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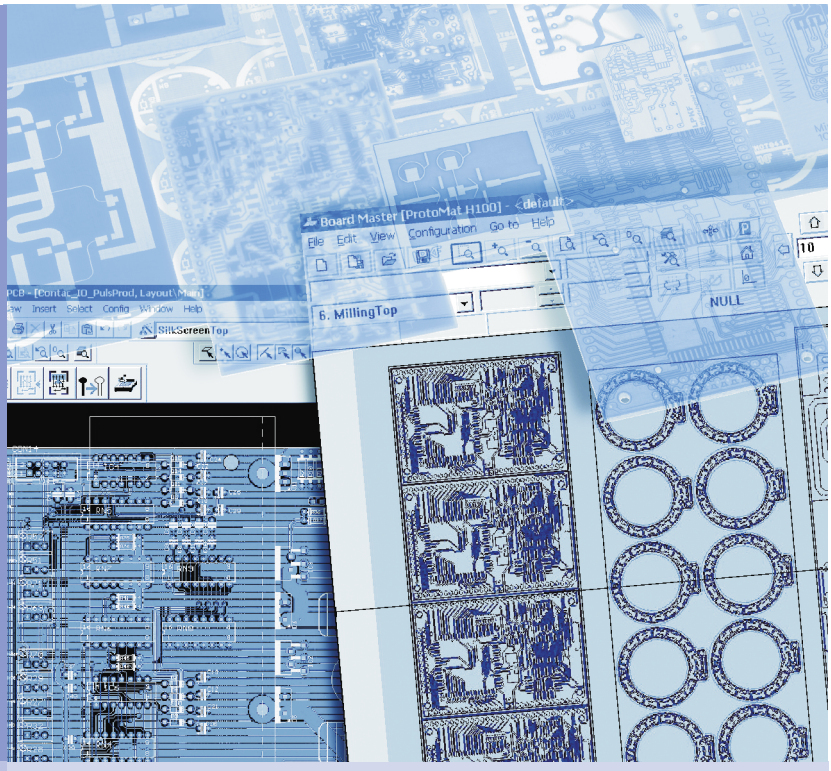

Manual

BoardMaster 5.1

LPKF
Laser & Electronics

Laser & Electronics

Manual BoardMaster 5.1

English, Version 1.0

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Preface

This Manual introduces you to operation of *BoardMaster* 5.1 for *Windows*™. LPKF *BoardMaster* is a program for automatic control of HP-GL-compatible LPKF circuit board plotters.

LPKF *BoardMaster* is capable of reading in, displaying and processing production data in LMD format (generated in LPKF CircuitCAM) as well as production data generated in HP-GL format

BoardMaster takes over complete control of the circuit board plotter. The WYSIWYG (What You See Is What You Get) display for the data to be processed, manual control of the circuit board plotter on the *Windows* surface as well as the present tool library with all required information ensures virtually complete automation of circuit board prototype production.

This Manual describes the way from LMD/HP-GL circuit board data generated by *CircuitCAM* or other programs, over job preparation right up to completion of the circuit board prototypes with the circuit board plotter.

The Manual introduces the basic control possibilities of *BoardMaster* step by step, allowing you to quickly complete your first circuit board in a simple manner.

Notes on this manual

Basic use of the *Windows* surface is not covered in this Manual. If you are not familiar with use of the various *Windows* objects, please first refer to your *Windows* documentation.

I. Manual outline

This Manual is divided up into the following chapters:

1. Safety Instructions
2. Installation
3. Operating interface
4. Production process
5. Troubleshooting
6. Appendix

II. Conventions used in this manual

Bold text is used to emphasize important information.

Illustrations are numbered continuously - Example: Fig. 5.

Italic sections are used to indicate reactions resulting from an action.

Words printed in *italics* indicate proper names.

Key inscriptions and menu terms are printed in **BOLD CAPITALS**.

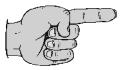
III. Notes on the symbols used

Danger!

This symbol is used to warn of danger to life or health..

Attention!

This symbol is used to identify hazards which may cause damage.



Note:

This symbol is used for notes intended to help you to avoid malfunctions in operation or help you to improve your procedures

IV. Legend

CircuitCAM	: Software used for data preparation
BoardMaster	: Software used for machine controlling
shearing winkel	: In the ideal case the angle between X aund Y-axis is 90 degrees. This results in a shearing angle of 0 degrees. The shearing angle is the relation of the two axes with respect to each other.

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1 Safety precautions

Always observe the following points for your own safety. The use of *BoardMaster* alone represents only a minor hazard potential.

- **Ensure that your computer is properly connected to the line power and to the circuit board plotter!**

- **Ensure that no one is present in the hazard area of the circuit board plotter during data transfer between *BoardMaster* and the circuit board plotter!**
- **Ensure that no one can enter the hazard area of the circuit board plotter and come into contact with the tools during operating phases controlled by *BoardMaster*!**

- **Ensure that it is not possible for unauthorized persons to operate *BoardMaster* when working with the circuit board plotter, for example during manual tool change or alignment of the base material!**
- **In the event of an emergency, shut off the circuit board plotter and PC connected to the circuit board plotter immediately!**
- **Always observe the safety precautions specified in the manual for the circuit board plotter!**
- **Also observe other safety precautions in this manual!**

2 Installation

2.1 System prerequisites

The minimum system prerequisites for installation of *BoardMaster* are:

- Pentium Processor with 700 MHz or faster
- 128 MB RAM (main memory), 256 MB recommended
- XGA grafics card, screen resolution 1024 x 768 pixel recommended
- Operation System: Microsoft *Windows* 2000/XP
- min. 4x-speed CD ROM drive
- RS232 or USB interface depending on the LPKF *ProtoMat* type

BoardMaster requires approx. 16 MB of free hard disk capacity for installation.

2.2 Scope of delivery

The *BoardMaster* scope of delivery includes:

- 1 x CD ROM with *BoardMaster* programm
- 1 x *BoardMaster* manual

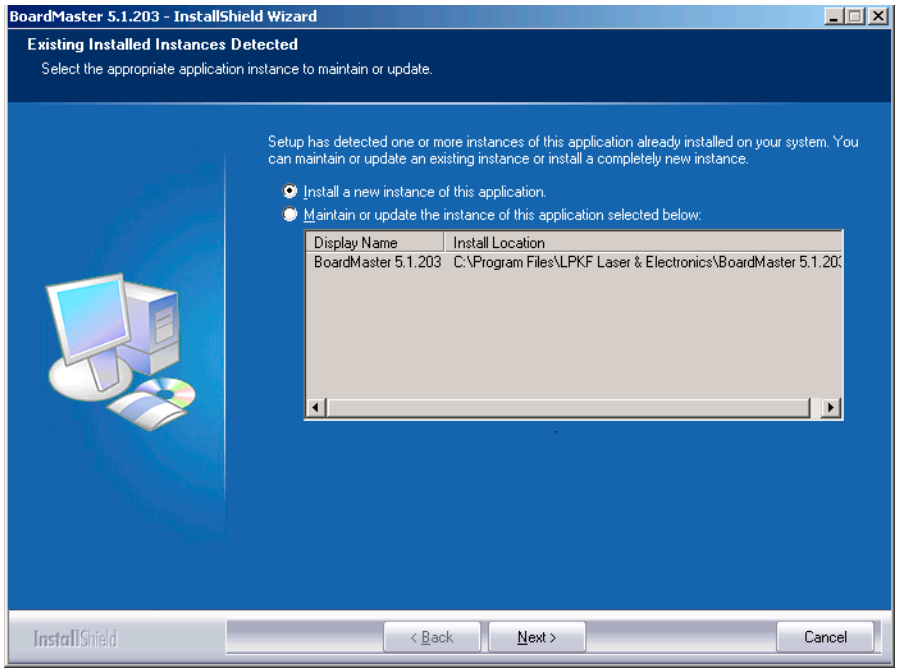
2.3 Installation

› Insert the *BoardMaster ...* & *CircuitCAM ...* CD into the CD-Drive and wait until the welcome Window „Rapid Prototyping PCB“ will be opened. Depending on the computer this can last up to one or two minutes.

› If the welcome window „Rapid Prototyping PCB“ is not opened automatically: Start the **setup.exe** file on the CD.

*The window **BoardMaster 5.1 InstallShield Wizard** will be opened:*

Fig. 1: Installation window

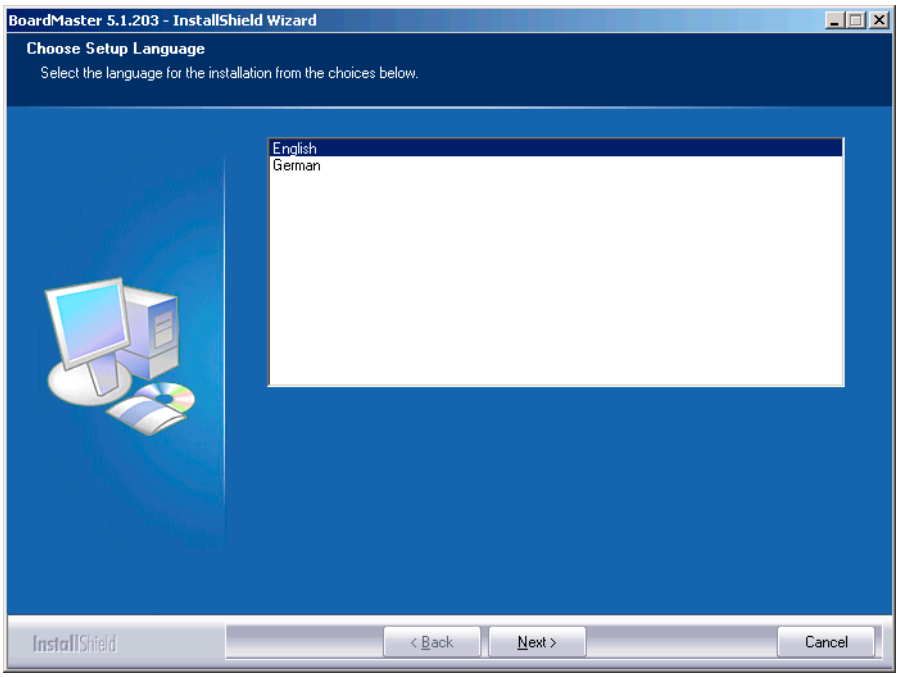


› Select the radio button “Install an new version of this product“.

› Click on **NEXT**.

Note: For updating an existing software version select the radio button “Update selected product shown in the list below“. Define the path to the programm folder and click on **NEXT**.

Fig. 2: Language selection



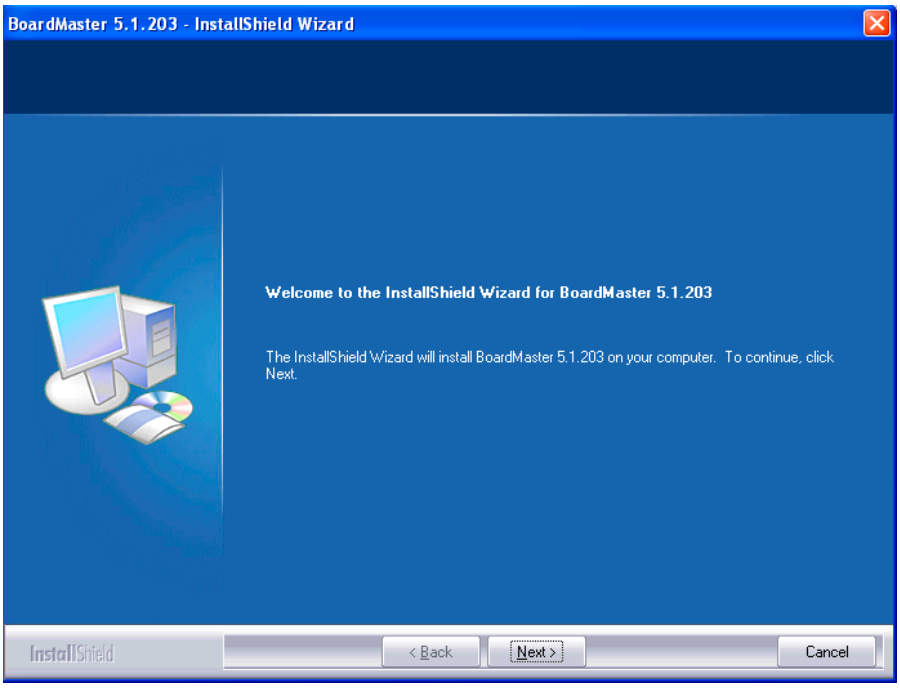
› Select the desired language (English or German).

Note: The selected language is just for the installation process. The language used for the software to be installed must be select later.

› Click on **NEXT**.

The following window will be shown:

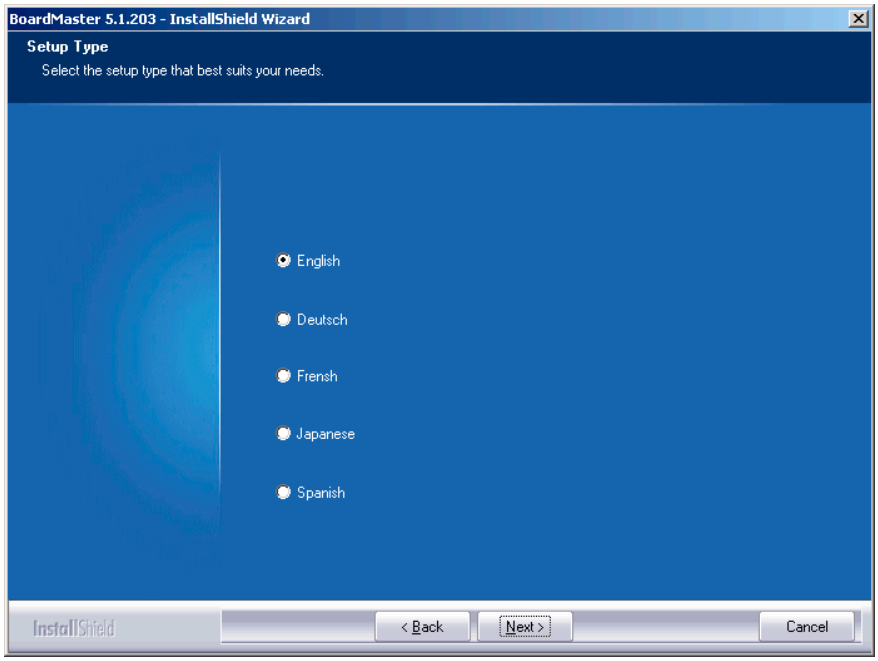
Fig. 3: Start of installation



› Click on **NEXT**.

