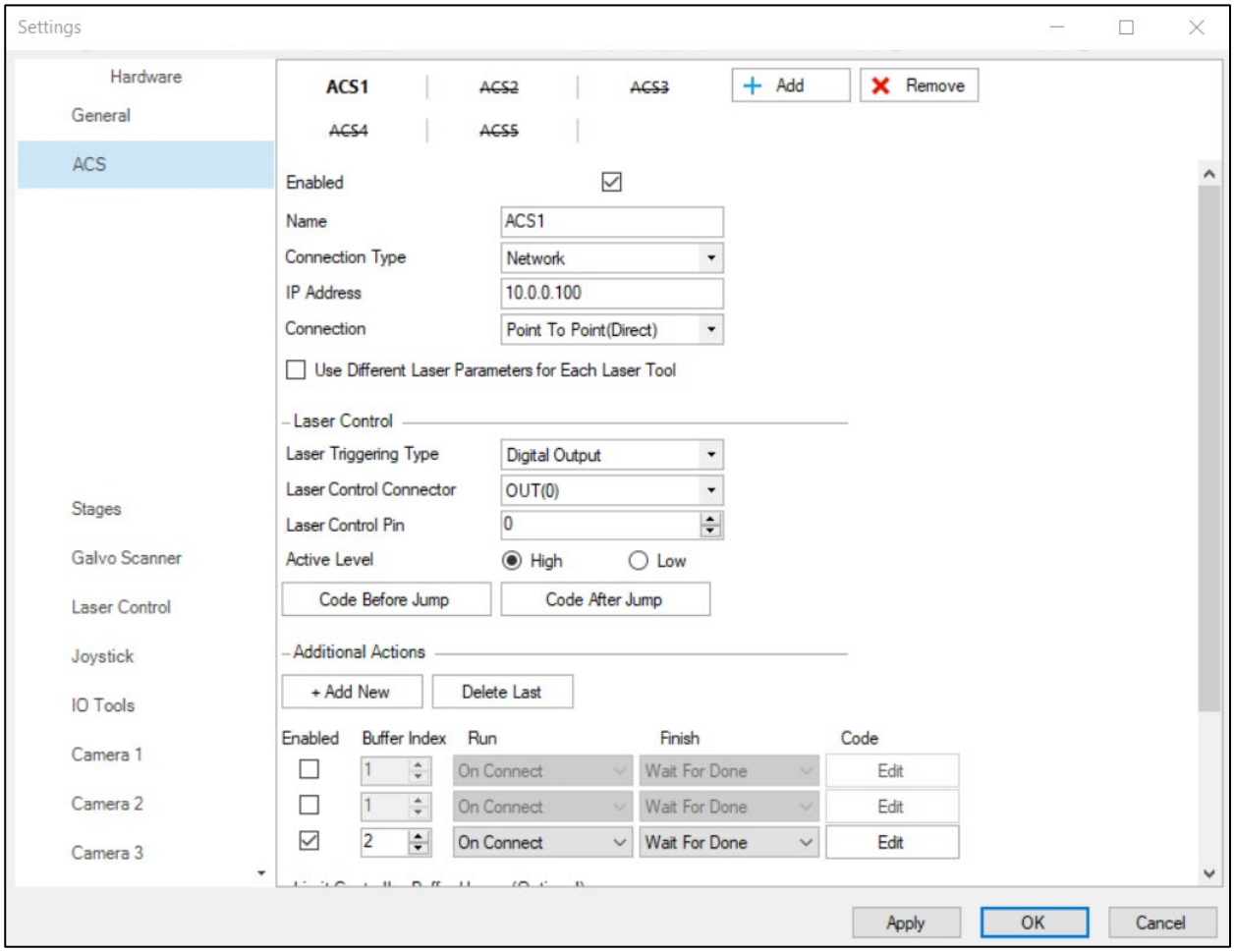


Image 3: ACS controller settings

Configuring positioning stages

Once your controllers are enabled and configured, go to File → Settings → Stages to configure your positioning stages.

Here you can select the controller, define a name and enter various parameters for each axis. The main parameters that should be defined are jump accelerations, jump speeds, min/max positions, and home parameters. Actual configurable fields of the stages might differ depending on your motion controller.

You can enable the axis by checking the Enabled box.

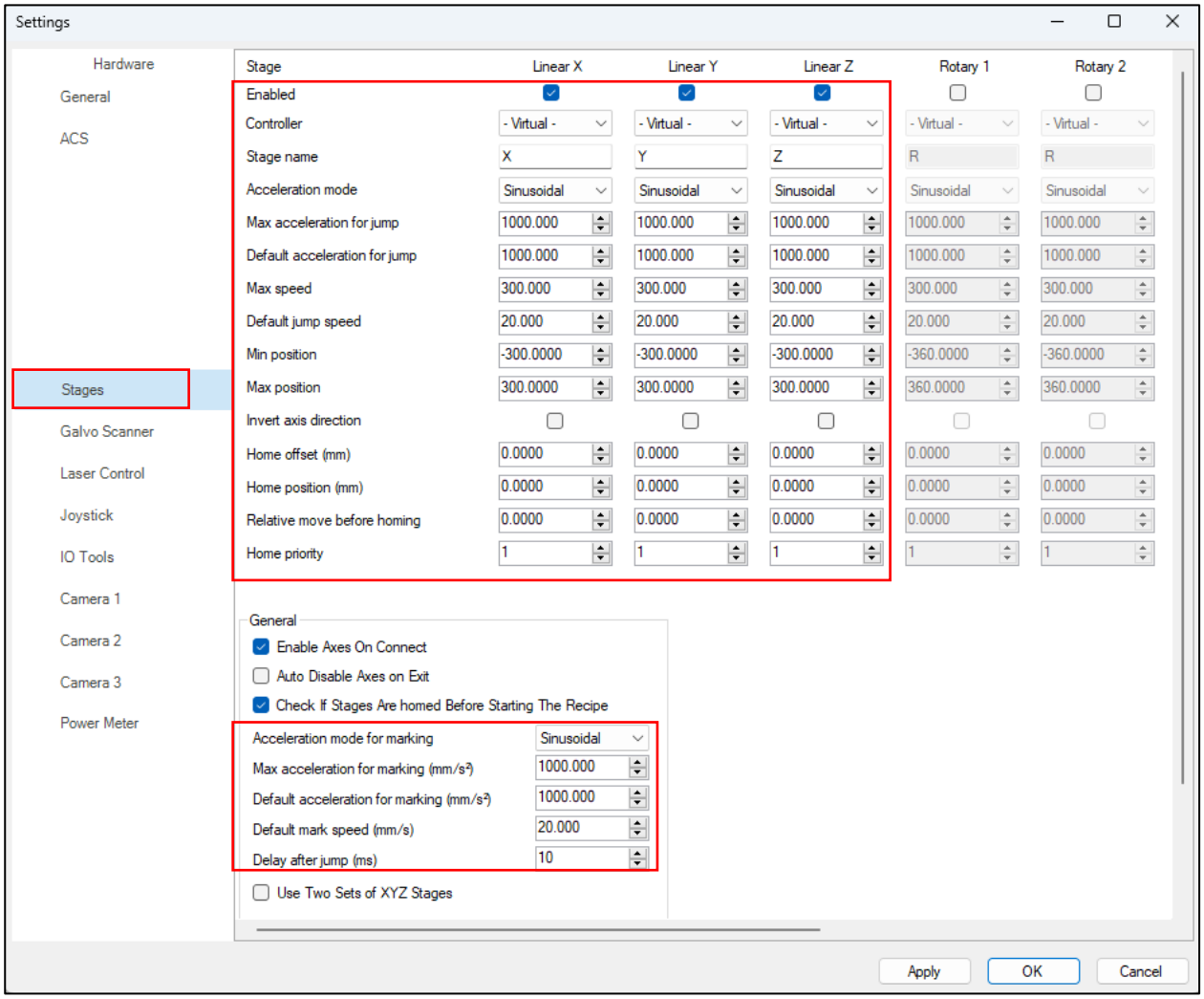


Image 4: linear and rotational stage settings

Generic settings for stages:

- 'Controller' selects which controller is used to control the stage. Different controllers can control different stages, though X and Y stages should have the same controller type.
- 'Stage Name' sets a name to be used in the software. The name does not need to correspond to the one in 'Controller'.
- 'Acceleration Mode' allows selecting whether the stage acceleration is linear (even acceleration) or sinusoidal (slower start and end with a steeper acceleration increase in the middle).
- 'Max acceleration' for jump sets maximum acceleration for jump (no laser firing) mode in mm/s2
- 'Default acceleration for jump' sets a default jump acceleration value used for jump motions.
- 'Max speed' sets the maximum available speed for that axis in mm/s. If a higher value than the one defined in 'Max speed' is entered in the Recipe, an error message will appear.
- 'Default jump speed' sets a default value in recipes for jump speed in mm/s when, for example, jumping from laser to camera, etc.
- 'Min/Max position' sets the axis travel limits. Both positions can either be positive, negative, or zero. Value is set in mm.

- 'Invert axis direction' inverts the coordinate direction compared to hardware settings. E.g., if in the controller settings, the coordinate increases when moving from left to right, with Invert direction checked, it increases moving from right to left.
- 'Home offset' adjusts the location that the axes move to after homing. Changing this setting enables you to set a new Home position for the motion stages.
- 'Home Position (mm)' sets a value for the position achieved after homing. For example, homing is done by touching the negative limit switch, then 'Home offset' moves the stage to a specific position, and the Home position states that that position is -100.
- 'Relative move before homing' moves stage a defined distance before homing action.
- 'Home priority' sets the homing priority for each axis. Axes are homed, starting with priority no. 1 and then moving down the list. Different homing priorities are necessary for some configurations to avoid crashes, e.g., lowering the Z axis not to damage the focusing lens.
- 'Auto disable axes on exit' – disables all the axes if the software is closed while still connected to the hardware.

In the settings above, the values were set for the jump acceleration. You can also set the acceleration mode, max acceleration, and default acceleration for marking.

'Default mark speed (mm/s)' is used as the default value in the marking parameters.

'Delay after jump (ms)' sets the delay (in ms) after every jump.

If the system has two sets of axes, for example, XYZ and another XY, you can define the second set of axes after checking 'Use Two Sets of XYZ Stages'.

NOTE: Stage controller drivers and software must be installed beforehand.