The following window will be shown:

Fig. 4: Program language selection



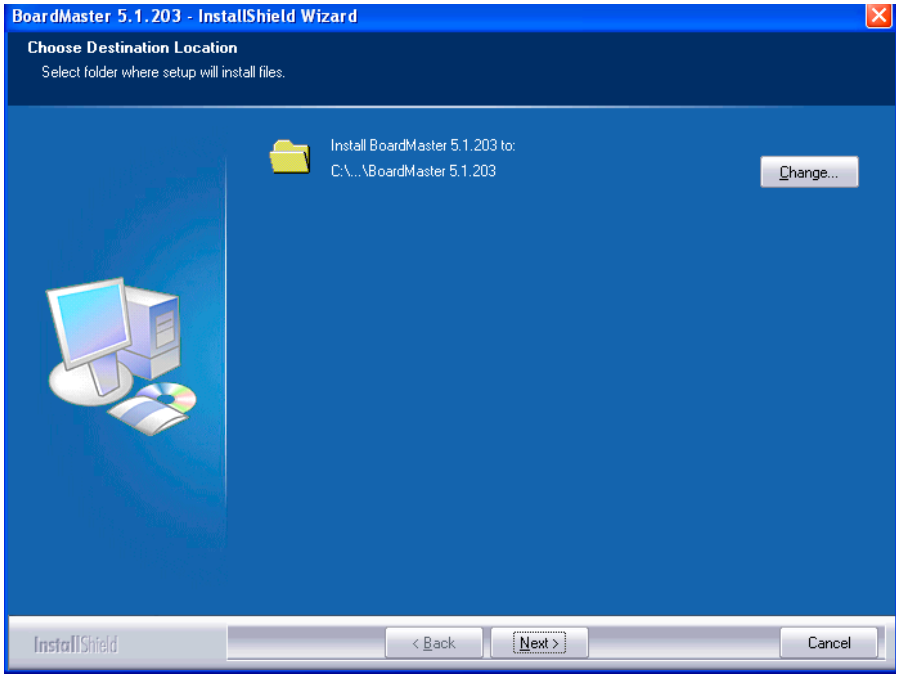
› Select the language for the *BoardMaster 5.1* operating interface.

› Click on the radio button for the choosen language, for example English.

› Click on **NEXT**.

› *The following window will be schown:*

Fig. 5: Installation folder selection

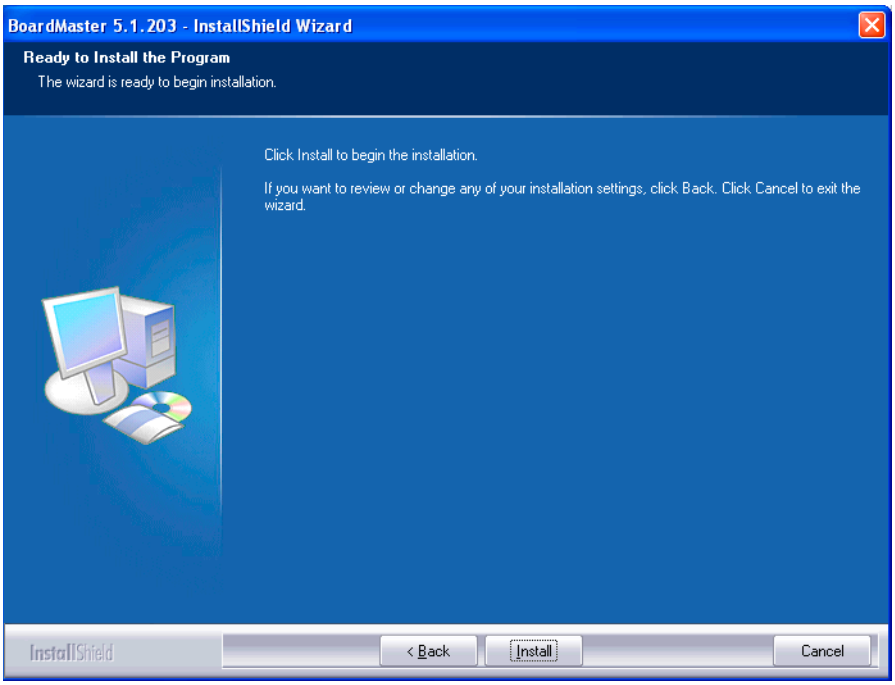


› Click on **NEXT**.

Note: The Install Wizard use a defined destination folder for installation. Click button **CHANGE** to change the destination folder.

The following window will be shown:

Fig. 6: Installation process



› Click on **Install**.

[ ] The *BoardMaster* installation will be finished automatically.

2.4 Start BoardMaster

After installation of *BoardMaster*, the Start menu contains a new program group “LPKF Laser & Electronics“, as well as a new linkage on your *Windows* desktop.

For error-free operation with your circuit board plotter, it is absolutely necessary to observe the switch-on sequence specified below:

- **Switch on the circuit board plotter.**
- **Wait until the green operating indicator on front or on the „data“-LED on the back panel of the circuit board plotter lights up.**
- **Start *BoardMaster*.**

Otherwise, the communication accomplished even when *BoardMaster* is starting, cannot be performed.

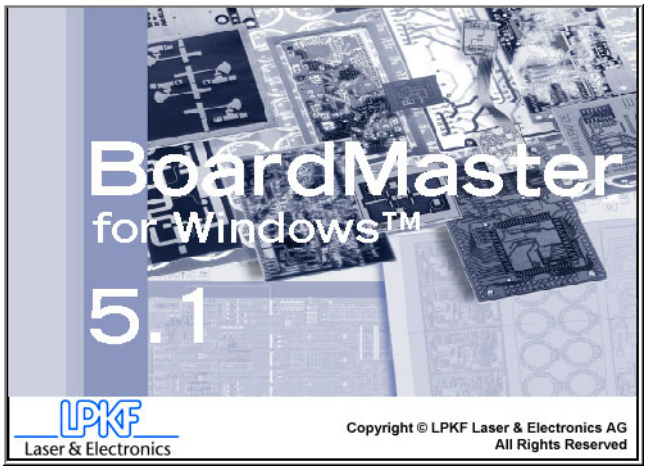
2.4.1 Startup the program

› Double-click on the *BoardMaster* icon on the desktop.

› Or click on **Start > Programme > LPKF Laser & Electronics AG> BoardMaster ...** .

The BoardMaster startup window will be opened.

Fig 7: Startup screen



This startup screen may be visible for up to 8 seconds, which is related to the communication between the PC and the machine, it does not represent an error. After that, the program start is automatically continued.

› In case of appearing the **Connection...** windows:

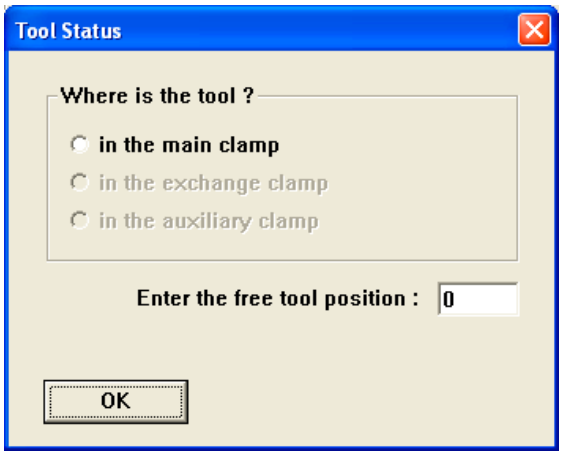
– Check the operating state of the circuit board plotter and connection cable between PC and circuit borad plotter.

– Check the connection settings (see chapter 3.1.4.6 “Connect“ on page 40)

› In case of appearing the **Tool status** windows:

– Select the tool position and click on **OK**.

Fig 8: Startup screen

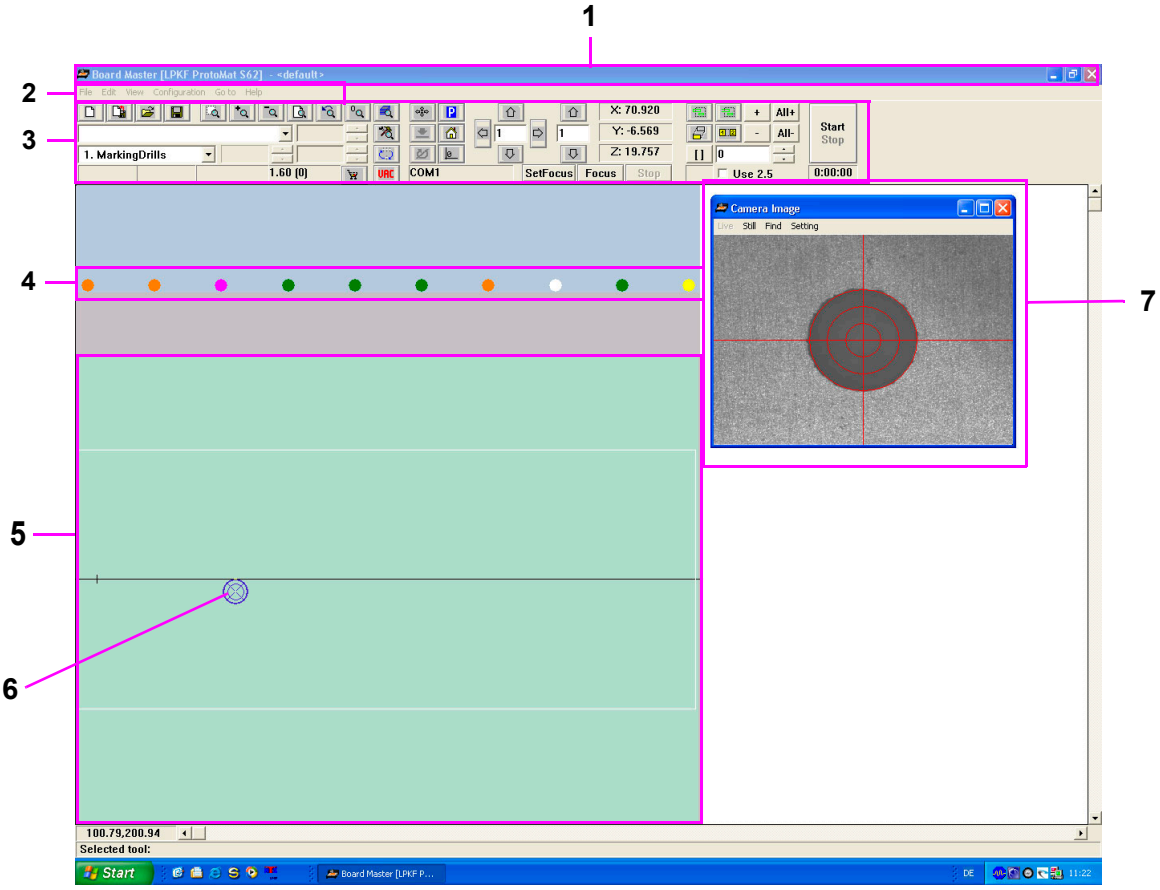


[ ] The BoardMaster operation interface will be opened.

3 Operation interface

The figure shows the *BoardMaster* operation interface:

Fig 9: *BoardMaster* window



1- title bar
2- menu bar
3- function bar
4- tool change position (optional, only *ProtoMat* S62/S100)
5- available workspace
6- blue crosslines indicates the actual position of the drill / mill head
7- camera window (optional, *ProtoMat* with camera system)

The *BoardMaster* operation interface is separate in several areas:

- The **title bar** indicates the program name with the declaration of the circuit board plotter type as well as the name of an loaded or new created job.
- The **menu bar** indicates the available menu functions.
- The **function bar** contains several bottons, displays and functions to control the circuit board plotter and to modify a job.
- The **workspace** indicates graphically the topview on the circuit board plotter.
  - This area is itself divided up into the actual **motion range** of the circuit board plotter (displayed in dark gray) and the area of the **base material** used (displayed in green) with the **circuit board data** to be processed. **Only in this area**

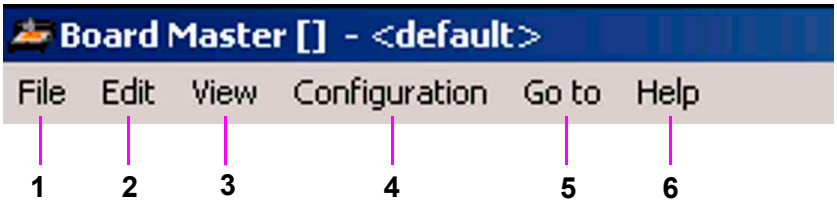
you can lower the head, therefore all data must be placed in this area.
You can adapt the graphic display of the working area to your specific requirements with the functions in the **VIEW** menu.

- The **display scroll bars** are located on the right of and below the working area and serve for moving the visible section into the working area.
- The current **mouse cursor position** is indicated at the left next to the horizontal scroll bar.
- The **status bar** below the horizontal scroll bar provides information on buttons, displays or areas where the mouse cursor is presently located.
- The **tool changing position** (for S62/S100) represents the stations 1-10 of the tool magazine.

3.1 Menu bar

The foloowing figure indicates the *BoardMaster* menu bar:

Fig 10: Menu bar



1- File menu
2- Edit menu
3- View menu
4- Configuration menu
5- Go to menu
6- Help menu

3.1.1 File menu

The functions of the **FILE** menu are used for file organisation and to close the *BoardMaster* program.

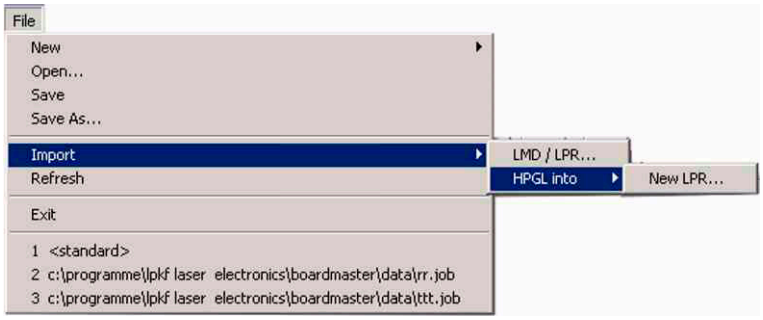
Fig 11: File menu

NEW	Use this submenu to create a new job file for a *BoardMaster* application.
OPEN	Use this submenu to open an existing job file- for the a *BoardMaster* application.
SAVE	Use this submenu to save a *BoardMaster* job file. The file name will be the same as displayed in the title bar.
SAVE AS	Use this submenu to save a *BoardMaster* job file under a new file name.
IMPORT	Use this submenu to import production data or project files into the *BoardMaster* program.
ACTUAL	Use this submenu point to refresh the actual job file.
EXIT	Use this submenu point to close the *BoardMaster* program.

3.1.1.1 Import data

Use the menu **IMPORT** to load production data or *BoardMaster* projects:

Fig 12: Import menu



LMD/LPR... Select this entry to import LMD files (*CircuitCAM* production data) or LPR files (*BoardMaster* HP-GL projects) into *BoardMaster*.

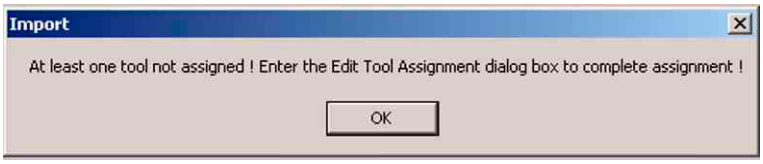
HP-GL into In this submenu, select the entry:

- **New LPR** to import the HP-GL files into *BoardMaster* and assign them to a new project.
- **STANDARD** to import HP-GL files into *BoardMaster* and assign them to a standard project.

Note: Version 3.x LMD files can also be imported. However, it is necessary to reassign the tools „Assigning Tools“ on page 85 and the production phases, because these names are not identical and *BoardMaster* cannot find the old names.

After importing LMD files, data is positioned immediately in the middle of the working area for the circuit board plotter. Moreover, the production data and the required tools are automatically assigned to the data: If it is not possible for *BoardMaster* to assign one or more tools, the following message appears:

Fig 13: Import message



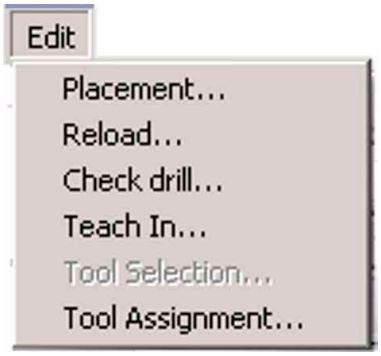
In this case, it is necessary to assign the tools manually in the tool assignment dialog box or to complete the tool library before importing the data again.

After exporting the files, all tools required are listed in the *CircuitCAM* report window.

3.1.2 Edit menu

All function of the **EDIT** menu are used to overwork the process file.

Fig 14: Edit menu



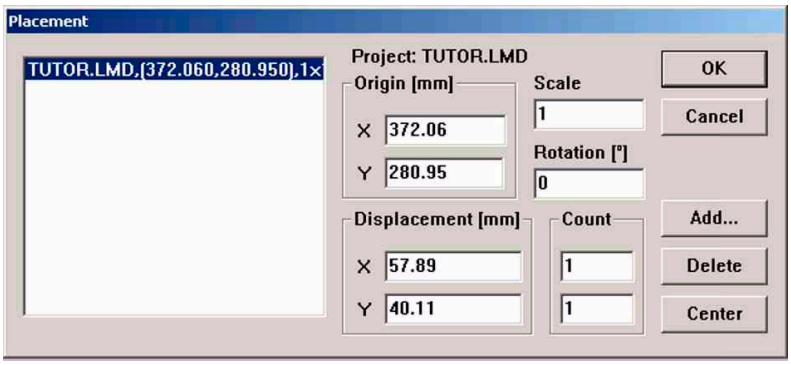
PLACEMENT	Select submenu **PLACEMENT** to place new project on the basic material.
RELOAD	Select submenu **RELOAD** to overwork already manufactured circuit boards.
CHECK DRILLL	Select submenu **CHECK DRILL** to monitor the tool during the production process.
TEACH-IN	Select **TEACH-IN** to edit a production process step by step in *BoardMaster*.
TOOL SELECTION	not supported
TOOL ASSIGMENT	Select submenu **TOOL ASSIGMENT** to assign the tool to every project seperately.

3.1.2.1 Placement menu

After you have imported or generated the required projects, you can place them in the *BoardMaster* working area. Imported projects are automatically positioned in the center of the working area or the predefined base material.

Click on **EDIT>PLACEMENT** to open the following submenu:

Fig 15: Placement menu



Place a project:

› Click on **ADD** and select a project from the list.
or:
Select a project from the list of the left side of the window to change the placement.

› Edit the text field **SCALE** to get the required scaling for the project.

Standard scale value is 1, indicating scale 1:1.

For application such as front plate and plate engraving other scales can be defined.

› Enter the desired position for the project in the working area in the text field X and Y under **ORIGIN**. These values refer to the **HOME** position for the circuit board plotter and the data origin.

If the exact position of the data in the coordinate system are not known, enter the value 0 and 0 here and position the project in the working area with the aid of the function bar or computer mouse.

› Select the appropriate offset for the project in the working area under **ROTATION**.

› To complete more than one prototype for a project, define the number of multiple boards under **COUNT**. Enter the number of boards in the X direction in the first text field and the number of boards in the Y direction in the second text field.

› Enter the interval of the boards under **DISPLACEMENT**. Enter the displacement of the boards in the X direction in the first text field and the displacement of the boards in the Y direction in the second text field.

The displacement of the boards in relation to one another must correspond to at least the length and width of the circuit boards, because otherwise, the boards would overlap.

Multiple boards can also be created with the function bar.

Place a project in the base material center:

› Select the corresponding project in the list field.

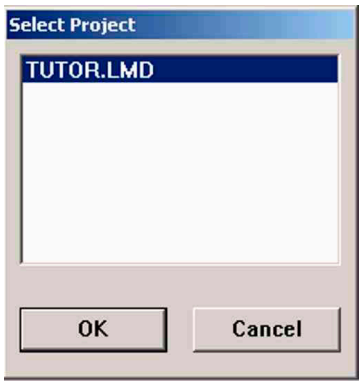
› Click on **CENTER** to position the selected project in the center of the base material.

Add further project for placing:

› Click on **ADD**.

› Select a project form the list for placing on the base base material additional.

Fig 16: Dialog box select project



› Click on **OK** to close the dialog box.

Delete a placed project

› Select the project with must be removed from the list.

Click on **CANCEL** to remove the placed project from the base material.

3.1.2.2 Reload material menu

The function **RELOAD MATRIAL** serves for reloading a circuit board which has already been completed and cut, in order to drill additional holes, engrave text or separate the conductors for coding.

The prerequisites for using the reload function include a circuit board requiring reprocessing and the circuit board data as LMD file with at least two identifiable points (holes, reference marks, vectors), which can be assigned to the corresponding points on the circuit board.

The main purpose of the reload feature is to position the data so that it coincides with the circuit board to be processed. For this purpose, two identifiable points in the data (reference points) are assigned to the corresponding points on the circuit board to be processed.

When **RELOAD MATERIAL** is selected, the floating dialog box is opened:

Fig 17: Dialog box reload material

Reload material

› If not already accomplished, open the **RELOAD MATERIAL** dialog box. Click on the radio button for **1.POINT** and select the first reference point on the data (center point of solder eye or hole, corner point).

› Click on  to bring **CENTER** or **EDGE** mark to the required position.

Only drill hole selection

Only pad selection

› Move the machining head with tool installed or the cross hairs on the camera (LPKF CircuitView Option) as exactly as possible to the appropriate point on the circuit board. For this purpose, use the motion keys on the function strip:

› Click on the **READ** button to import the point.

› Actived radio button **2. PIONT** and repeat the above desribed procedure for the second reference point (**3. POINT** and **4. POINT**).

› Mark the check box **ENABLE.**

› Close the dialog box **RELOAD MATERIAL** by clicking **OK.** A data reload will be activated.

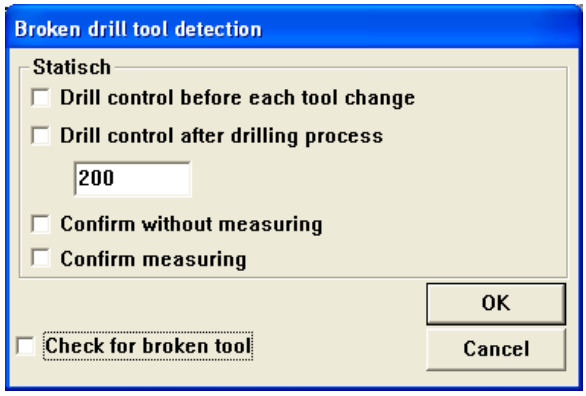
› Mark all data to be transmited to the circuit board plotter. Th data will be recalculated acc. to the position on the printed circuit board after clicking **START** button.

To avoid the data adjustment of further jobs deactived the check box **SETTINGS**. Click on **OK** to leave the function and close the dialog box.

3.1.2.3 Drill break control

Click on **EDIT>BROKEN DRILL TOOL DETECTION** to open the following dialog box:

Fig 18: Dialog box Check drill



If you activated the check box CHECK FOR BROKEN TOOL the following check functions are available:

Drill control before each tool change	Click this check box to activate the broken drill tool detection before every tool change.
Drill control after drilling process	Click this check box to activate the broken drill tool detection after a number of drills, defined in the input field below.
Confirm without measuring	Click this check box to drill a test hole automatically via *BoardMaster*. *BoardMaster* compare the hole dimension with the default parameter. If the hole dimension miss the default parameter *BoardMaster* generates a error message and the tool must be changed.
Confirm measuring	Click this check box to drill a test hole. The user must check the hole dimension and must confirm the correct hole dimension.
Check for brocken tool	Click this check box to activate the broken tool check.

› Select the required function for broken tool check and click on **OK**.

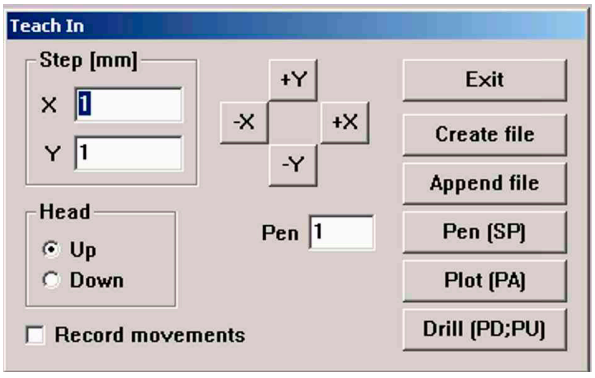
Note: The functions described above are only for *ProtoMat* types with camera option.

3.1.2.4 Teach-In

The *BoardMaster* program offer the possibility of programming drilling and milling data from a template (film or circuit board) with the aid of a Teach-In process. For this purpose, fasten the template to the circuit board plotter and move to the individual positions to be programmed with the aid of the camera image in LPKF *CircuitView* (option). The HP-GL file completed in this manner can be read into *BoardMaster* after programming and output to the circuit board plotter.

Click on **EDIT>TEACH-IN** to open the following dialog box:

Fig 19: Dialog box Teach-In



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STEP [MM]	The values entered under X and Y [mm] indicates the distance moved when the motion buttons (+X, -X, +Y and -Y) are pressed once. To program the drill holes in an IC enter a value of 2.54 mm here. This corresponds to a pad interval of 1/10".
HEAD	The command for lifting or lowering the head can be programmed by clicking one of the two radio buttons (UP, DOWN). The head remains in the selected position until the other radio button is activated. This function is not used to create a drilling file, but only for programming milling or contour data.
RECORD MOVEMENTS	All movement command are stored in the selected file when this check box is activated.
+X, -X, +Y, -Y Buttons	These buttons serve for moving to a desired position. If one of these buttons is clicked, the machining head moves in the selected direction by the value entered under **STEP**.

PEN	The pin number entered in this editing field is written to the selected file as the **SELECT PEN** command. This allows all drilling data even with different diameters to be combined in one drilling file. Example: Pin 1 for 0.7 mm, pin 2 for 0.9 mm and so on.
EXIT	Clicking this button discontinues the Teach-In process and closes the recorded drilling or milling file.
CREATE FILE	By clicking this button *BoardMaster* requests entry of the name of a file in which the data to be programmed are to be stored. Here, it is possible to either create a new file or to write over a file already present.
APPEND FILE	Click this button to select a drilling or milling file which already exists to which the additional drilling or milling data are to be appended. The new data are appended at the end of the selected file.
PEN [SP]	The pin or tool number selected under **PEN** is added to the drilling or milling file as the **SELECT PEN** (SP) command when this button is clicked. It serves for differentiation of the individual drill diameters.
PLOT [PA]	Click this button to move the head (when **RECORD MOVEMENT** is switched off) at angles not equal to 90°.
DRILL [PD;PU;]	Click this button to program a hole at a position moved to previously. This causes the command sequence **PEN** down, **PEN** up to be written into the file. This command chain corresponds to a drilling command for the circuit board plotter.

› Fasten the template (film or circuit board) on the circuit board plotter as parallel as possible to the axis.

› Click on **EDIT**>**TEACH-IN** to open the dialog box.

› Click the **SAVE** button to create a file in which the data is to be stored. Enter a name for the file.

After you have entered the corresponding name, the **TEACH-IN** dialog box reappears.

› Switch on the option **RECORD MOVEMENTS**, before starting the reading operation.

The file to be created is an HPGL file meaning that it is also written according to the steam for an HPGL file.

› First enter the desired pin number under PIN and then click the **PEN (SP)** button.

› Then move with the aid of the motion keys **(+X, -X, +Y, -Y)** to the hole positions to be read in and press the **DRILL (PD;PU)** button.

› After reading in all of the required holes, the data is stored automatically, you can exit the **TEACH-IN** dialog box by pressing the **EXIT** button.

The recorded coordinates are then available in the HPGL file created previously.

› Now select **IMPORT>HPGL TO>NEW LPR...** in the file menu, select the HP-GL file just created and enter a name for the new LPR project.

› To produce something with this newly created file using *BoardMaster* and the machine, open the **EDIT PROJECT** dialog box to assign all required product phases and tools to the HP-GL file.

Moreover, set the unit corresponding to the machine resolution (e.g. 0.0079375) in the **EDIT PROJECT** dialog box (this value is also given in the settings **SETTINGS** dialog box in the **CONFIGURATION** menu).