Configuring galvo scanners

The galvo scanner settings can be configured in File → Settings → Galvo scanner. To start configuring, you need to enable the galvo scanners by checking the 'Enabled' checkbox at the top of the Settings window. Then, select the controller type from the drop-down list. If your scanner is not on the list, a separate plug-in must be installed.

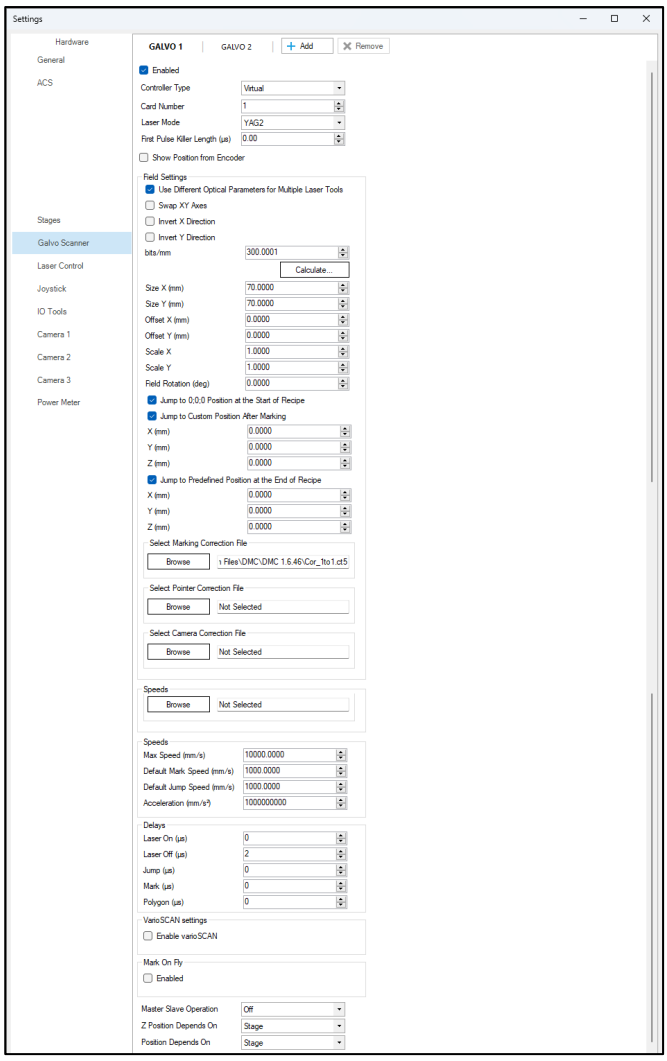


Image 5: galvo scanner configuration

These are the settings that should be adjusted before use (bold – required):

Galvo scanner settings:

- 'Controller Type' is used to select your controller (RTC4-6, Canon, virtual, or any other supported controller).
- *(Only applies if you use an RTC controller)* 'RTC Card Number' selects the number of RTC cards if more than one is used.
- 'Laser Mode' sets the laser mode. Please look at the scanner controller manual for reference.
- Field Settings:
    - 'Swap XY Axes' swaps the X axis with the Y axis and vice versa. (can be corrected with the calibration tool)

    - 'Invert X, Y direction' inverts axis direction (changes positive values to negative and vice versa) (can be corrected with the calibration tool)
    - 'bits/mm' sets your field size/resolution
        - Pressing 'Calculate' allows you to calculate the correct bits/mm value. Mark a square with DMC and measure its actual size. Enter the square size in the Rectangle command and the actual measured size.
    - 'Size XY' sets field size in X and Y directions.
    - 'Field Rotation' rotates the field around the 0;0 position. (can be corrected with the calibration tool)
- 'Select Marking Correction File' sets a lens correction file for the scanner.
- 'Pointer correction file' and 'Camera correction file' options are used for the guide laser and camera if they are mounted through the galvo scanner.
- 'Move to 0;0;0 Position At The Start Of The Recipe' moves galvo scanners to zero coordinate before doing anything else. It helps to avoid confusion when using relative coordinates.
- 'Move to Predefined Position After Marking' moves galvo scanners to a set position after galvo scanners are finished with their actions (e.g., at the end of a Recipe, before the motion of the Z stage, before actions by other devices). The fields X, Y, and Z define that position.
- Speeds:
    - 'Max Speed' Set the max speed of the scanner.
    - 'Default Mark Speed' sets the default motion speed when the laser is on.
    - 'Default Jump Speed' sets the default motion speed when the laser is off.
    - 'Acceleration' is used just for time estimation calculation.
- 'Delays'. See the Controller card manual for the galvo scanner delay information. (can be tuned later).
- 'VarioSCAN Settings' (only applicable if the galvo scanner is 3D).
- 'RTC5' sets specific RTC5 settings.
- 'Mark on-fly' (only applicable if the scanner supports this functionality and the system has XY stages).
- 'Position Depends On'. Use the 'Stage' option if only one set of XY axes exists. If there is no stage in the system, use 'None' and set up the relation accordingly if you have two sets of XY stages.
- 'Z position Depends On' chooses the dependence for the Z axis. If there is only one set of axes in the system, choose 'Stage' or leave 'Stage and Stage2'. If there is no Z axis, choose 'None'.

NOTE: Scanner controller drivers and software must be installed beforehand.

Configuring laser tools

Laser triggering and, in some cases, laser power and rep rate control are configured in the Laser Control section in File → Settings → Laser Control.

Steps to configure laser triggering control:

1. Select Laser Firing Control Device. Select the appropriate device depending on whether you want to trigger the laser from the galvo scanner controller or the positioning stages controller. Triggering should come from the device that controls the motion during laser processing.
2. Connect your laser to the triggering device according to your laser and triggering device manuals.
3. Select Triggering Control Mode supported by your laser source. Triggering mode should be described in your laser operator's manual.

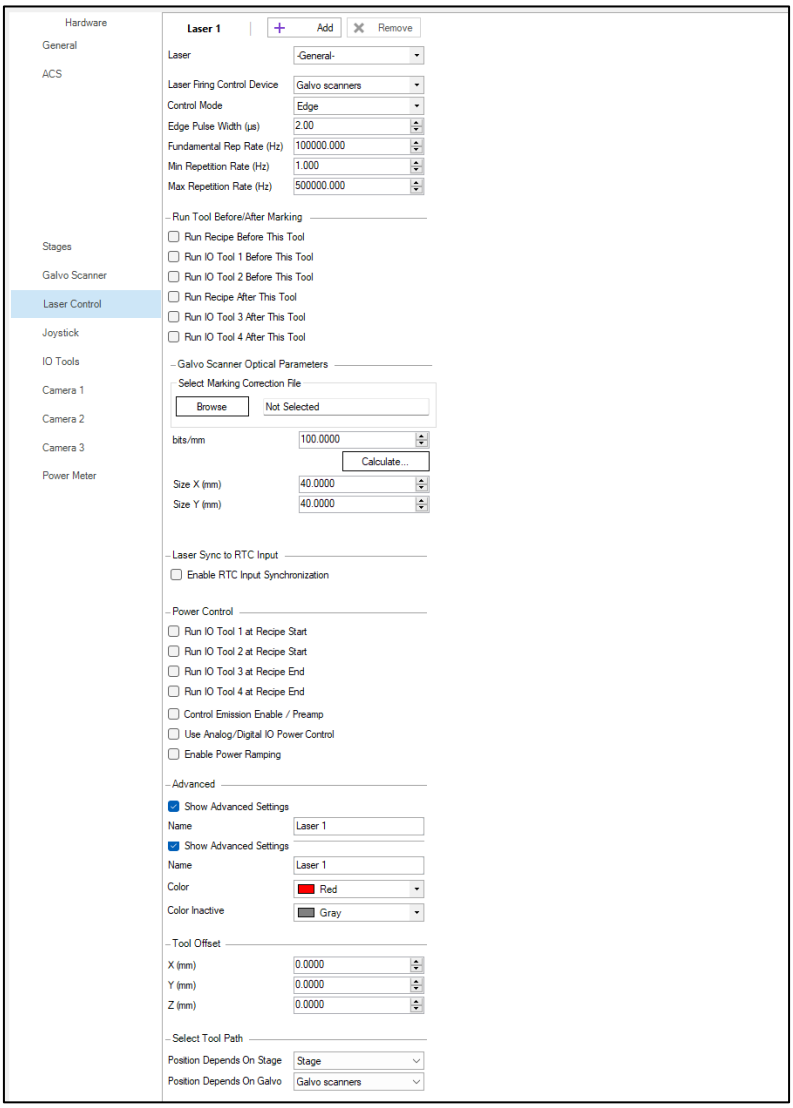


Image 6: laser control configuration

- 'Edge mode' triggers the laser at the rise of the High signal only (used for individual pulse triggering or frequency setting by triggering signal).
- 'Gate mode' triggers while the High signal is ON (all pulses during the High signal go through).

4. In the case of Edge triggering mode, enter edge pulse width. Different devices need a different time to react to signal change. The value should be described in the laser operation manual.
5. Enter a Fundamental Rep Rate at which the laser source is working. It is a repetition rate set in the laser source itself. In some cases, when a frequency divider triggering mode is being used, make sure that this value is correct and up to date because it is used for triggering frequency calculations.
6. Set Min and Max Repetition Rates. Laser sources have an upper repetition rate value and usually a minimum repetition rate value. They should be described in your laser's operation manual. These values are only used to limit the repetition rate value that can be typed in.

Some lasers support laser power control with analogue input or 8-bit digital output. This function can be configured by enabling 'Use Analog/Digital Power Control' to be later used in Marking Parameters. Instead of using voltage to describe power, a voltage-power or voltage-pulse energy correlation table might be uploaded.

In some cases, for example, when you have two laser heads, you also need to enter the laser offset into the laser tool settings (Tool Offset), entering the values for X-Y-Z directions. The system takes this into account when calculating trajectories after compiling a recipe.

At this point, all the essential settings are configured, and it is possible to do marking with most of the systems.

The following steps are not required for basic setup.

Configuring IO Tools

Sometimes there might be a need to control Input/Output interfaces using the DMC software.

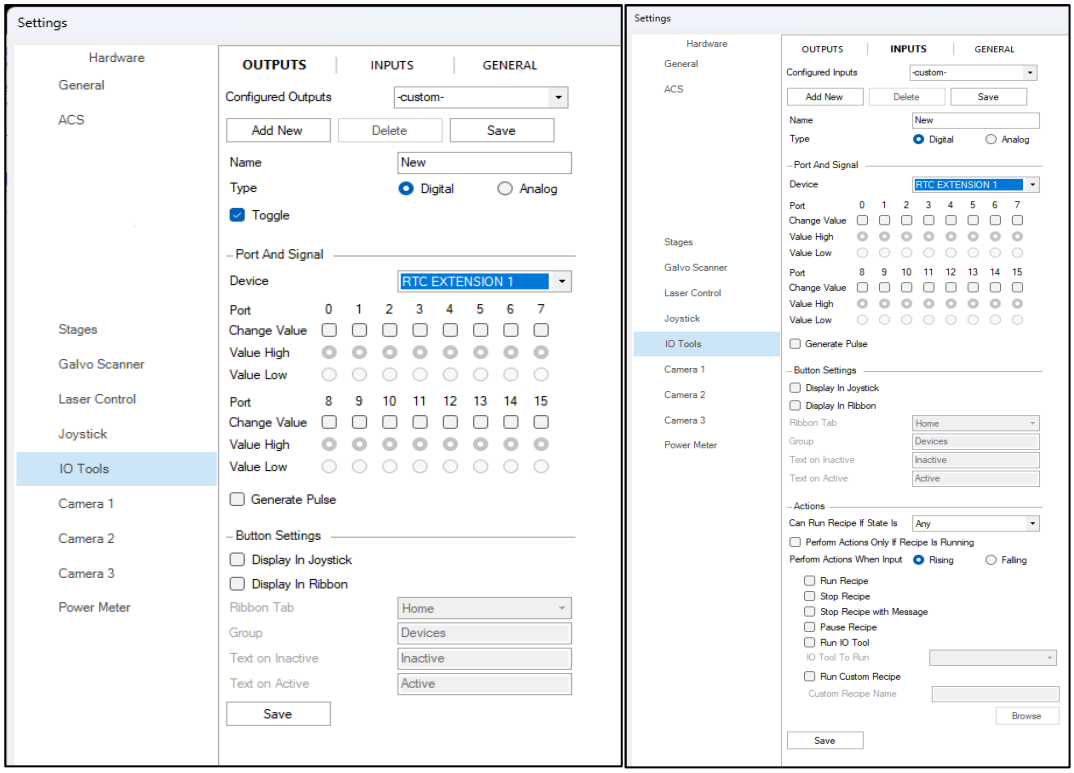


Image 7,9: IO tools configuration

To start configuring the Output, click Add New. Then choose the name, type, and if this output is a toggle. Toggle means that, for example, one run of this output sets the output to high, and a repeated run sets it back to low - like a switch.

Choose the device for the output, the port, and the value to send.

The user can also add this output as a button in the ribbon or the joystick for easy access. Text on Inactive/Active displays the text depending on whether the output is enabled.

Click Save (up top) to save the output.

The same procedure is for the inputs. Inputs also have another feature. It is possible to monitor the input and run/stop/pause the Recipe according to its value. Or it can allow running the Recipe if the input value is the one defined.

Click Save at the top of the page to save your input. Caution: If you click Apply or OK before pressing Save, the IO configuration will not be saved, and the entered values will be discarded.

The General tab is for configuring the distance/height sensor connected through the general input.

From the Configured Outputs/Inputs drop-down, you can select IOs that were already configured and edit them if necessary.

Camera settings

Camera setup can be found in the Camera / Vision section.

SOFTWARE CONTROLS

Preview window

The visual representation of a Recipe is displayed in the Preview Window. The preview window is a WYSIWYG (What You See Is What You Get) window displaying the machining motion path. In some cases, additional information, like 3D models, may be displayed for better visual reference.

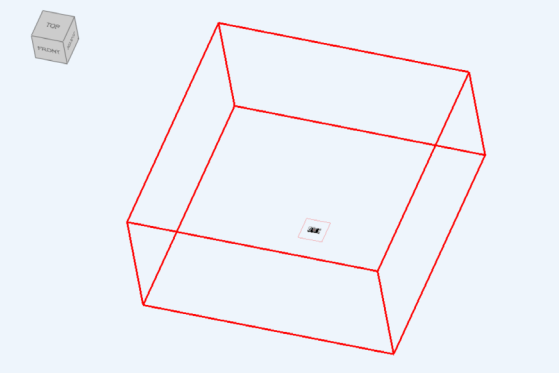


Image 8: preview window

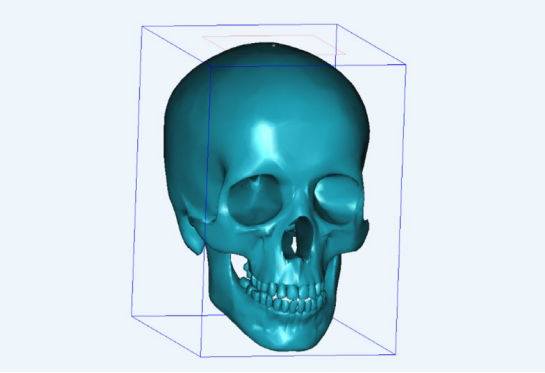


Image 9: preview window

Views

·■ **Red lines** mark the limits of your machining area.

·■ **Black lines** mark the motion trajectories where the laser is firing (marking lines). For the 3D Object command, marking lines are displayed differently for better visual distinction. **Orange** and **cyan** lines on a 3D Object are marked as well.

·■ **Blue arrows** represent the jump trajectories, where the laser is off, and no machining is performed.

·■ **Grey dot** represents the current laser position. When no motion is performed, the position is 0;0;0.

·■ **Red dot** represents the current laser position and means that the laser is currently firing.

·■ **Red**, ■ **green,** and ■ **blue** lines of 1mm thickness represent the coordinate axes X, Y, and Z, respectively.

Controls

The view in the Preview Window is controlled by tools from the Ribbon Menu View Tool Group or by mouse and keyboard.

·To select an object, *Left-Click* on it.

·To pan the view, *Right-Click* and drag or use the *Arrow Keys* on your keyboard.

·To rotate the view, hold the *Middle Mouse Button* and drag. Alternatively, *Ctrl + Left Arrow, Ctrl + Right Arrow, Ctrl + Up Arrow, and Ctrl + Down Arrow* key combinations can be used to rotate the 3D view by 15°.

·To zoom in/out, use the *Mouse Wheel* or *Page Up / Page Down* keys on your keyboard.

·To zoom into an object, press the *Home* key on your keyboard.

·To reset the view, press the *End* key on your keyboard.

·To toggle the wireframe display on or off, press the *W* key on your keyboard.

·To assign mouse coordinates to a variable, *Right-Click* in the Preview Window and choose '*Assign mpos variable*' in the drop-down menu.

Select and drag

Objects can be selected and dragged (repositioned) by using the mouse. Left-Click to select an object. The mouse pointer moves to the closest snapping point of the object.

Move the mouse pointer while holding the Left Mouse Button and release it at the desired position. Snapping works only for the selected point of the object.

Virtual joystick

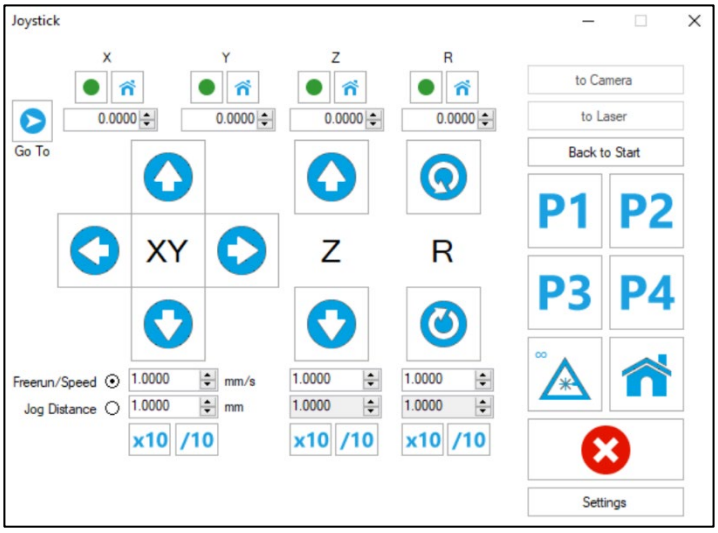


Image 10: virtual joystick

Virtual Joystick (Joystick) enables manual control of the positioning stages through a graphical user interface (GUI) as well as keyboard shortcuts. You can use the keyboard arrow keys to move in the X and Y directions and Page Up/Down to control the Z-axis. The +/- keys can be used to adjust the speed for all axes, and the F key (which can be disabled in Settings) is used to activate the laser.

RECIPE BUILDING AND RECIPE FLOW

For simple recipes, such as basic marking tasks, you can import a CAD file or draw objects by hand with simple geometrical tools like Circle, Line, Arc, Rectangle, and Polyline. Each tool, when used, has its own line in the Recipe window. You can set parameters such as Position and Size in the Command window for better precision.

Geometry tools

Geometry tools create motion trajectory commands for positioning stages, galvo scanners, or other motion devices. Geometry commands are added to the Recipe by clicking on them in the ribbon menu.

Commands appear in the Recipe Window after drawing it or pressing enter. Each added command has its own settings that appear in the Command Window.

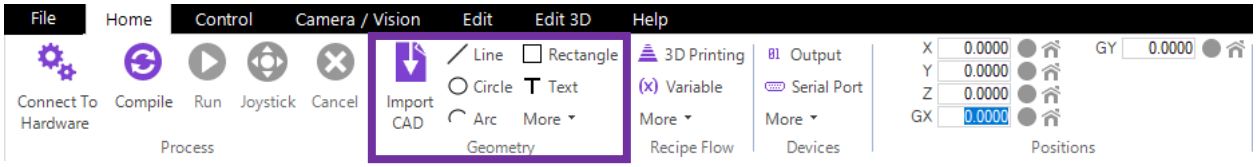


Image 11: geometry tools

Recipe Flow tools

The Recipe Flow section describes the usage of tools/commands in the Recipe Flow group in the Home tab.