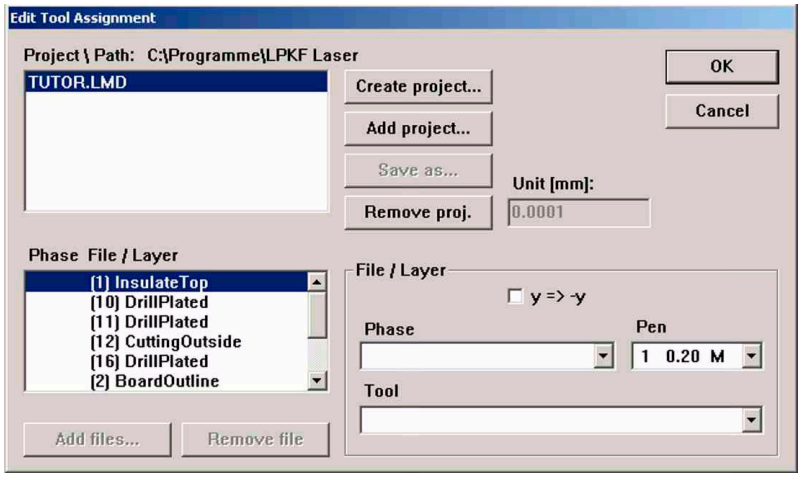
Note: Please do not forget to reset the unit back to the original value after completion of this operation.

3.1.2.5 Tool assigment

Every *BoardMaster* job consist of one or more projects. A project is general definded as a printed circuit board imported as LMD file or HP GL project.

Click on **EDIT>TOOL ASSIGMENT** to open the following dialog box:

Abbildung 20: Dialog box tool assigment



Generally the production data will be imported via the file menu. Projects like LMD data from *CircuitCAM* or HP GL files can also added via this dialog box.

The LMD files generated during export in *CircuitCAM* contain the production data for the entire circuit board. The LMD files imported into *BoardMaster* are listed in the project list. The *CircuitCAM* layers with their production phases (phase) are listed in the field Phase file/Layer. Each of these entries contains one or more pieces of tool information (pins) with the assigned tools from the *BoardMaster* tool library (tool).

If automatic tool assignment was not possible (see above), it is necessary to edit the tools manual:

› Select a **LAYER** without tool assigment from the list.

› Open the Pin list field and check whether a tool is assigned to each “PEN”.

› If not, select the tool to be used here from the Tool list field.

Repeat this assigment process until all tools are correct assigned.

3.1.3 View menu

To adapt the graphic display of the *BoardMaster* working area to the specific requirements of the user the functions in the **VIEW** menu can be used:

Fig 21: View menu

ZOOM AREA Select submenu **ZOOM AREA** to display a freely selectable cutout of the working area to fill the screen.
For this purpose, press the left-mouse button and hold down while moving the mouse to define the desired area. You can also select this function by clicking  on the function bar.

ZOOM IN X1.5 Select submenu **ZOOM IN X1.5** to increase the graphic display by a factor of 1.5.

ZOOM OUT /1.5 Select submenu **ZOOM OUT /1.5** to decrease the graphic display by a factor of 1.5.

MACHINE Select submenu **MACHINE** to display the entire working surface of the circuit board plotter in the working area.

MATERIAL Select submenu **MATERIAL** to display the entire base material surface in the working area.

ALL PROJECTS Select submenu **ALL PROJECTS** to display all positioned projects as large as possible in the working area.

PREVIOUS Select submenu **PREVIOUS** to return to the previous screen display.

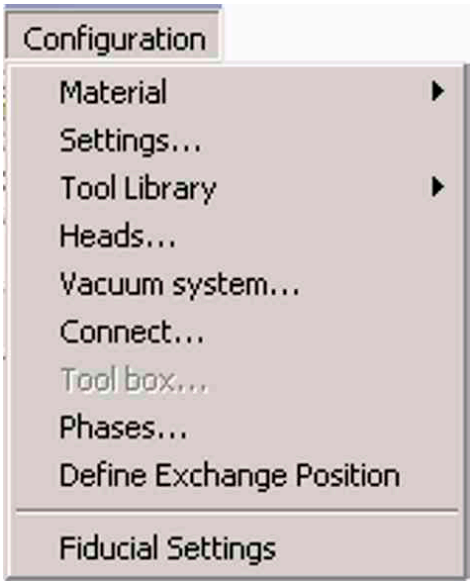
BOTH SITES Select submenu **BOTH SITES** to change back and forth between simultaneous display of both sides of the circuit board and display of only one side of the circuit board.

REAL TOOLS	Select submenu **REAL TOOLS** switch display of the milled lines in the actual width ON and OFF. The actual width of the milled lines is defined in the tool library.
DEFAULT FONT	Select submenu **DEFAULT FONT** to change back and forth between the *Windows* system font and the font set under **CHANGE FONT** for display of the text.
CHANGE FONT	Select submenu **CHANGE FONT** to select the font to be displayed when the **DEFAULT FONT** is deactivated.
COM REPORT	Select submenu **COM REPORT** to save the interface communication between computer and circuit board plotter (*ProtoMat*) in a log file.
CAMERA	Select submenu **CAMERA** to activate the camera (optional).

3.1.4 Configuration menu

All configuration settings with are used for *BoardMaster* or the connected circuit board plotter are grouped under this menu point:

Fig 22: Configuration menu



MATERIAL	Select submenu **MATERIAL** to edit the material dimension.
SETTINGS	Select submenu **SETTINGS** to change or edit general process parameter.
TOOL LIBRARY	Select submenu **TOOL LIBARAY** to edit the tool library.
HEADS	Select submenu **HEADS** to open the head dialog box.
VACUUM SYSTEM	Select submenu **VACUUM SYSTEM** to open the exhausting dialog box.
CONNECT	Select submenu **CONNECT** to open the interface dialog box.

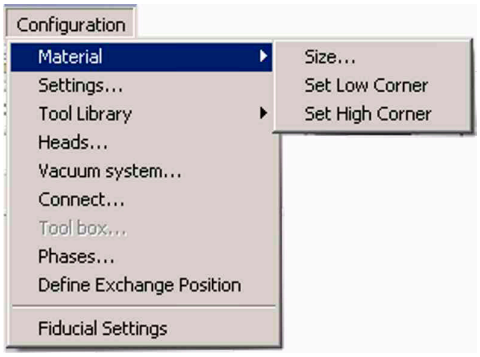
TOOL BOX	Select submenu **TOOL BOX** to open the WZ magazin dialog box.
PHASES	Select submenu **PHASE** to open the phase dialog box.
DEFINE EXCHANGE POSITION (*ProtoMat S42* only)	Select submenu **DEFINE EXCHANGE POSITION** to open the position read dialog box.
FIDUCAL SETTINGS	Select submeu **FIDUCAL** to open the fiducal dialog box.

3.1.4.1 Material

By preparation of a new job first of all the size of the base material must be defined. It is necessary because BordMaster must display the actual work space inside the work area to support the optimal placing of the circuit board data.

Click on **CONFIGURATION>MATERIAL** to open the following submenu selection:

Fig 23: submenu selection material



This submenu provides two options to define the material size:

- use **SET LOW CORNER/HIGH CORNER** to edit the material size via moving the drill/mill head and reading the coordinates.
- use dialog box **SIZE** to edit the material size manual.

Size definition via moving drill/mill head:

Precise determination of the base material size can be accomplished with the circuit board plotter connected with the functions **SET LOW CORNER** and **SET HIGH CORNER** in the submenu **MATERIAL** in the menu **CONFIGURATION**.

Danger! The following instructions starts the circuit board plotter.

Ensure that no one can enter the motion range of the circuit board plotter. Danger of pinching and crushing!

Also observe the safety precautions in the circuit board plotter manual!

› Move the drill/mill head of the circuit board plotter with the arrow keys to the “front right corner” (X/Y-Min) on the circuit board material.

› Click on **CONFIGURATION>MATERIAL>SET LOW CORNER.**

› Move the drill/mill head of the circuit board plotter with the arrow keys to the “rear left corner” (X/Y-Max) on the circuit board material.

› Click on **CONFIGURATION>MATERIAL>SET HIGH CORNER.**

After the base material size has been defined, it is displayed in dark gray in the *BoardMaster* working area.

Note: Always observe the specified sequence for setting the coordinates (first front right corner, then rear left corner)!

When defining the material size, observe attachment strips and the size of the working depth limitation as well as the position of the reference hole pins.

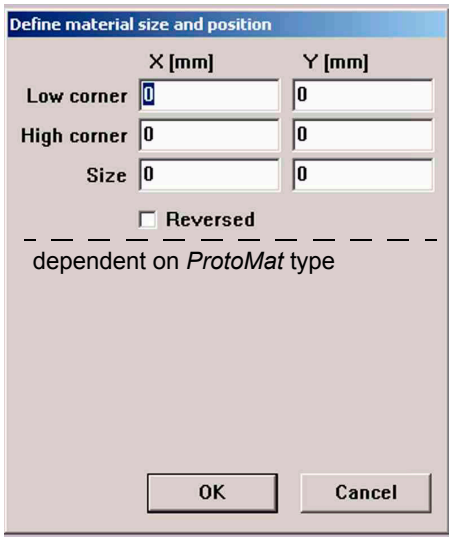
When a new job is defined; the already defined material size is deleted.

Manual input of the material size:

Note: This possibility for defining the size should only be used for preparing a job when the circuit board is not connected, because precise entry in consideration of the positioning on the circuit board plotter and the position of the reference holes in the base material is not possible.

Click on **CONFIGURATION>MATERIAL>SIZE** to open the following dialog box:

Fig 24: Dialog box material size



Note: The dialog box is splitted in two parts. The upper part is identically for all *ProtoMat* types and is use for the input of the base

material size. The lower part is depending on the actual *ProtoMat* type and is used for the input of informations like material thickness or free moving high. For more detail information take a look into the respective machine manual.

The size of the base material can be defined by manually entering the corresponding values in the text fields. The size calculated from the values in the upper text fields is displayed in the text field **SIZE**.

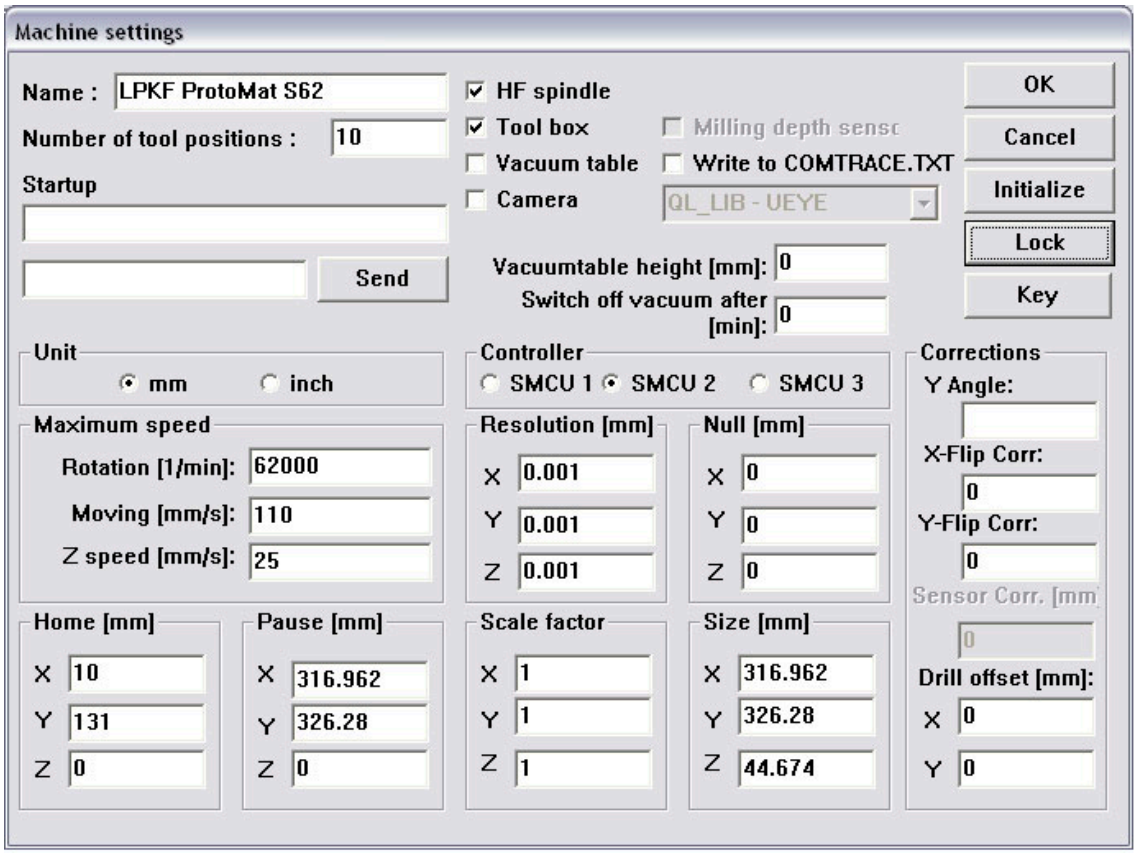
After exiting this dialog box by clicking **OK**, the base material area is displayed in dark gray in the working area.

Always observe that the minimum values (possibly negative sign) are entered under X-MIN / Y-MIN and the maximum values under **LOW CORNER.**

3.1.4.2 Machine settings

Click on **CONFIGURATION**>**SETTINGS** to open the following submenu:

Fig 25: Submenu machine settings



NAME	The drill/mill plotter type will be displayed in this text field, the same type name as indicated on the *BoardMaster* title bar. This indication is use for information only and has no relevance for the operation process.
NUMBER OF TOOL POSITIONS	The number in this text field indicates the number of tool change positions. The number varieds depending on the drill/mill plotter type: *ProtoMat 95s* always 30, ProtoLaser always 23, LPKF Automill always 7, *ProtoMat* S62/ S100 10.
UNIT	Click on one of the two options to have the length, diameter coordinates and so on displayed either in inch or metrically.
SEND	Click on this button to send the command in the entry field to the left of the button to the circuit board plotter. For this function it is not necessary to click first on the button **UNLOCK**. For the command syntax please read the manual of the circuit board plotter.
ROTATION [1/min]	The number in this text field indicates the maximum speed of rotation of the spindle of the circuit board plotter.
MOVING [mm/s]	The number in this text field indicates the maximum speed of movement of the circuit board plotter when the machining head is lifted.
RESOLUTION [mm]	The numbers in these two fields define the distance which the circuit board plotter moves in X or Y direction at one step of the stepping motor. Do not change these values under any circumstances as otherwise the correct scaling of the output cannot be guaranteed.
CORRECTION [mm]	This value (in millimeters) compensates the installation position of the sensor with respect to the tool measurement. This value is part of the *ProtoMat* S60 factory settings and it is stored in the ini-file.
Write to COM-TRACE.TXT	Click this check box to the log data into the COMTRACE.TXT file.
MILLING DEPTH SENSOR	This function activates the measurement of the surface milling tools (only *ProtoMat* H100).
CORRECTIONS	Compensates for a shearing angle that developed subsequently between the axes. This setting may only be made under the instructions of the Support Department of the LPKF AG
FLIP CORRECTION	Failures cause by turning around of the cicuit board will be equalized with this function. Change this adjustment under the instruction of LPKF support devision only.
SMCU 3 CONTROL	Controller type SMCU III for *ProtoMat* S42 (up manufacturing year 2008).