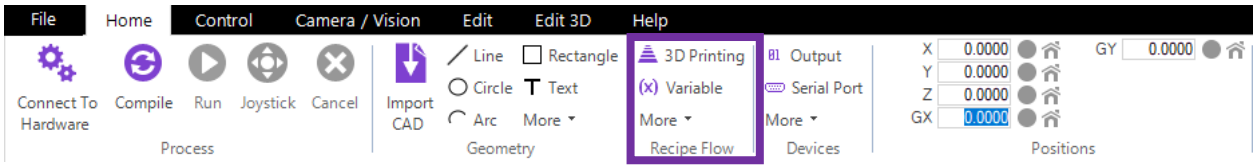


Image 12: recipe flow tool group in the Home tab

Recipe Flow commands affect other commands' behaviour during a Recipe's execution.

Recipe Flow Commands can be called from the Recipe Flow Group. The selectable commands are:

- 3D Printing - combines 3D objects to control the entire printing process
- Variable - creates a variable to be used instead of a specific value in Command Parameters
- Loop - repeats the commands included in the cycle a defined number of times
- Array - replicates the object within the command as an array (with constant or variable parameters)
- If - enables you to execute the commands that are included within it based on certain conditions
- Dialog - brings up a dialogue box
- Pause - adds a pause in the Recipe

- Marking Parameters - sets the speed and laser triggering parameters. The specified parameters are used until a new Marking Parameters command is called
- Transform - allows you to modify existing geometries in multiple ways
- Z Map - lets you scan and map the surface with a camera or height sensor and export the surface to STL format or automatically adjust for the difference in Z
- Export Data - enables you to export a wide range of data, such as variables, parameters, measurements, the current state, camera images, and more.
- CAD Alignment - used for part alignment using machine vision.
- Find Corner - uses the camera to find a corner of an object
- Find Edge - uses the camera to find an edge of an object
- Find Large Circle - uses the camera to find a circular object which does not fit into the camera view
- Image Processing - allows you to import an image from a file or use a camera view, analyse it, and extract edges of objects seen in the image/camera view for later use in the recipe.
- Alignment - enables you to use machine vision for part alignment or measuring part features.
- Status - displays information in the status bar.
- Chart - lets you plot some data in a chart.
- Camera Stitching - allows you to combine multiple camera views into a larger image, which can then be saved or displayed. This feature enables you to capture a bigger area than would be possible with a single-camera view
- Recipe - imports a saved recipe file as a single command
- Note - enables you to add notes to the recipe, which are only visible to the user and do not affect the functioning of the software. It lets you record information related to the recipe for reference or further use
- Cancel Execution - allows you to terminate a recipe that is still in the process of being executed. This enables you to quickly stop a recipe without having to wait for it to finish
- Joystick - opens the Joystick interface through a command in the recipe
- Wait - pauses the recipe until a TRIGGER signal is received via RCM. Once the signal is received, the recipe execution continues from that point
- and more…

Device tools

The Devices section describes the use of tools/commands in the Devices group in the Home tab.

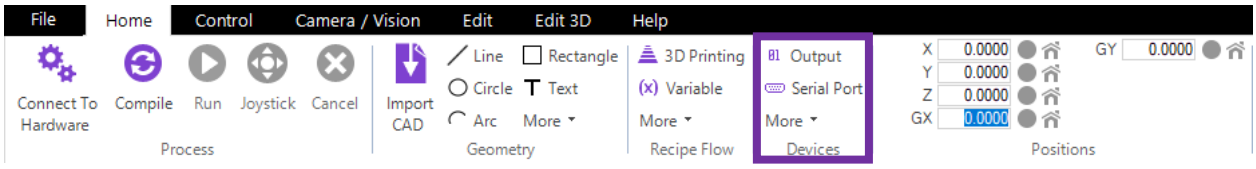


Image 13: devices tool group in the Home tab

Device Commands control the behaviour of hardware devices during the Recipe execution.

Device Commands can be called from the Devices. The available commands are:

- Output – controls the digital and analogue outputs
- Serial Port – controls Serial Port
- Stitching – combines galvo scanner and linear stages motion
- Axis – moves, homes, enables, disables specific axis
- Wait For Trigger – adds a pause in the process until specific digital input is triggered
- Input - allows the user to read analogue or digital input from a selected device
- Camera Control - allows the user to access camera settings from the Recipe Window
- External Start - enables you to run the RTC command list with an external start and stop
- Laser On/Off - allows to turn the laser on/off or trigger the laser emission for a specified time interval.

Recipe creation

Recipes are built in the Recipe tab on the left. You can change the order of actions with the up/down arrows and delete actions with the red cross. All the commands in the Recipe are executed in the order from top to down.

Some of the commands act as parent commands and have child commands which belong to them (e.g., Loop is a parent command, and all commands included in the Loop are child commands to Loop). Parent commands have a triangle symbol, which (when clicked) expands or subtracts the view of child commands. Child commands are also indented to the right. There might be several layers of Parent-Child relations, with one child command being the parent command for others.

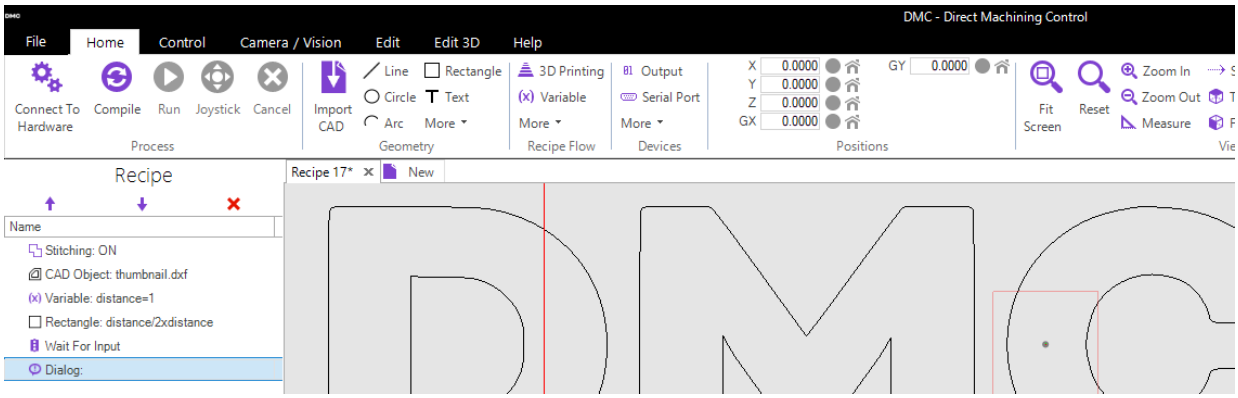


Image 14: recipe being built in the recipe flow tab

Drawing a shape

To generate geometry in DMC, go to the Geometry tab and click on the shape you want to draw.

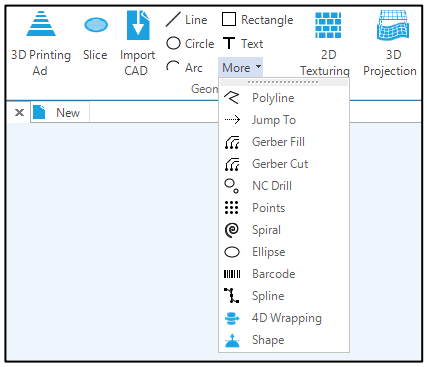


Image 15: geometry tools

Importing an object from a CAD file using the Import CAD function is also possible. The object you import can be either 2D or 3D.

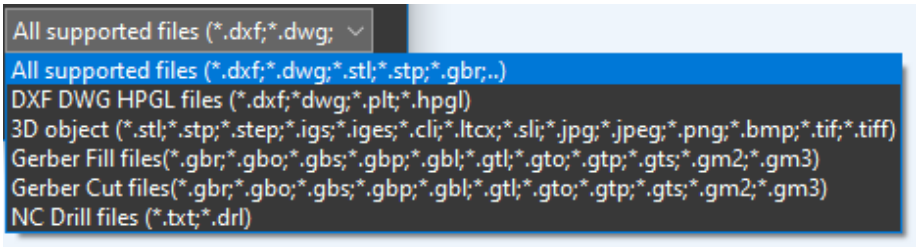


Image 16: supported CAD file types

Editing CAD objects

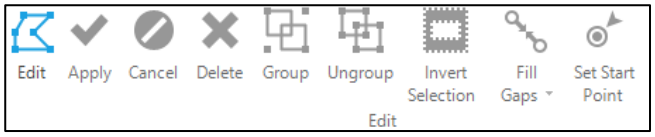


Image 17: edit group tools

In DMC, CAD files can be edited through the Edit menu tab. This functionality is available only for CAD files. If you have selected geometries designed in DMC, then you need to convert the geometries to CAD objects. To do that, click the To CAD Object button (found in the Edit tab in the top Ribbon).

CAD Edit allows:

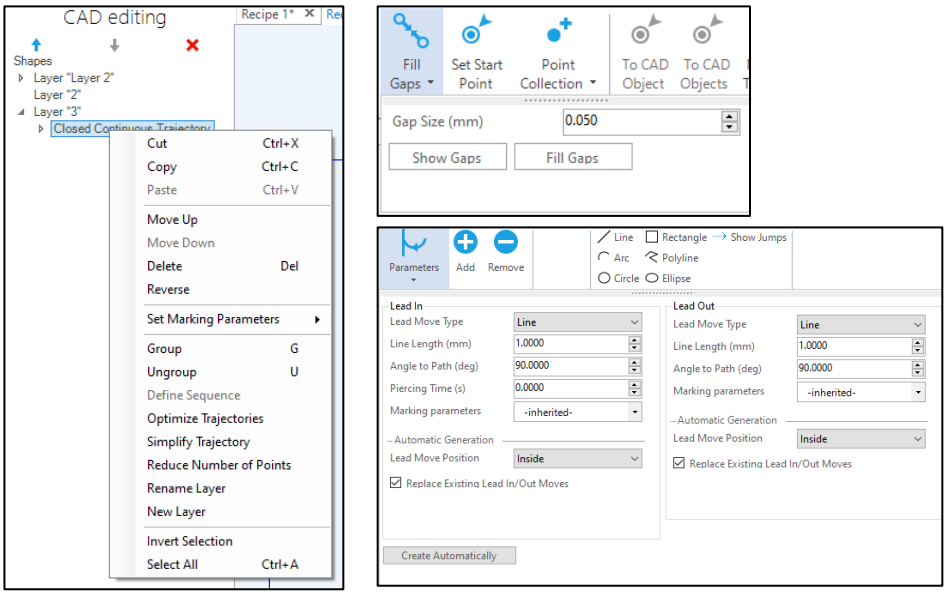


Image 18: different menus use with CAD objects

- Editing / creating new Layers for CAD
- Deleting parts of the CAD
- Adding geometries to the CAD
- Optimizing trajectories
- Setting different Marking Parameters for different elements on CAD
- Filling Gaps
- Setting Start Points
- Defining Lead Ins and Outs

- Converting trajectories to tangential arcs and lines
- Approximating with polylines
- Editing nodes
- etc.

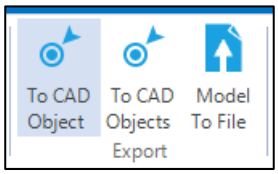


Image 20: exporting objects

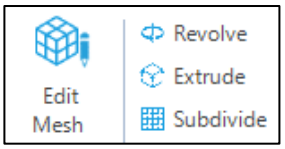


Image 19: 3D Edit tools

DMC allows converting geometries designed in DMC to CAD objects and then exporting those CAD objects to files. To convert geometries to a CAD object, please select all the geometries to convert in the Recipe window and click on To CAD Object.

You can edit 3D Objects using 3D Edit tools (requires additional plug-ins to DMC). Using them, you can create 3D shapes from 2D objects by revolving, extruding, and editing mesh (delete, select normal, etc.).

COMMAND PROPERTIES

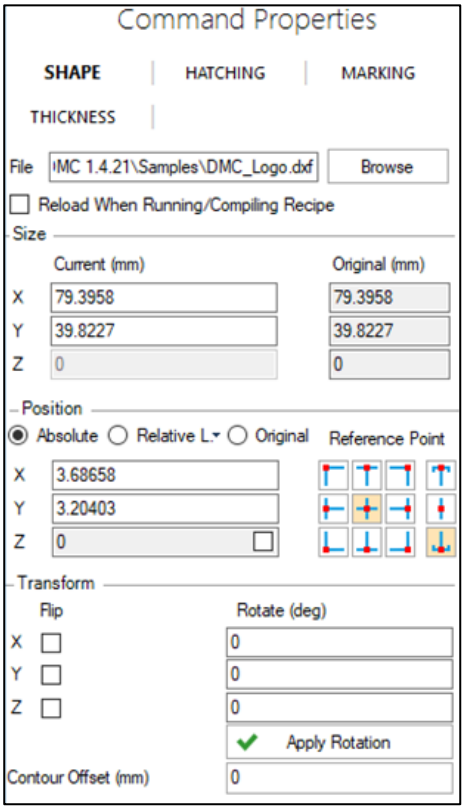


Image 21: command properties of an object. The selection of Tabs and parameters will vary depending on the selected entry in the recipe.

The Command Properties Window (default position on the right side of the screen) is where the respective settings can be found for a **Command,** an imported **Object**, or a **Device** used in the **Recipe**. Variables and Formulas can be inserted inside all the text fields in the Command Properties window.

Shape parameters

Each object that is drawn or imported has its Position settings that are displayed in the Command window. Depending on the object type, position settings may be displayed with or without a reference point.

When the Reference Point option is available, Position represents the position of the object's selected reference point, e.g., centre or top left corner.

The 3x3 grid represents the reference point selector for XY, and the 3x1 grid represents the reference point selector for Z.

After selecting the reference point, compile the Recipe to see the result.

When the Reference Point option is unavailable, Position represents the position of the Start or End of the object, e.g., the Start and End coordinates of a Line.

The object's Position can be described in Absolute and Relative coordinates or Original coordinates of the imported object (DXF, STL files).

Absolute coordinates describe an object's position in relation to 0;0 of DMC's coordinate system.

Relative coordinates describe an object's position in relation to:

- the reference point of the last object done before it (Relative R.)
- or to the last laser position (Relative L.)

Original coordinates represent the original object coordinates set in the CAD (DXF, STL, Gerber) file. It is convenient to use Original coordinates when multiple objects that need to be positioned precisely in relation to one another (e.g., Gerber file with trace marks and NC drill file with via holes in PCB) are imported.

Another parameter that can be changed is Size — changing the X and Y of an object scales it. For drawn objects (e.g., Rectangle), X and Y sizes can be changed independently, changing the object's aspect ratio. The aspect ratio is locked for imported objects (e.g., DXF, STL files). Thus, after changing the size in one dimension – others are recalculated accordingly.

NOTE: make sure the size is less than the galvo field or add a Stitching Command if stages are available in the setup.

Transform settings allow the user to flip and rotate objects. The Flip option inverts the object's coordinates along the selected axis, while the Rotate option rotates the object around the selected axis and reference point. When some of the parameters are changed, all the parameters are recalculated again in the order above, so everything needs to be recompiled to see the results of the transformation.

Hatching parameters

Hatching is a tool to fill the volume of an object. Hatching is available for any closed contours.

The Hatching tool can be accessed for Circle / Rectangle / Import CAD tools by clicking on HATCHING in the Command Parameters menu.

The settings used in Hatching are:

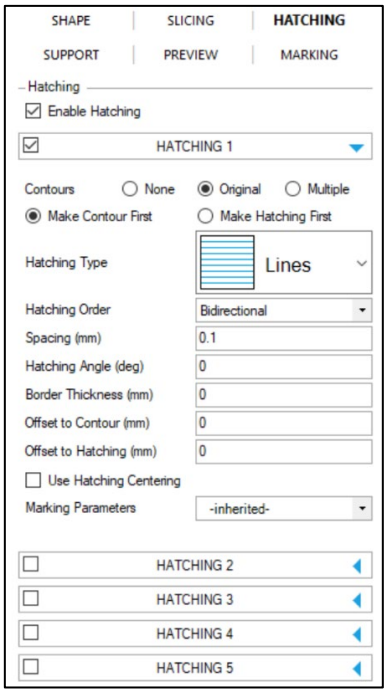


Image 22: hatching parameter selections (e.g., type, order, spacing, angle, offsets, etc.)

- 'Contours' can be selected as None, Original or Multiple. None – leave motion trajectories only for the hatching. Original – keep the original contour. Multiple – allows defining multiple contours.
- 'Make Contour First / Make Hatching First' sets whether contour or hatching lines are machined first (when Hatching is enabled).
- 'Hatching Type' allows the selection of different hatching modes for different applications/effects.
- 'Spacing' sets a distance [mm] between hatches (lines, dots, contours).
- 'Hatching angle' rotates [deg] hatching pattern.
- 'Border thickness' – when some positive number in mm is specified, fill the border of set thickness around the contour with hatching (not the whole shape).
- 'Offset to Contour' generates a new contour with a set distance from the original one. The original contour is deleted. Offset values can be positive or negative.
- 'Offset to Hatching' sets an offset distance, so hatching is started not at the contour but some distance offset from the border. This function is usually used for beam spot compensation. If 'Offset to Contour' is used, 'Offset to Hatching' is calculated from the new offset contour.
- 'Marking parameters' selects different Marking parameters for Hatching. (Marking parameters can be saved in the Marking tab).
- 'Use Hatching Centering' option positions the hatching lines at the centre of the shape.

Marking parameters

The 'Marking Parameters' command sets marking parameters like speed and laser triggering for the next section of the Recipe. These parameters are used until the next 'Marking Parameters' command.

If different Marking parameters are set in one of the geometry commands, it will override parameters set by the 'Marking Parameters' command.

The default value of Marking Parameters is -inherited-, which uses the same settings used in the previous command. If there is no previous command, default parameters are used.

The settings used in marking are:

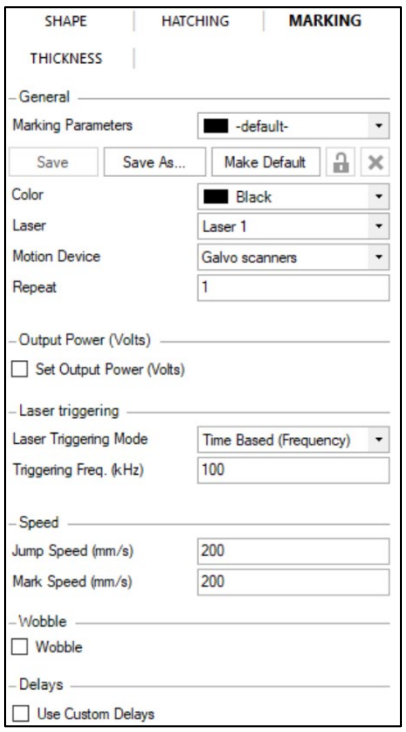


Image 23: marking parameters window

- Color. Draws lines with the selected colour.
- **Motion Device**. Selects the device that performs the motion—usually positioning stages or galvo scanners. Some further options are available only for certain galvo or positioning stage controllers.
- Repeat. Repeats trajectories a set number of times. If an object has depth, it is repeated layer by layer - all repetitions are done for one layer, and then the next layer is machined.
- **Laser Triggering:**
    - Laser Triggering Mode sets a mode for laser triggering. Available options are:
        - Position Based (Pulse Pitch) sets the laser firing trigger based on the current position (must be supported by the motion hardware).
        - PSO allows for maintaining uniform laser pulse distribution in space during stages of acceleration or deceleration.
        - Time-Based (Frequency) sets the laser firing trigger at a specific frequency (must be supported by the laser source).
        - Time-Based (Frequency Divider) sets laser firing frequency by dividing the fundamental laser frequency (set in the DMC settings) by an integer value (1, 2, 3..), so it allows through every second, every third, and so on the pulse of the laser.
        - Duty Cycle sets laser Triggering Frequency and duty cycle (usually used with CO2 lasers). Available only when laser control mode Gate is selected in File>Settings>Laser Control.
        - The 'No Triggering' option does not trigger the laser at all.
    - Pulse Pitch (only in Position Based mode) sets the distance between two laser pulses (or laser firing positions to be precise) in mm.
    - Pulse Burst (only in Position Based mode) sets how many pulses are shot per laser firing position.
    - Triggering Frequency (only in Time Based (Frequency) mode) sets laser triggering frequency in kHz.
    - Frequency divider (only in Time Based (Frequency Divider) mode) sets divider for default laser frequency.

- **Speed**
    - Jump Speed X, Y, Z sets jump motion speed for each axis in mm/s (when the laser is not firing).
    - Mark Speed sets combined marking motion velocity for all the axes in mm/s. Speed is determined as a total linear speed along the motion trajectory (when the laser is firing).