SMCU 2 CONTROL	Controller type SMCU II for *ProtoMat* H100, *ProtoMat* X60 (up manufacturing year 2004), *ProtoMat* H60, *ProtoMat* S62.
SMCU 1 CONTROL	Controller type SMCU I for LPKF 91s, LPKF92s, *ProtoMat* 91s, 91s/VS, 92s*,93s and *ProtoMat* 95s also *ProtoMat* C20, C30*, C60, C100/HF, M30*, M60 and X60.

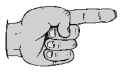
BoardMaster is capable to operate two types of control. Selection of the control type is done in the field **CONTROL** and is preset for the circuit board plotter selected in the setup.

Note: The type of control should not be changed as otherwise the correct data transfer with the corresponding syntax is no longer possible.

To prevent a change by mistake of the parameters listed in the dialog field MACHINE SETTINGS if you want to make a deliberate modification you have to click on the button UNLOCK (password protected) to enable the editing of a parameter.

During installation, the machine parameters of the circuit board plotter are read from the initialisation disk that is supplied together with the plotter. Thus all important values like machine size and the position of the **HOME** position (data origin on the axis of reflection) are already programmed at the factory. The circuit board plotter is immediately ready for operation.

All important information like **HOME** position and area of travel must be sent from *BoardMaster* to the control of the circuit board plotter.



Note: In case the individual INI-file is lost it may be necessary to newly initilise the circuit board plotter.

If the plotter parameters must be set anew or corrected, please follow the instructions in chapter „Initialization of Circuit Board Plotter“ on page 104.

A chain of commands in plotter syntax can be entered in the text field **START LINE**. The commands are stored in the initialisation file when *BoardMaster* is closed and are sent to the circuit board plotter when *BoardMaster* is started.

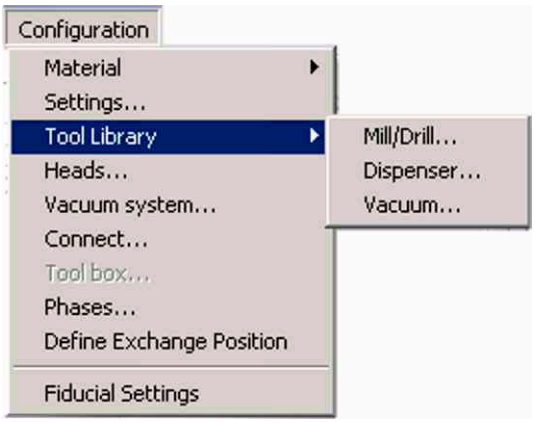
All inputs in the dialog field **MACHINE SETTINGS** are transferred to the plotter when **OK** is clicked to leave the program and they are stored in the initialisation file when *BoardMaster* is closed. Thus they are available at each new start of the program.

3.1.4.3 Tool library

The *BoardMaster* program provides tool libraries containing tools available from LPKF with all specific tool settings. The tool library files are available in three versions: *.TOL for drilling and milling tools, *.DIS for dispensing needles and *.VAC for evacuation needles (only with LPKF AutoContac). All lists can be changed and stored for later use.

Click on **CONFIGURATION>TOOL LIBRARY** to get access to the several tool libraries:

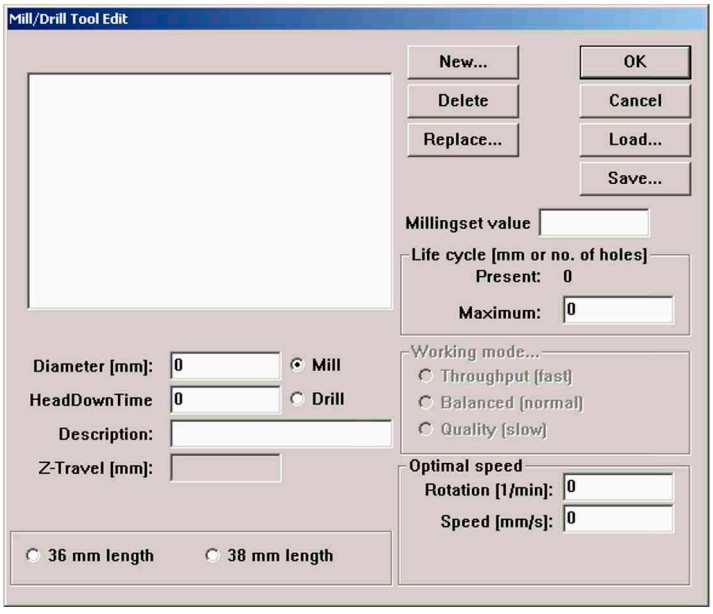
Fig 26: Tool library submenu



The tool library contains the definitions of all necessary tools inclusive their characteristical features for the circuit board plotter operation. To add tool or change existing tools the following parameter description must be observed.

› Click on **CONFIGURATION>TOOL LIBRARY>MILL/DRILL** to open the following dialog box:

Fig 27: Mill/Drill tool edit menu



NAME LIST	This list field contains the name of the tool. The selection of the name should provide information on the type of tool to facilitate later selection in other program sections. After selecting a tool in the list field, you can display its settings and change them if required. The names selected here must coincide with those in *CircuitCAM*. This name allows automatic tool assignment when importing LMD files.
DIAMETER [mm]	The number in this text field indicates the diameter of the tool. This value allows automatic tool assignment when importing LMD files and the display of the actual diameter in the graphic working area.
HEAD DOWN TIME	The number in this text field indicates the time interval in seconds between the command “Lower head” and the command “Raise head” for the drilling tool.
DRILL/MILL	The tool can be defined as a milling or drilling tool by clicking one of these two options.
DESCRIPTION	An additional description of the tool can be entered in this text field. However, this specification has no significance for the production sequence.
LIFE CYCLE [mm or no. of holes]	The number in the text field **MAXIMUM** specifies the maximum cutting path or maximum number of holes for the tool. In the text field **PRESENT**; the cutting path already cut or the current number of holes for the tool is indicated. The tool change procedure can be started by clicking **REPLACE** and after replacing the old tool, the specification in the text field **PRESENT** is reset to 0.
OPTIMAL SPEED	The speed in the text field rotation defines the optimum rpm for the machining spindle. The number in the text field **MILLING** defines the optimum feed rate for milling tools.
MILLING INFEED [mm]	Value in millimeters for milling depth (engraving tools L=36mm) and infeed (cutting mills L=38mm). All milling tools that only machine the surface of the material or engrave it penetrate into the material with this value, after the zero position was detected by the depth sensor prior to that. Cutting mills are not detected by the depth sensor. Then the value only indicates the further infeed.
WORKING MODE	Here parameter sets or profiles can be assigned to each tool. There are the profiles **THROUGHPUT, BALANCED, QUALITY**. Parameters speed, acceleration and dwell times can be stored for each of the three axes, they apply to „lower head“ (drilling) and „head down“(milling). These profiles are stored in an MCH-file and are preset for the various working mode profiles.

Note: The speed is used automatically only for circuit board plotters with variable spindle speed. For all other circuit board plotters with variable motor speed, the optimal speed must be set by hand on the control. The optimal speed to be set is, however, indicated by *BoardMaster* upon tool change.

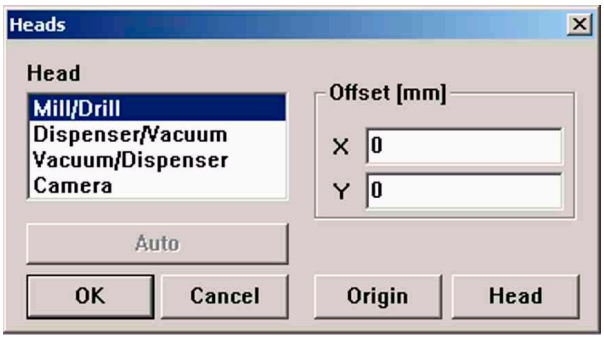
All changes in the tool library can be stored in a tool file (*.TOL) and loaded again later. The file to be loaded when *BoardMaster* is started can be defined in the machine file "*.MCH" with the command "#INCLUDE".This also applies for production phases, the dispenser and vacuum tools.

By clicking on **SAVE** all changes of the tool file (*.TOL) will be saved. Click on **LOAD** to reload this data file later on.

3.1.4.4 Heads

Select **CONFIGURATION>HEADS** to open this dialog box:

Fig 28: Dialog box Heads



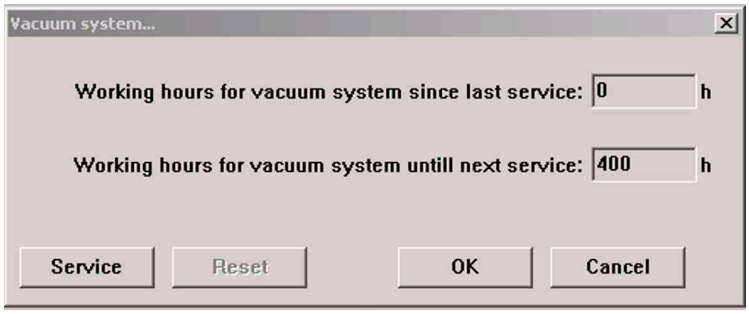
The tool heads are listed on the left side and the corresponding offsets are in the X/Y text fields on the right side ofthe window:

HEAD	The milling/drilling head serves as a reference for all other options mounted on the head. Its offset should therefore always be set to X = 0 and Y = 0.
OFFSET [mm]	The distance between a light dot or camera option mounted on the machining head and the machining head is defined here. This can be used for precise positioning for reloading circuit boards already completed. A detailed description of how these offsets are calculated is given in the following chapter.
AUTO (*ProtoMat* S62/S100 only)	This function is used to calibrate the camera offset automatically. The calibration process needs a inserted tool and a base material fixed on the object table.

3.1.4.5 Vacuum system

Select **CONFIGURATION>VACUUM SYSTEM** to open this dialog box**:**

Fig 29: Dialog box vacuum system

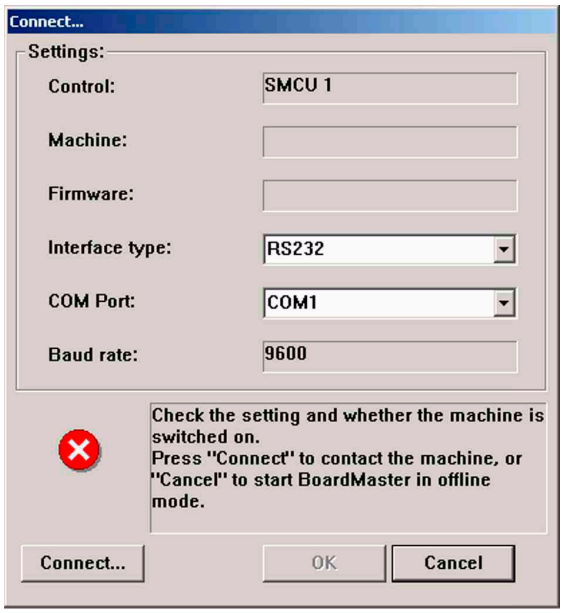


Use the submenu **VACUUM SYSTEM** to call up the status of the vacuum system. The operation hours will be reported.

3.1.4.6 Connect

Select **CONFIGURATION>CONNECT** to open this dialog box:

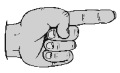
Fig 30: Dailog box connect



CONTROL MACHINE	Inserted automatically Selectable machine configurations: **H100 –2003-:** *Protomat* H100 Manufacture Year 2003 **H100 –2004-:** *ProtoMat* H100 Manufacture Year 2004 **H60** *ProtoMat* H60 **S-Serie (Firmware 2.7.9)** *ProtoMat* S62/S100 *ProtoMat* S42 **SMCU_2AX**: *ProtoMat* 91s, 91s/VS, 92s, 93s, C20, C30, C30s, C40, C60, C100/HF, M30s, M60, M100, L60, X60 **SMCU_2AX Toolchange:** *ProtoMat* 95s, 95s/II **SMCU3AX:** *ProtoMat* D100, M60/3D **X60:** *ProtoMat* X60/II X60 III: *ProtoMat* X60 / III
FIRMWARE	Display of the particular firmware version.
INTERFACE TYPE	Used communication ports of the control PC. Selectable interfaces RS 232 or USB (USB only for *ProtoMat* types with LPKF motion.net™ controller - Firmware update possible)
COM PORT	Selection of the computer interface with is connected to machine
BAUD RATE	9600, 38400 or 57600 depending on the connected *ProtoMat* type.
CONNECT	To establish the connection to the machine click the CONNECT button.

The editable parameter of the serial interface for the several Circuit Board Plotter types are listed in the table below:

Circuit Board Plotter type	Baud Rate	Data Bit	Stop Bit	Parity	Protocol	FIFO
LPKF 91s / 92s ProtoMat 91s, 91s/VS, 92s*, 93s und 95s* ProtoMat C20, C30*, C40, C60, C100/HF, M30*, M60 und X60	9600	8	1	non	Hard-ware	No
ProtoMat H100, H60, S62/S100	57600	8	1	non	Hard-ware	Yes
ProtoMat S42	38400	8	1	non	Hard-ware	Yes



Note: Using the *ProtoMat* S62 or S42 the FIFO buffer must be actived (see table above)!

Set this parameter via *Windows* system control:

Windows 2000/XP: System - Hardware - Device manager
(Login: “Admin“!!!)

Check the connection between the computer and the circuit board plotter if *BoardMaster* get no access to the circuit board plotter after the startup of the program.