Thickness parameters

These settings allow engraving/cutting according to the shape. The user must define the thickness, choose the cutting step (Layer thickness/dZ), can rotate or shift the Hatching with each step (Change Hatching Angle/Hatching Offset X/Y). 'Return Z to start' returns the Z to the start level before the cutting.

While using the Circle tool, similar settings can be changed in the 'Drilling' section.

CAMERA/VISION

Camera settings

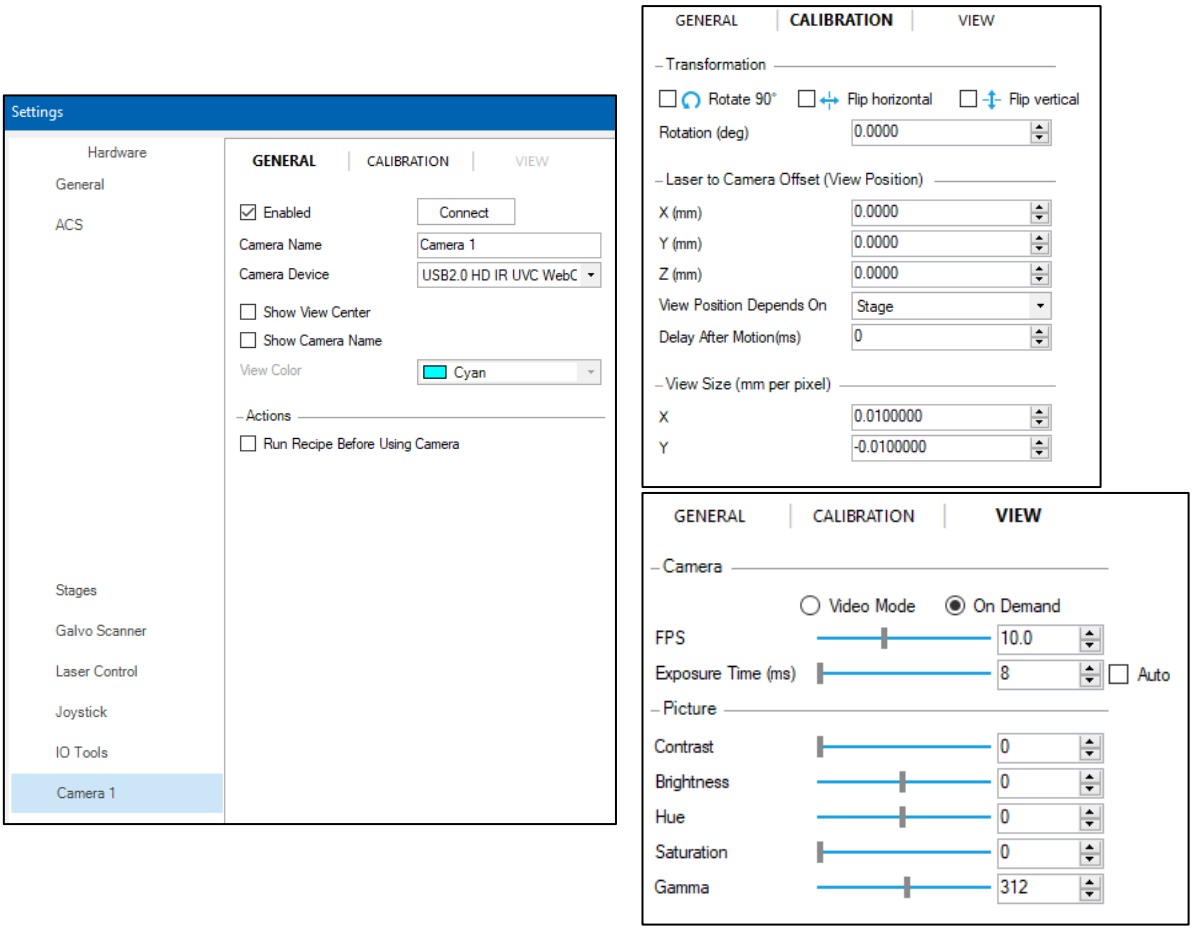


Image 24: Camera setup windows in DMC Settings.

In DMC, the user can add up to three cameras. The settings for each of these, such as camera name, image size, and others, can be changed individually in File → Settings → Camera 1/2/3.

To start, click enable. Type in the camera name if the default does not suit. Choose the available camera from the list to connect and click Connect. Now the camera should be connected.

In the Calibration tab, you can set the Laser to Camera Offset and View Size, but there is no need to do that since DMC has automatic calibration (more about that in the subsection below. If the camera is on the Z axis, please choose the View Position Depends On as 'Stage'. If two sets of axes are being used, choose accordingly. Delay after motion adds a delay if the camera view lags a bit to stabilise the image.

Please adjust the camera and picture settings in the View tab to get a good view. These settings are default, but they can always be adjusted when needed in the ribbon.

NOTE: If the webcam was used as a camera and the picture settings became grayscale, you can always readjust them in DMC settings to the appropriate ones. Put all Picture settings sliders to the centre; this sets the camera back to full colour. Once saved, these settings stay the same for Windows.

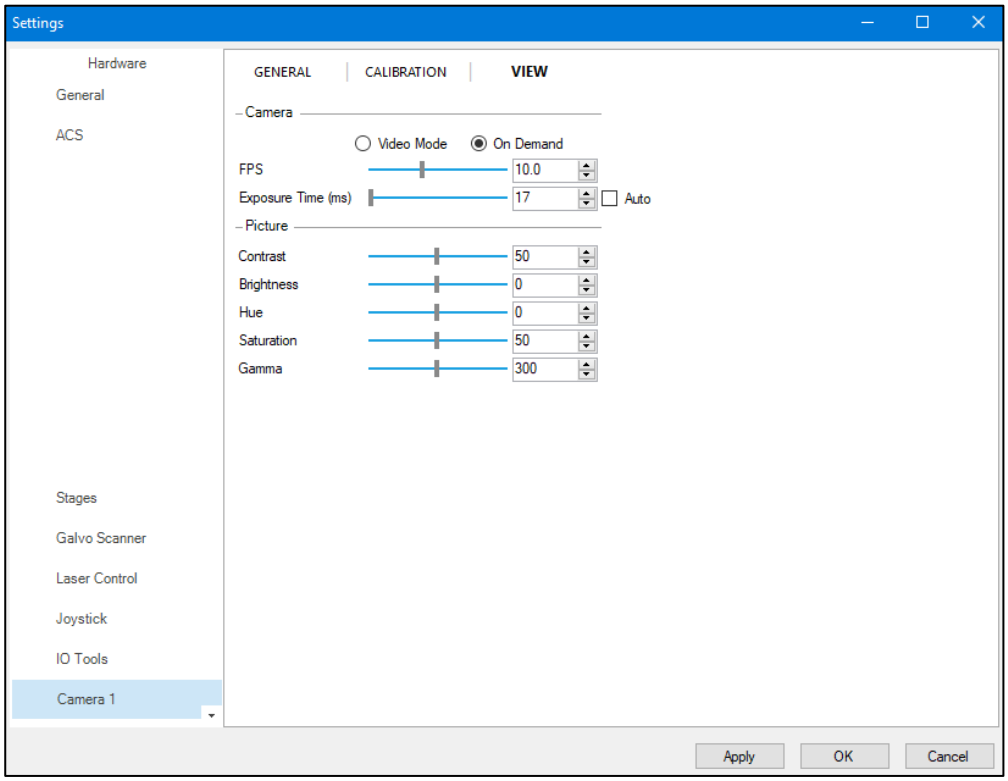


Image 25: camera view settings

Camera calibration

Before using the camera for marking, the camera should be calibrated.

Usually, it is difficult to calibrate machine vision cameras with a small view area. For this, DMC has automatic calibration tools.

To calibrate, we use the tools inside the Calibration group. There are a few methods that can be used to calibrate the camera:

Mm per pixel detection – uses stages and moves them in all directions to detect orientation/flipping and view size (mm per pixel).

Set View Size/Position – allows you to define the Laser to Camera Offset and adjust the scale if needed. To use this, first mark an object with the laser, then, using the Joystick, move the camera until the result is visible. Using the Set View Size/Position tool in the DMC preview window, drag the camera image to match the shape designed in DMC. This will ensure that the scale of the objects inside DMC is accurately matched to those in the real world.

Perspective correction (not recommended) does correction of the camera perspective. Changing the perspective stretches and distorts the preview; thus, we recommend placing the camera perpendicular to the surface and avoiding using this function altogether to reach the best results.

The user should use the mm/pixel tool first, then try marking something and matching the marked shape with the camera view using Set View Size/Position.

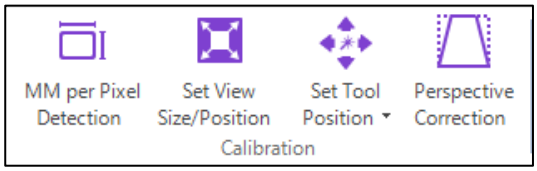


Image 26: tools for camera calibration

The camera can be calibrated by scale (mm/pixel) and offset with DMC tools to match real life. Once the camera is calibrated, process trajectories will match perfectly with the actual marking results (as per Image 27).

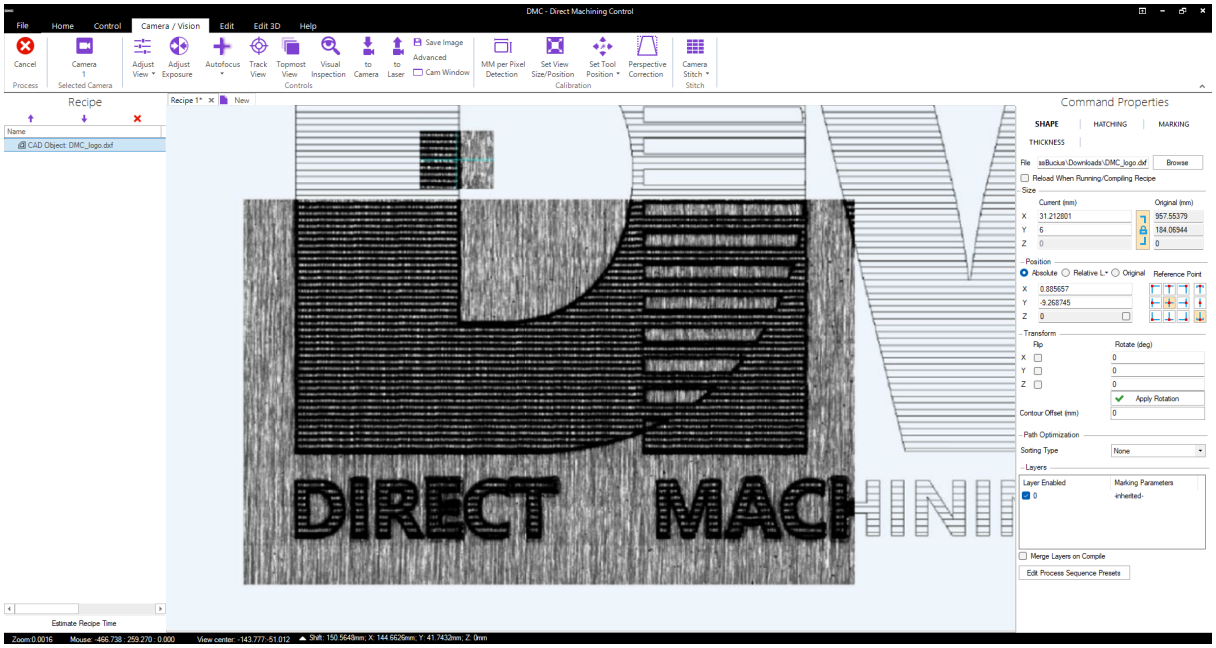


Image 27: properly calibrated camera – trajectories match the marking results.