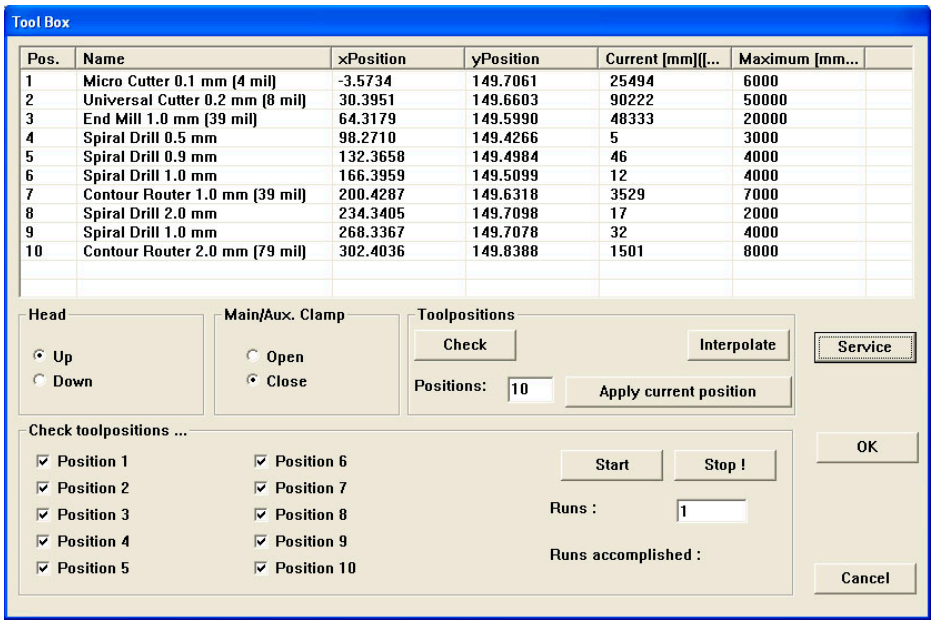
Also compere the serial interface parameter of the *Windows* system control with the listed parameter in the table above.

Note: The main reason for a faulty communication are not correct protocol settings for the serial interface. Take care that Hardware handshake and not XON/XOFF is used for protocol.

3.1.4.7 Tool box

Note: The *ProtoMat* S42 do not support this function.

Fig 31: Dailog box connect



Pos. 1 to 10	List of tools.
Head	Click on the radio button **UP** to lift the head for 5 mm. Click on the radio button **DOWN** to drop the head for 5 mm.
Main/Aux. Clamp	Click on the radio button **OPEN** to open the main clamp or aux. clamp (H100). Click on the radio button **CLOSE** to close the main clamp or aux. clamp (H100).

Tool position	Click on the button **CHECK** to check a selected tool position. Click on the button **INTERPOLATE** to calculate the tool positions 2 to 9 automatically, when tool position 1 and 10 are already known. Click on the button **APPLY CURRENT POSITION** to accept the manual correction of the tool position.
Check tool position	Click the check box 1 to 10 to define the tool positions for the check procedure.
Start/Stop	Click on the button **START** to start the check procedure for the selected tool positions. Click on the button **STOP** to finish the check procedure. The value in field RUNS define the number of check procedure repeats.
Service	Click on the button **SERVICE** (password protected) to change the parameters and settings.
OK	Click on the button **OK** to save the settings.
Cancel	Click on the button CANCEL to leave the menu without taking over the actual settings.

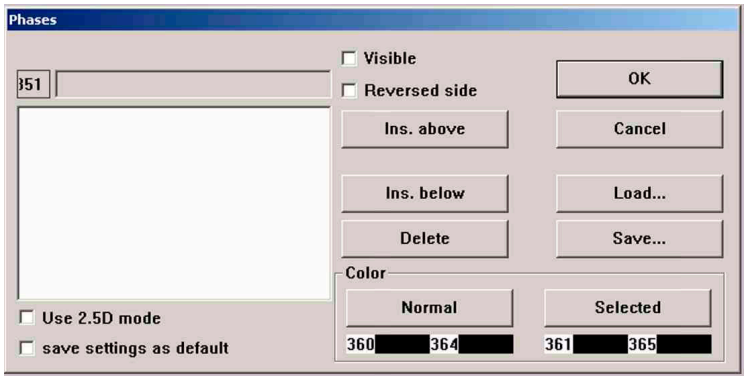
3.1.4.8 Phases

All data to be transferred to the circuit board plotter by *BoardMaster* must be assigned to a certain production phase. These production phases define a work sequence which does not require any manipulations by the user. An example of such a manipulation would be through contacting the circuit board or turning the base material. The only exception here is manual tool change. This assignment is prepared in *CircuitCAM* and is accomplished automatically in *BoardMaster*.

Some production phases are already defined in the initialization file. However, you can adapt these production phases to your specific requirements at any time. The names of the production phases must coincide in *CircuitCAM* and *BoardMaster*.

Click on **CONFIGURATION>PHASES** to open the dialog box:

Fig 32: Dialog box phases



All standard defined production phases are listed in the list field. After selecting a production phase, you can view its settings and change them if required.

Two settings are required for each production phase:

- The color with which the data assigned to this production phase is to be displayed. This setting serves for differentiation of the various production phases on the working area.
- Definition of the circuit board side (visible = component side or reversed = soldering side) for the production phase. Mark the indicator box **REVERSE SIDE** for all production phases for processing the bottom of the circuit board. All other production phases for which the indicator box **REVERSE SIDE** is not marked, are defined for processing the top.

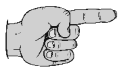
Generating a new prduction phase:

› Inside production phase listmark the production phase where the new production phase will be inserted above or below.

› Edit name of the production phase into the text field.

› To insert the production phase on the relevant position click on **INS ABOVE** or **INS BELOW**.

By clicking **SAVE** all changes within the menu **PHASES** will be saved in a phase defintion file (*.PHS) and can be loaded by clicking the **LOAD** button.



Note: On one-sided material, the option “REVERSE SIDE” should be activated for the phase “CUTTING OUTSIDE“! This eliminates the necessity of turning the base material.

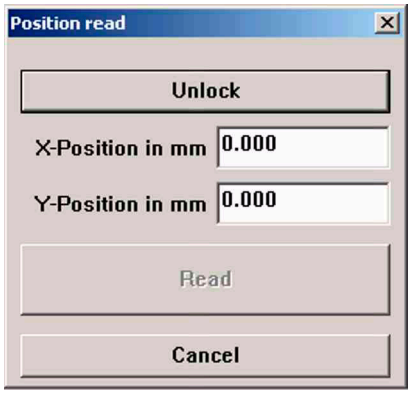
Intention of the phase files:

1-2layer.phs	Production of a 1 or 2 layer printed circuit board.
4layer.phs	Production of a 4 layer (Multilayer) printed circuit board (sequential build-up method).
6layerpin.phs	Production of a 6 layer (Multilayer) printed circuit board (registration pin method).
8layerpin.phs	Production of a 8 layer (Multilayer) printed circuit board (registration pin method).
soldermask.phs	Cutting of solder foil “system EasySolder“

3.1.4.9 Define the tool change position

This function must be used by machines without tool change bank. Click on **CONFIGURATION>DEFINE CHANGE POSITION** to open the following sub menu:

Fig 33: Position read

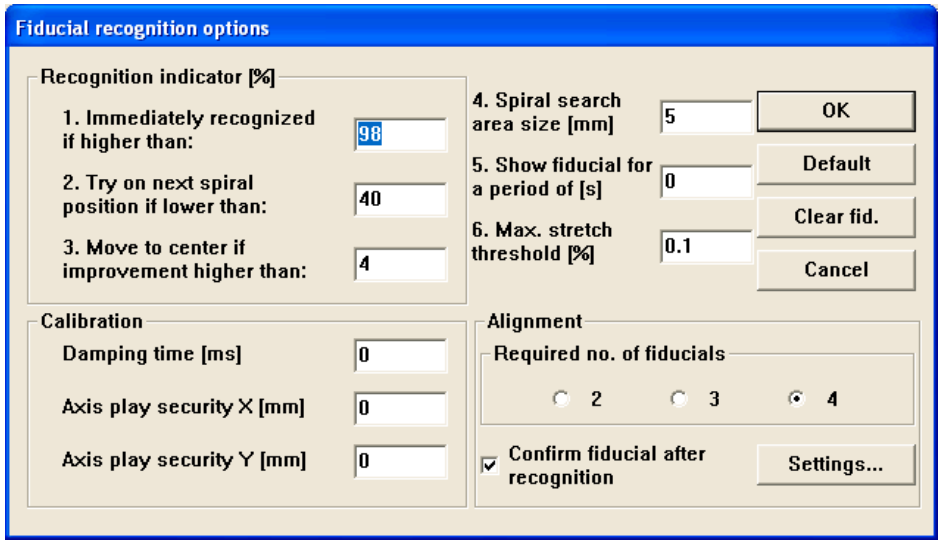


UNLOCK	Click on the **UNLOCK** button to read in a new tool position..
READ	After the machine is moved to the relevant position this position can be saved by clicking the **READ** button.
CANCEL	Click the **CANCEL** button to leave this menu.

3.1.4.10 Fiducials

Click on **CONFIGURATION>FIDUCIALS** to open the following sub menu:

Fig 34: Fiducial settings



Recognition Indicator [%]

1 Immediately recognized if higher than	Edit a value to define the acceptance of the camera analysis (default: 98)

2 Try on next spiral position if lower than	Edit a value to define the point where the camera analysis will not detect a object as an fiducial (default: 40)
3 Move to center if improvement is higher than	Edit a value up to this point the divergency of the fiducial detection will be ignored (default: 4).
4 Spiral search area size [mm]	Edit a value to define the dimension of search area (default: 5).
5 Show fiducials for a period of [s]	Edit a value to define the display time for detected fiducials.
6 Max. stretch threshold [%]	Edit a value to define the maximum divergency between reality area and the fiducial detection area (default: 0.1).
OK	Click on the button **OK** for taking over the settings.
DEFAULT	Click on the **DEFAULT** button to reload the factory settings.
CLEAR FID.	Click on **CLEAR FID.** to delete the number of required fiducials.
CANCEL	Click on the **CANCEL** button to leave the menu. All settings will not taking over.
Calibration	
Damping time [ms]	Edit a value to define the measuring delay time (default: 0).
Axis play security X [mm]	This function is not supported. The value must be 0.
Axis play security y [mm]	This function is not supported. The value must be 0.
Alignment	
Required no. of fiducials	Click on radio button 2, 3 or 4 to define the number of searched fiducials.
Confirm fiducials after recognition	Click on the check box to get a confirm message after every check procedure.
Settings...	Click on the button **SETTINGS...** to change the camera contrast, brightness and so on.

3.1.5 Go to menu

Danger:When an entry in the menu GO TO is selected, the connected circuit board plotter starts moving! The hazard of pinching and crushing exists!
For this reason, ensure that no one can enter the motion range of the circuit board plotter during the operating phases!

This menu provided functions for moving the drill/mill head to definded positions:

Fig 35: Go to menu (S42)

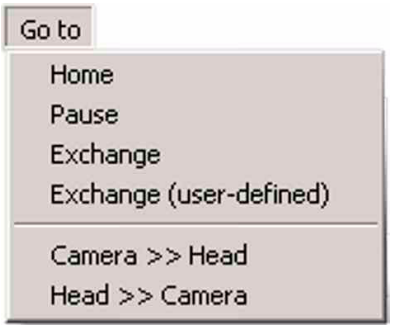


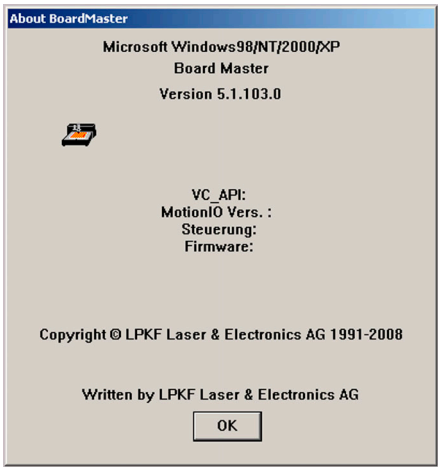
Fig 36: Go to menu (S62/S100/ H100)

HOME	Select **HOME** to move the the drill/mill head to the **HOME position** (data origin).
PAUSE	Select **PAUSE** to move the drill/mill head to the **PAUSE** position (standard Xmax/Ymax).
EXCHANGE (*ProtoMat* S42 only)	Select **EXCHANGE** to move the drill/mill head to the **exchange position** (standard Xmin/ Ymin).
EXCHANGE (user-defined, *ProtoMat* S42 only)	Select **EXCHANGE** (user-defined) to move the drill/mill head to the **user-defined exchange position**.
ZERO POSITION (*ProtoMat* S62/S100 only)	Select ZERO POSITION to move the drill/mill head to the tool change position (default: Xmax/Ymax).
CAMERA >> HEAD (optional)	Select **CAMERA>>HEAD** to move the camera to the actual position of the drill/mill head.
HEAD >> CAMERA (optinal)	Select **HEAD>>CAMERA** to move the drill/mill head to the preset (original) position.

3.1.6 Help menu

Click on menu **HELP** to get the actual program information:

Fig 37: Program information



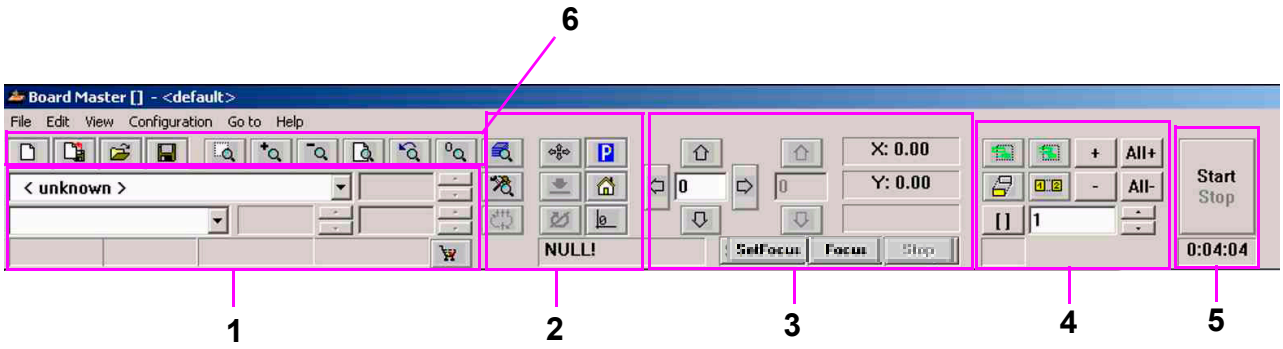
› Click on **OK** to close the menu.

3.2 Function bar

The function bar in *BoardMaster* includes functions for positioning and copying projects on the base material as well as for control of the connected circuit board plotter. Moreover, the function bar provides important status information on the machining process.

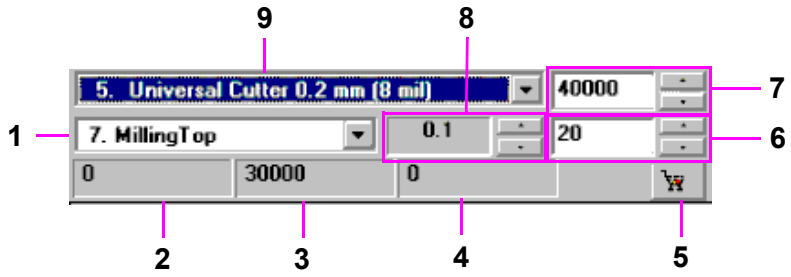
This short summary contains a list of all features in the function bar. The individual features and meanings are explained briefly. Each function includes a reference to the corresponding page in the manual containing a detailed explanation when present. The hot keys for the function are also listed following the page number.

Fig 38: Function bar



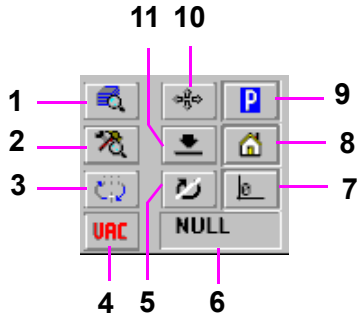
1- Job informations
2- Tool and control functions
3- Mill control functions
4- Marking functions
5- Process control functions
6- File functions

Fig 39: Job information



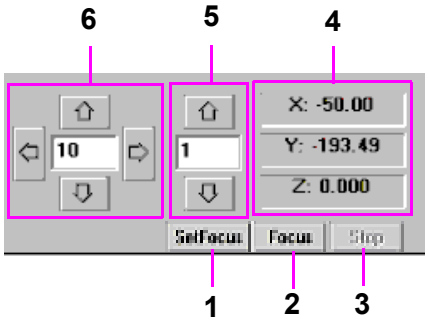
1- Display or selection of the active job phase
2- no function
3- no function
4- Display: Quantity drill hols or length mill line (in mm)
5- Connect LPKF-Online-Shop
6- Display: Drilling process time (in s) or feed motion (in mm/s)
7- Display: Speed drill spindle (unit: 1/min)
8- Display. Impact depth of the tool (in mm) - only H100
9- Display or selection of the active phase

Fig 40: Tool and control functions



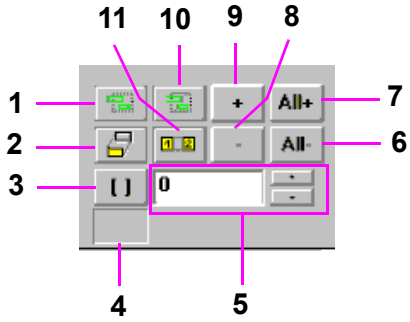
1- Display: Configuration Phase
2- Display: Configuration “Active Tool Library“
3- Dialog box: Tool Position
4- Switching ON/OFF vacuum/exhausting
5- Switching ON/OFF milling spindle
6- Display interface
7- Drive drill/mill head to coordinates zero point
8- Drive drill/mill head to HOME position
9- Drive drill/mill head to PAUSE position
10- positioning of the XY table with the computer mouse
11- ?

Fig 41: Milling functions



1- Camera function: adjust fokus - optional
2- Camera function: fix fokus - optinal
3- Camera function: stop fokus - optional
4- Display: vector index
5- Manual movement drill/mill head Z axis
6- Manual movement drill/mill head X/Y axis

Fig 42: Marking functions



1-Select area - lines crossing the area
2- Move project
3- Activate/deactivate marked lines
4- ?
5- Display: Quantity marked lines
6- Undo marking data
7- Marking data of all production phases
8- Erase selected data from mark
9- Add selected data to mark
10- Select area - lines inside the area
11- Duplicate project

3.2.1 Status information

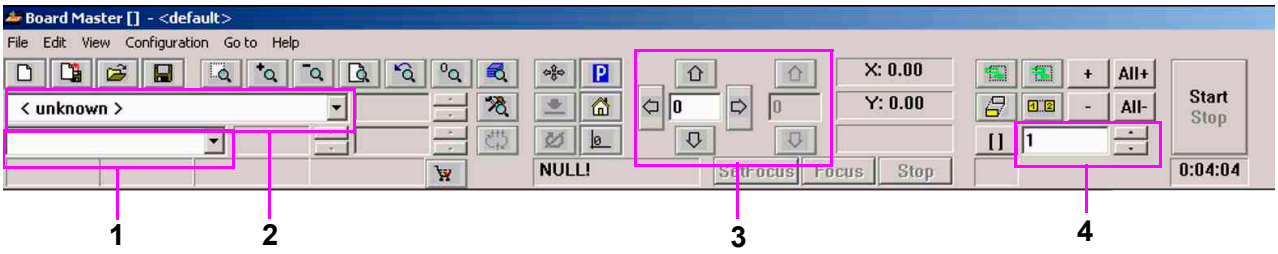
Fig 43: Status information

1	**INTERFACE**	This display provides information on the interface set for transferring the control data. Here **NULL** means that the data is not sent to an interface. When the mouse is moved over this display field, the values set for the interface are indicated in the status bar.
2	**Actual mill/drill head position**	Display of the actual drill/mill head position with all three axis: X/Y/Z.
3	**Vector quantity**	Display the number of finished project vectors.
4	**2.5D MODE**	The thickness of the material is divided into various processing layers. The number of layers depends on the depth with which the tool penetrates the material. The penetration depth must be individually adapted to each tool. The settings that are made can be stored in the hob. When the option is enabled with a checkmark, then the following dialog appears.
5	**Duration estimation**	Display of the estimated duration time in hours:minutes with is calculated for the activated production phases. Single selections will not included in the time calculation.

3.2.2 Changeable parameter

The display fields indicated here can be edited and thereby adapted to your requirements.

Fig 44: Changeable parameter



1	**Tool**	This list field shows the tool used for the current production phase.
2	**Current production phase**	The current production phase is indicated in this list field.
3	**Step size for manual control**	This text field allows definition of the step width by which the drill/mill head is moved each time one of the six Arrow buttons (outlined with dotted line in figure above) is clicked. The text field can be marked and the value can be increased or decreased in defined steps with the + or - button.
4	**Vector index**	This text field allows you to define the vector index. An index is counted with each line segment or arc segment. Here, it is possible to define the vector index at which processing is to be started, for example.

3.2.3 Positioning functions

Move projekt

Activate this button to move a project in the operating area. Position the cursor on the project to be moved, press the left mouse key and drag the project to the desired position with the mouse key depressed.

The project appears as a dark area while it is being moved.

Duplicate project

Activate this button to duplicate a project and position the copy in the operating area. Position the cursor on the project to be duplicated, press the left mouse key and drag the copy of the project to the desired position with the mouse key depressed.

The copy of the project is represented as a dark area during duplication.

Note: Each time a project is moved or duplicated it is necessary to reactivate the corresponding button.

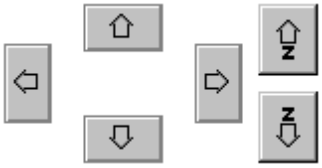
Click a project with the right mouse key to open the PLACEMENT dialog box and display the settings for this project.

In this dialog box you can correct the reference point values for positioning projects on the same X and Y coordinates (align). If the control key is pressed and held down, while clicking and holding down the left mouse key on the project, the project is moved only in the X or in the Y direction.

You can also use the PLACEMENT dialog box for rotating a project (after positioning with the mouse) by changing the setting ROTATION.

3.2.4 Manual control functions

Danger! After activating one of the following buttons on the function bar, the connected circuit board plotter is put into motion! Ensure that no one can move into the hazard area of the plotter during the operating phases controlled by *BoardMaster*!



Manual control
The head can be moved in the directions +X, +Y, -X and -Y with the aid of the arrow keys. Pressing one of the arrow keys once, moves the head by the value entered on the function bar in the entry field STEP FOR MANUAL CONTROL in the selected direction (See "Changeable Settings" on page 24). Motion in the X and Y direction can also be accomplished by holding down the Ctrl key on your keyboard and pressing the arrow keys on the keyboard. The Z-axis can be moved with the keyboard by pressing the Ctrl key and actuating the Page ↑ or Page ↓ key.

Move using the computer mouse
Click this buttons to move the drill/mill head to the position in the operating area which you click with the left mouse button. If you continue to hold down the left mouse button, you can move the mouse and the head follows the motion of the mouse after it has reached the mouse starting position. This function allows the head to be moved to any desired location very quickly for defining the material size. To control the XY table with the mouse motion again it is first necessary to activate the button again.

Home position
Click this button to move the drill/mill head to the **HOME** position. This position is principally moved to in order to check the existing reference hole system or to produce a new one.

Zero point
Click this button to move the drill/mill head to the zero point of the X-Y coordinate system. This position is generally moved to before switching the circuit board plotter off

Vacuum
Click this button to switch the vacuum system ON or OFF. Please note that the vacuum system cannot be switched OFF when the drill/mill spindle is running.

Drill/mill spindle ON/OFF
Click this button to switch the drill/mill spindle ON or OFF.

Pause position
Click this button to move the drill/mill head to the Pause Position. This position is used when material is to be exchanged or when material is to be turned round.

3.2.5 Selection functions

Before selecting, you must have activated all phases to be assigned data and which you want to process. Detailed information on activation is given in the chapter “Phases”. Data must be selected before it can be sent to the plotter for processing. Only data in the activated phases can be selected.

The following buttons are available on the function bar for selecting the data:

Mark all
Click this button to mark all data for the enabled production phases. The data marked are displayed in a lighter color on the monitor.

Cancel mark all
Click this button to cancel all marking of the data.

Select area
Click this button to select a data area. For this purpose, press the left mouse key and hold it down while dragging the mouse over the desired area.

This function also selects lines crossing the area. The selected data are displayed in white on the monitor.

Select area (only inside)
Click this button to mark a data area. For this purpose, press the left mouse key and hold it down while dragging the mouse over the desired area.

This function marks lines crossing the marked area only up to their first support coordinate outside of this area. The marked data is indicated in white on the monitor.

Note: It is necessary to reactivate the corresponding button each time an area is selected.

Mark selected data
Click this button to add selected data to the marking.

Cancel selected data
Activate this button to delete selected data from the current marking.

Selected lines
Increase or decrease the number in the window with the small arrow buttons to the right. Each number stands for a certain vector (section of line). The entire job is processed vector for vector in the sequence of this numbering. It is possible to select a certain vector or a number of vectors for subsequent marking. For this purpose, it is necessary to select the number of the corresponding line with the aid of the right arrow button. Then, it is necessary to activate the function “Selected lines” by clicking  . You can then increase or decrease the number with the arrow buttons to select each selected vector and display it in white on the monitor. These selected lines can be marked by clicking  or added to a marking. If vectors already marked are selected in this manner, they can be unmarked by clicking  .
This function can be deactivated by clicking  .

Furthermore this function allows to select a project to start with a determined vector index value. Enter the vector value from which the project is to be processed. Confirm the function with  and then the vector value is increased using the keyboard entry (for example by adding a number, e.g. 564 becomes 5640). The subsequent routes are then represented in white and can be added to the selection by pushing the  button.

3.2.6 Production phase control function

Danger! After activating one of the following buttons on the function bar, the connected circuit board plotter is put into motion! Ensure that no one can move into the hazard area of plotter and come into contact with the tools during the operating phases controlled by *BoardMaster*!

Start
Click this button to transfer the marked data for the enabled production phase to the plotter over the serial interface.

Stop
Activate this button to discontinue data transfer to the plotter after starting.

Attention: After clicking the stop button, the plotter does not stop immediately; first, it continues to process the data in the buffer! The click on the stop button only interrupts transmission of data to the plotter!

4 Production process

This chapter describes the principle procedure to produce a prototype of an double-sided, not through connected circuit board with *BoardMaster* step by step.

You will learn to work with *BoardMaster* and the circuit board plotter shortly if you adhere the following instructions.

4.1 Preparing BoardMaster start

For error-free operation with your circuit board plotter, it is absolutely necessary to observe the switch-on sequence specified below:

- **Switch on the circuit board plotter.**
- **Wait until the green operating indicator on the front panel or the data LED on the back panel of the circuit board plotter light up.**
- **Start *BoardMaster*.**

Otherwise the communication between computer and circuit board plotter can not be implemented after the *BoardMaster* program starts.

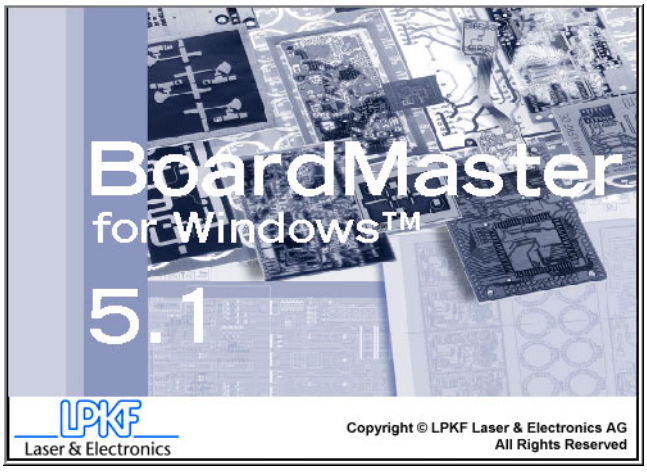
4.1.1 Start BoardMaster

› Double-click on the *BoardMaster* on the desktop.

Or click on **Start>Program>LPKF Laser & Electronics AG> BoardMaster ...** .

The BoardMaster startup window will be opened:

Fig 45: Startup screen



This image may be visible for up to 8 seconds, which is related to the communication between the PC and the machine, it does not represent an error. After this time period, the program start is automatically continued.

› If the message **CONNECT..** will be opened:

– Check the power switch of the ciruit board plotter - position I (ON). Check the data connection cable between computer and circuit board plotter - interface plugs and cable are correct installed.

– Check the connection settings (see chapter 3.1.4.6 “Connect“ on page 40).

The BoardMaster operation interface will be opened.

BoardMaster is waiting of corresponding message of the drill/mill head (the continuing movement of the drill/mill head).

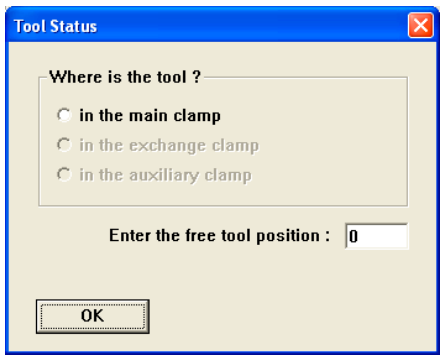
As soon as the plotter sends the requested reply to the computer, the program is continued normally.