Using cameras in DMC

In DMC, the camera is integrated into the unified work area represented by stages and scanners.

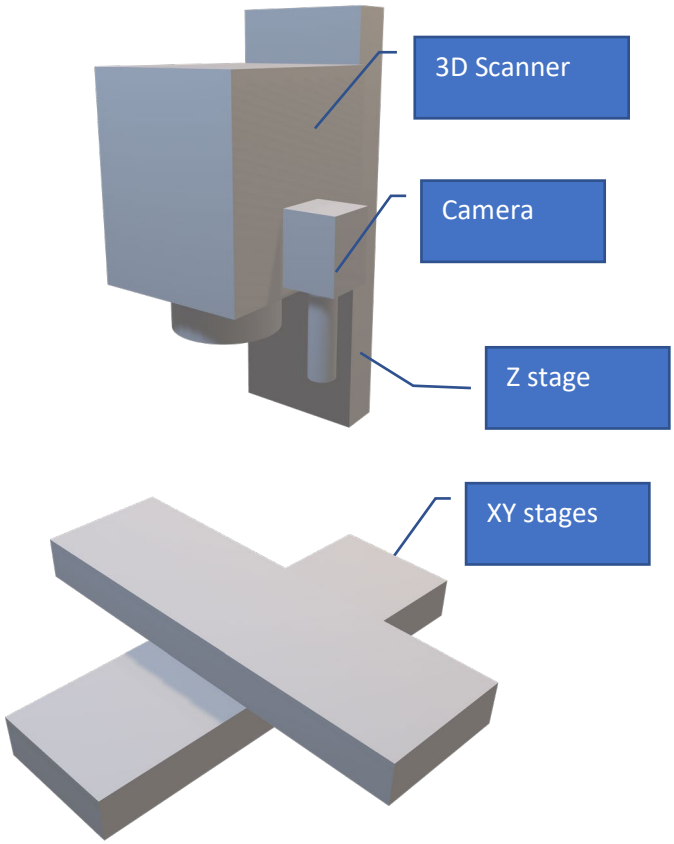


Figure 1: principle scheme of a system that can be controlled with DMC.

A rectangle display will appear inside the preview area when you connect a camera.

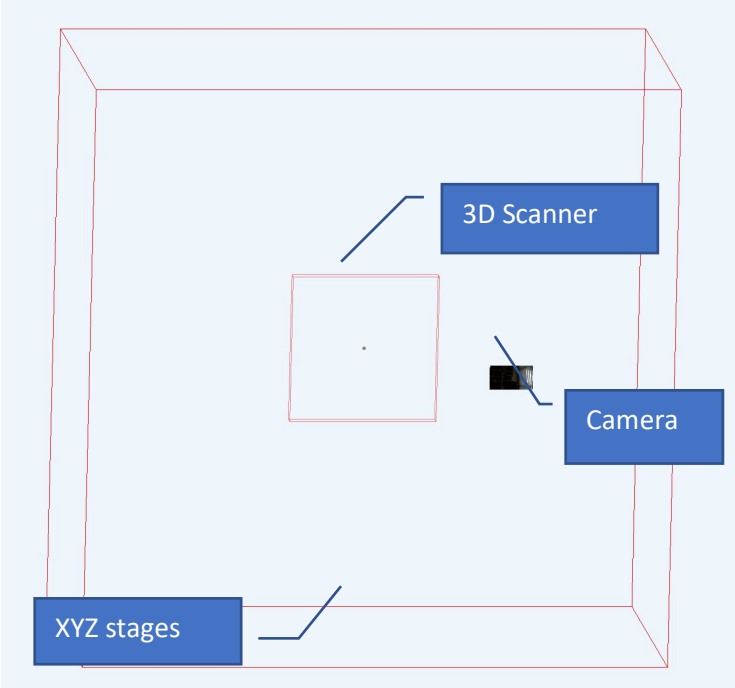


Image 28: preview window with the marked areas of the galvo scanner, stage, and camera.

The black rectangle is the camera with the appropriate scale and offsets in the whole working area.

Also, connecting a camera reveals an additional tab called Camera / Vision. It contains tools used when working with cameras.

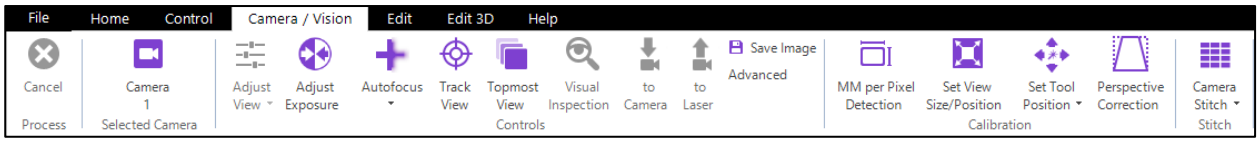


Image 29: camera tools and functions

The user can use shortcuts 'to Laser' and 'to Camera' to move the sample with the stages below the laser or the camera. Also, tools like '**Visual Inspection**' allow exploring the working area with the camera easily. With 'Visual Inspection', the user clicks on the screen where he wants to see the view, and DMC jumps with the stages to that location to see it with the camera.

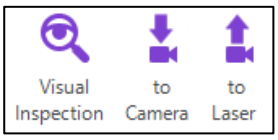


Image 30: visual inspection, to camera, to laser tools in DMC

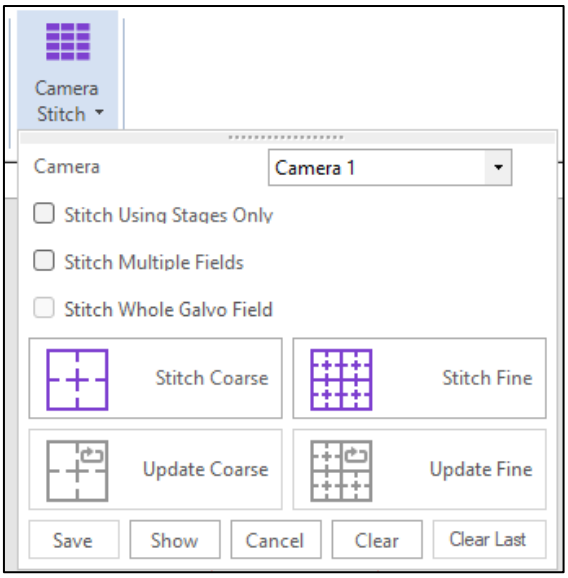


Image 31: camera stitching tool in DMC.

Another helpful tool to explore a larger sample is to use '**Camera Stitching**'. With it, the user defines the area to display, and DMC scans this area with stages and then stitches the images together.

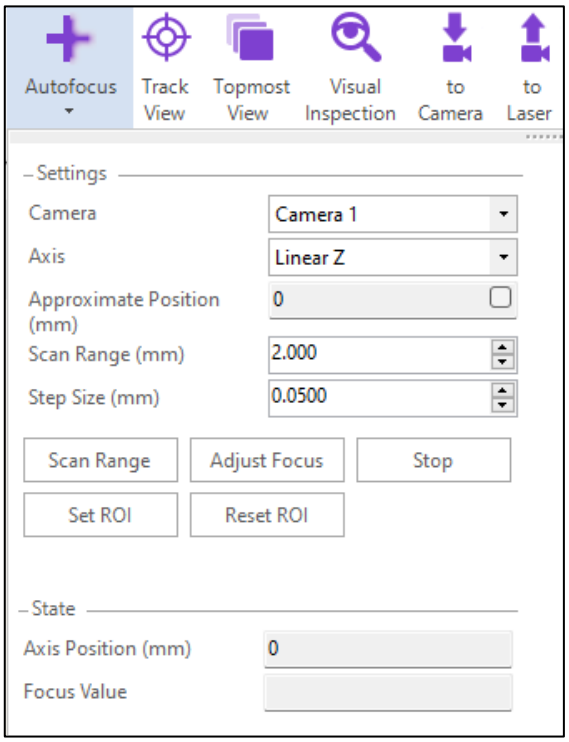


Image 33: autofocus tool in DMC

If the camera is on the same Z stage as the galvo scanner, and the camera's focus is also the laser focus, the user can use **Autofocus** to automatically focus the camera view and get the laser in focus as well.

The camera can also be used during the process in the Recipe for alignment commands, Z-map feature, or to find the focus.

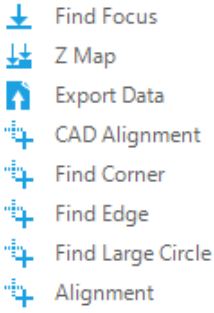


Image 32: some of the DMC tools using Machine Vision

Z-map is the feature that can use the camera or distance sensor to scan the defined area and find the profile of the surface. Then, according to this data, the trajectories are transformed to compensate for surface unevenness.

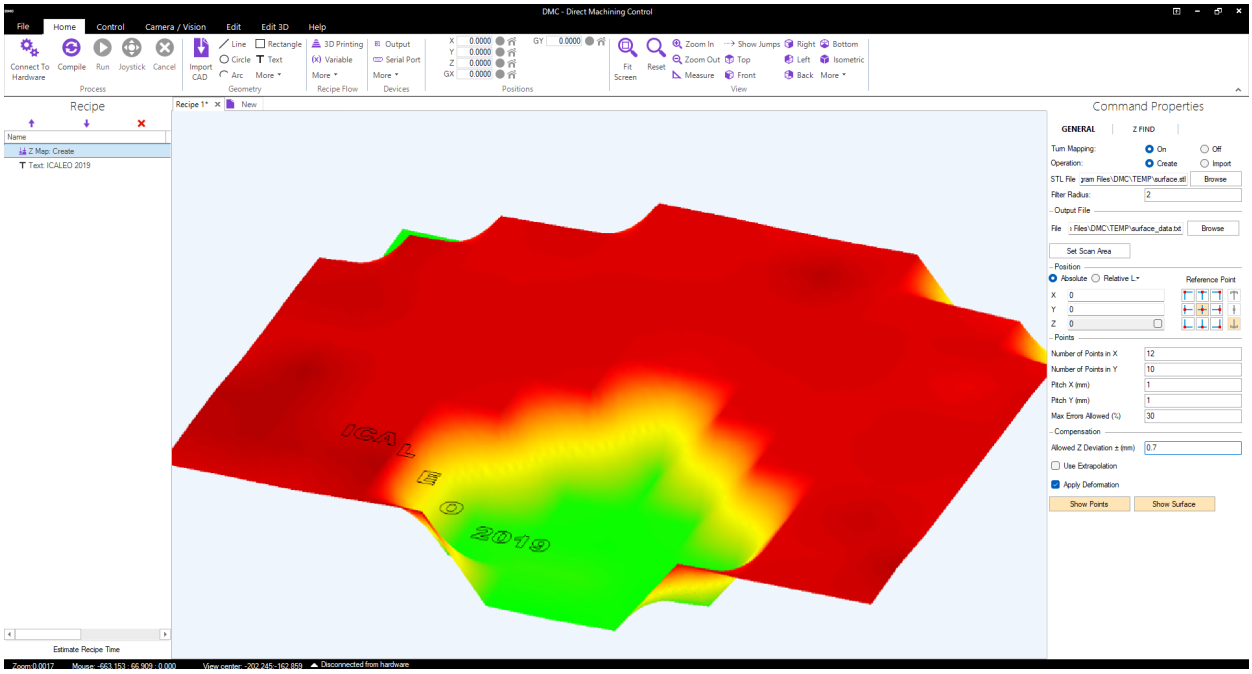
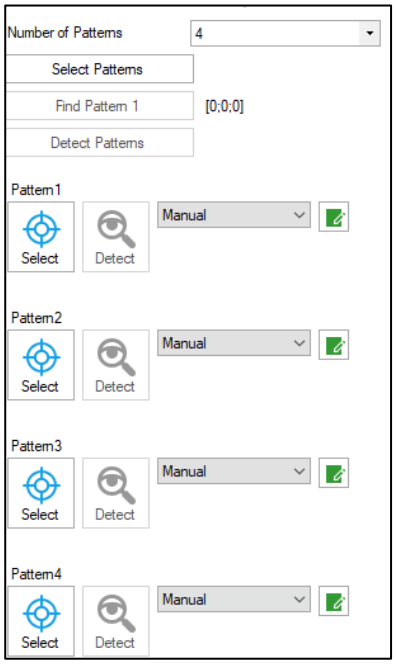


Image 34: Z-map tool in DMC for surface scanning.



All the **alignment functions** can use machine vision for automatic feature detection for CAD alignment to the real part.

CAD Alignment allows selecting parts of CAD to align to the camera view. The user selects the fiducials on the CAD, and then DMC can automatically detect the fiducials on the part to align the CAD according to it.

Other alignment or feature detection tools can find certain features using a camera, and then the user can utilise the resulting data in a recipe or do the alignment accordingly.

Image 35: CAD alignment tool settings in DMC

The machine vision setup window in Image 36 shows just a part of the features that can be found using the machine vision module.

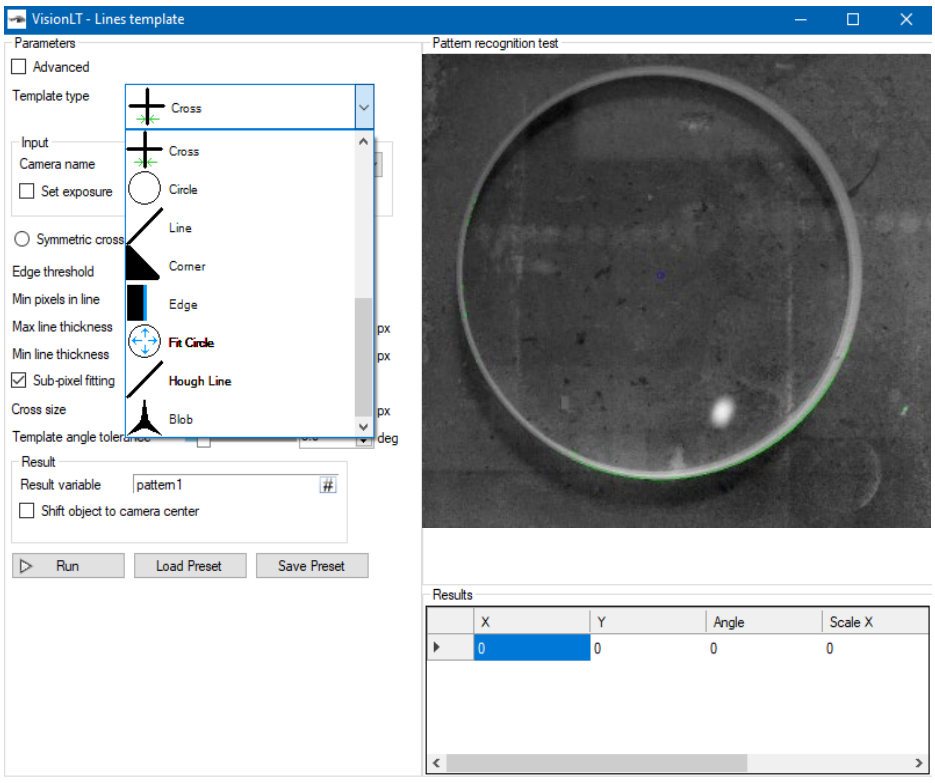


Image 36: Machine Vision setup window in DMC

Calibrating other tools using a camera and Machine Vision

The camera can also be used for stage and galvo scanner calibration. These tools are also available in DMC for easy and accurate system calibration.

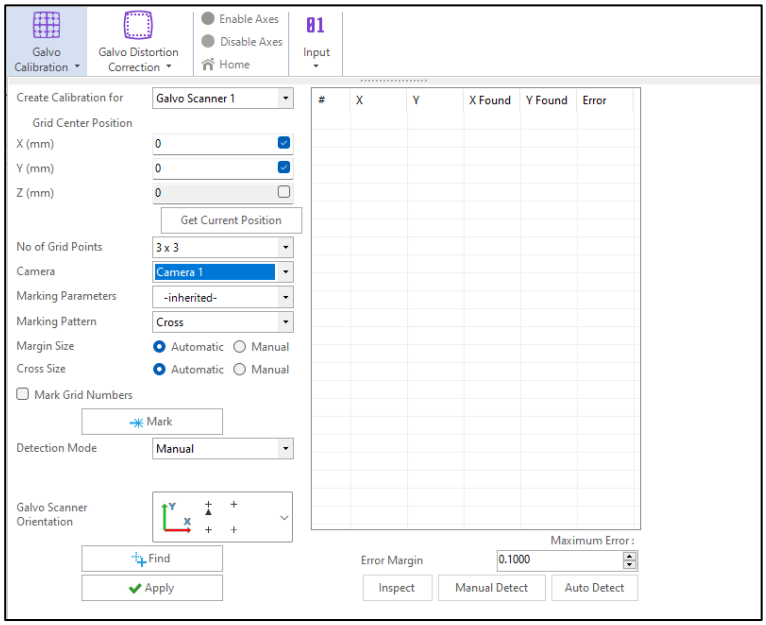


Image 37: Galvo scanner Calibration tool in DMC.

Galvo Calibration tool generates a grid according to the scanner configuration in DMC, and then the user marks this grid by pressing 'Mark'.

After marking, the user can click 'Find', and the galvo scanner orientation will be found using the stages and the camera. Each grid mark is recorded (manually or automatically using Machine Vision). After inspecting the results, the user can generate a calibration file. This procedure can be repeated a few times for even better accuracy.

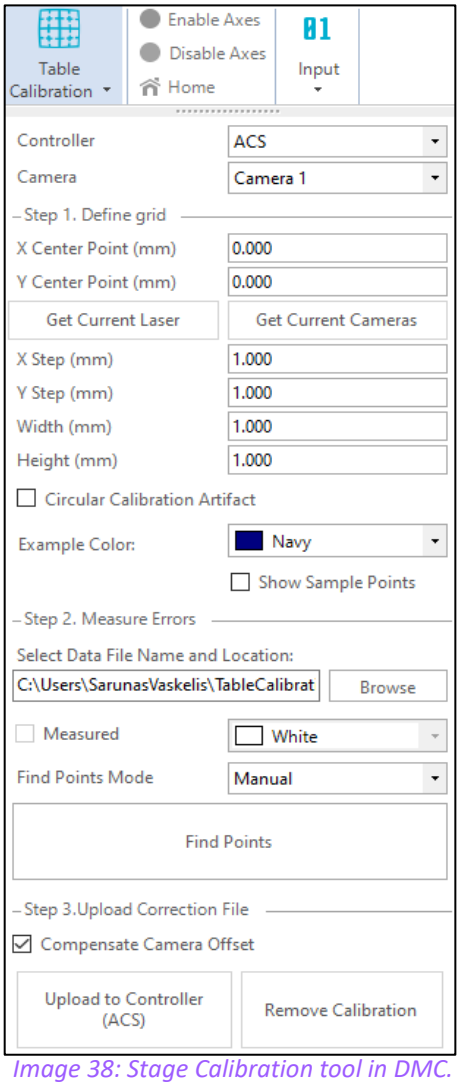


Image 38: Stage Calibration tool in DMC.

The **Stage Calibration tool** works similarly. Instead of marking, the user uses the grid's calibrated plate. Then, DMC's Machine Vision is used to find each mark to generate the stage calibration file. This function works with several different controllers.