4.1.1.1 Tool status

Note: The following informations refer to the *BoardMaster* application with *ProtoMat 95s*, 95s/II and S62!

Using a *ProtoMat 95s*, *95s/II*, H100 S62 or S100 the dialog box **TOOL STATUS** will be opened after starting *BoardMaster*.

Fig 46: Tool status



Caution:It is absolutely necessary to establish where a tool is located at switch on. Then, the free tool position can be entered in the tool box. Note: Position 1 = Tool 1 all the way to the left, Position 30 = Tool 30 is therefore all the way to the right in the tool box

After starting *BoardMaster* for the first time, the **TOOL STATUS** dialog box appears as illustrated above. The actual status, meaning where a tool is located and which position is free in the plotter tool box for this tool, must be defined by the user. Each time the program is restarted, the tool status present the last time the program was closed is displayed. This can then be confirmed simply by pressing **OK**.

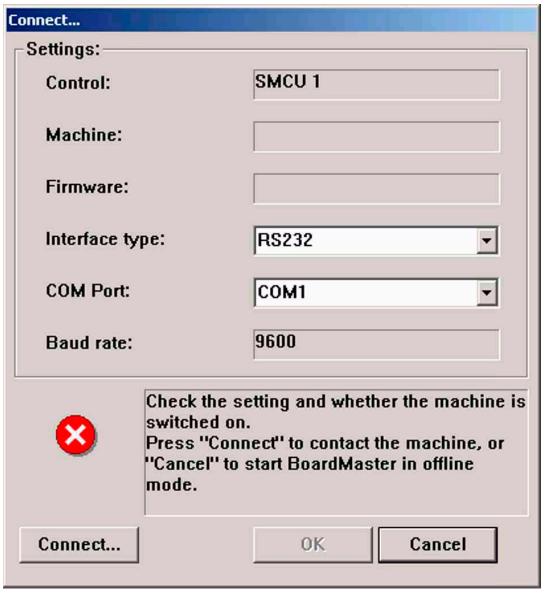
If the status displayed does not coincide with the actual status, it is necessary for the user to correct the status.

Then, the program asks whether the tool is to be put back in the tool box upon exiting *BoardMaster*.

4.1.1.2 Check interface

If the circuit board plotter are not detected automatically the dialog box **CONNECT** will be opened. In this case the connection settings must be changed.

Fig 47: Dialog box Connection



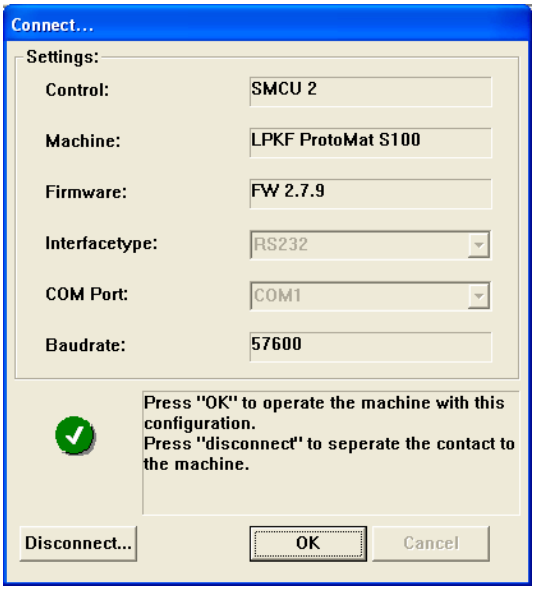
› Make sure that the circuit board plotter is switch on. Check the control light on the drill/mill head - the light must lit on.

› Make sure that the needed settings of the Circuit Board Plotter are inserted and check the system settings of *Windows* (see installation instruction).

› Click on **CONNECT**.

The following window will be shown:

Fig 48: Dialog box Connection



When the communication between computer and circuit board plotter has been successfull established the *BoardMaster* operation interface will be opened.

Note: By clicking **CANCEL** the *BoardMaster* operation interface will be opened but the circuit board plotter can not be controlled via software. To change the connection settings click on **CONFIGURATION>INTERFACE** and use the **CONNECT** dialog box to establish a connection to the circuit board plotter.

[ ] The *BoardMaster* operation interface will be opened.

4.1.2 Insert base material

› Click on **GO TO>PAUSE** to move the drill/mill head to **PAUSE** position**.**

We recommend using the base material already present on the circuit board plotter. The first base material board is already mounted for precisely this reason to make introduction easier for you. Drilling and positioning material of other sizes is not described here.

› Fasten the base material with adhesive tape on all four sides (we recommend Tesakrepp 5250).

Further steps for all *ProtoMat* types:

In order to process data created with *CircuitCAM* or similar software, it is first necessary to import them into *BoardMaster*.

View base material:

The work area of the base material must be visible on the monitor. Define the the displayed sector via *BoardMaster*. This definition has no influence on the production process.

Fix material size view:

Define the base material size.

4.1.3 Import production data

The “Working Instructions” for *BoardMaster* indicating the method for processing the base material are contained in the production data. They are generated by *CircuitCAM* or a similar program and must first be imported:

You can import the LMD production data (e.g. TUTOR.LMD) generated by the *CircuitCAM* software or the HP-GL project files already generated by *BoardMaster*. At this point, we will now import a file in LMD format (Tutor.lmd).

› Import the file Tutor.LMD by clicking the entry LMD or LPR...in the submenu IMPORT in the menu FILE and select a file (e.g. “Tutor.LMD“). This file can be found in the directory C:\Program files\LPKF50\Data\.

Tool allocation:

A tool must be assigned to each production phase so that *BoardMaster* “knows” which tool to use for each individual program phase (milling cutters, drills of different sizes, engraving, etc.). As a rule, *BoardMaster* accomplishes this itself, as is the case when importing Tutor.lmd. However, if you are processing an HPGL file, this will have to be accomplished manually. In this case, please read the next Chapter „Assigning Tools“ on page 85 before continuing here.

› If you are working with an HP-GL file, assign the appropriate tools/ phases to the imported production data for projects (**EDIT>TOOL**

ASSIGNMENT). Otherwise, simply continue on to the next processing step.

Place production data:

You now have the possibility of positioning the imported production data as desired on the base material to define how they are to be machined later.

› Position the imported production data or projects by selecting the entry **PLACEMENT**... in the menu **EDIT** or click the button  on the function bar. You can then move the image of the production data with the mouse and position it by holding down the left mouse key..

Save Job

› Click on **FILE>SAVE AS** to save the job under a customized name after all projects are placed.

4.1.4 Select first production phase

Each production phase such as “Milling bottom” must be selected separately and prepared for processing (assignment of correct tool, etc.). Start with the first production phase:

› Select the production phase “Milling bottom“ from the function list in the list box **PRODUCTION PHASE** (see figure below).

Fig 49: List production phase Milling Bottom

Mark data:

Theoretically, it is possible to process only certain sections of this production phase by correspondingly selecting the data. For this reason, it is always necessary to first select the desired areas to be processed. Since the entire production phase is to be processed here, we select all data for this phase:

› Click on All+ to mark all data.

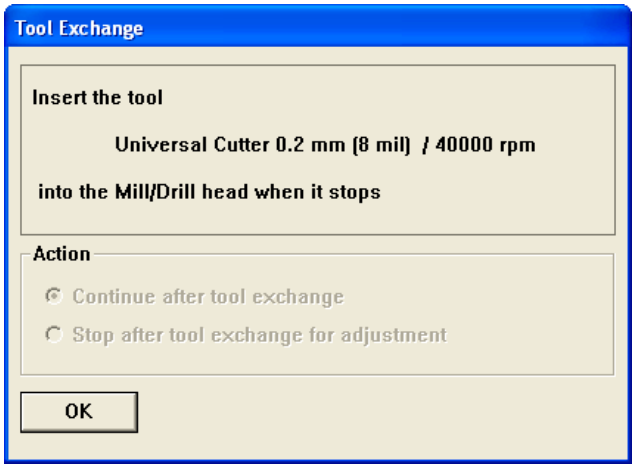
Danger!Activating one of the following buttons on the function bar, sets the connected circuit board plotter in motion! The danger of pinching and crushing exists!
Ensure that no one can enter the hazard area of the circuit board plotter during the operating phases controlled by *BoardMaster* or come into contact with the tools!

Starting milling operation for selected production phase:

› Click on Start Stop to transmit the mark data to the circuit board plotter via the serial interface.

If you use a machine without automatic tool change, the machine first moves to the tool change position if not already positioned there and the following message appears:

Fig 50: Tool change



This message always appears when a tool is to be changed. If you use a *ProtoMat* S62/S100/H100 then skip the following steps.

› Now install the first tool required in the machining head (see machine manual).

› Click “Stop for change after tool transfer” and then click **OK** to close the message box.

› Now set the cutting depths if you are operating the circuit board plotter for the first time.

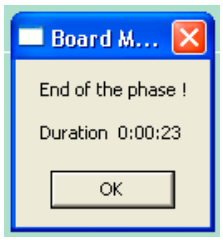
› Switch on the vacuum!

› Click on 

again.

The production phase “Milling bottom“ is run. Then the following message appears:

Fig 51: End phase

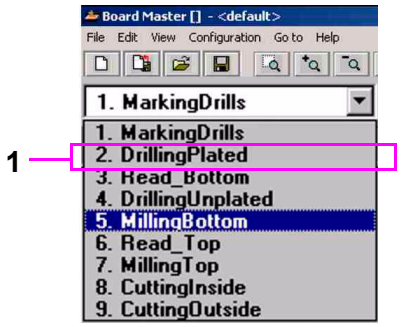


› Click on **OK**.

4.1.5 Select second production phase

› Select the production phase Drilling Plated on the function bar in the list box **PRODUCTION PHASE** (see figure below).

Fig 52: List production phase Drilling Plated



Mark data:

› Click on All+ to mark all data.

Danger! Activating one of the following buttons on the function bar, sets the connected circuit board plotter in motion! The danger of pinching and crushing exists!
Ensure that no one can enter the hazard area of the circuit board plotter during the operating phases controlled by *BoardMaster* or come into contact with the tools!

Starting drilling operation for selected production phase:

› Click on Start Stop from the function bar to send the selected data for the current production phase to the circuit board plotter via the serial port.

The message "Tool Change" appears.

› Now install the required tool.

› Click Stop for change after tool transfer and then **OK** to close the message box.

› Adjust the drilling depth.

› If necessary, click **Continue after tool transfer** and then click **OK**.

› Switch on the vacuum!

› Click on Start Stop again.

The production phase is completed.

Continue to comply with the subsequent drill requests by installing the tool (drill) as requested and then click **OK** until the production phase is completely processed.

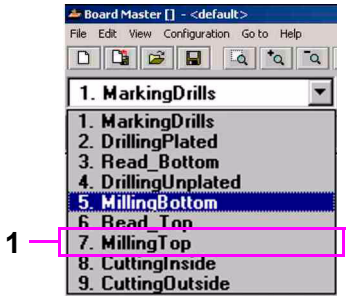
Turning base material:

› After drilling and milling the bottom, move the head to the Pause position (menu bar **GO TO-PAUSE**) and turn the base material around the X axis and fasten it again with adhesive tape.

4.1.6 Select third production phase

› Select the production phase Milling top on the function bar in the list box **PRODUCTION PHASE**.

Fig 53: List production phase Milling tool



Mark data:

› Click on All+ to mark all data.

Danger!Activating one of the following buttons on the function bar, sets the connected circuit board plotter in motion! The danger of pinching and crushing exists!
Ensure that no one can enter the hazard area of the circuit board plotter during the operating phases controlled by *BoardMaster* or come into contact with the tools!

Starting milling operation for selected production phase:

› ***Switch on the vacuum!***

› Click on Start / Stop on the function bar.

The selected data for the current production phase are transferred to the circuit board plotter via the serial port.

The operations for changing tools and setting the milling/drilling depth are repeated. Proceed as described for the first production phases.

4.1.7 Select fourth production phase

Note: In this production phase, the circuit board is cut out of the base material. During this operation, pay attention to the cutting depth of the milling tool used here. (!)In this particular case(!) adjust the milling depth visually! If required, in the same manner as

adjusting the drilling depth. Here, it is important that the cutter cut through the entire thickness of the base material without cutting deeply into the drilling subsurface!

› Select the production phase **CUTTING OUTSIDE** on the function bar in the list box **PRODUCTION PHASE**.

Mark data:

› Click on the **ALL+** button to mark all data.

Danger!Activating one of the following buttons on the function bar, sets the connected circuit board plotter in motion! The danger of pinching and crushing exists!
Ensure that no one can enter the hazard area of the circuit board plotter during the operating phases controlled by *BoardMaster* or come into contact with the tools!

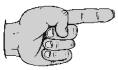
Starting milling operation for selected production phase:

› Switch on the vacuum!

› Click on the **START/STOP** button of the function bar.

The selected data of the actual production phase will be transmitted to the circuit board plotter via the serial interface.

The operations for changing tools and setting the milling/drilling depth are repeated. Proceed as described for the first production phases.



Note: Observe that it is always necessary to switch the auto motor function back on before proceeding after any adjustment of the drilling or milling depth!

› When the production phase “Cutting outside“ has been completed, move the circuit board plotter to the PAUSE position.

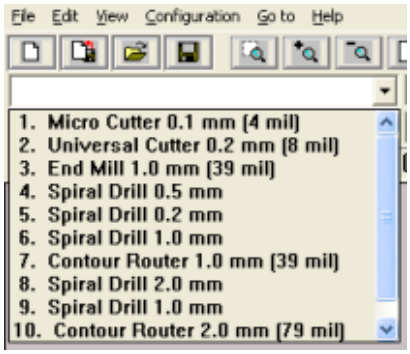
The double-sided circuit board is now finished. It can be broken out of the base material carefully. If you want to process the data for other production phases (dispensing, milling inner layers of a multiple layer board, etc.), follow the instructions above in the same manner for these phases. For this purpose, read the corresponding chapter in the manual.

4.2 Tool change

4.2.1 Manual tool change

The list **TOOLS** inside the function bar is listing all tools of the tool library. On top of the list are the tools with will be used during the actual production phase, marked with „*“:

Fig 54: Tool list



If no production phase is selected the first production phase of the production phase list is active.

When processing a production phase, the user are always requested to install the tool to be used next when a tool change is required.

If a different tool is selected from the list, the machining head moves to the tool change position. Simultaneously the message appears on the screen that the present tool is to be replaced with the tool just selected.

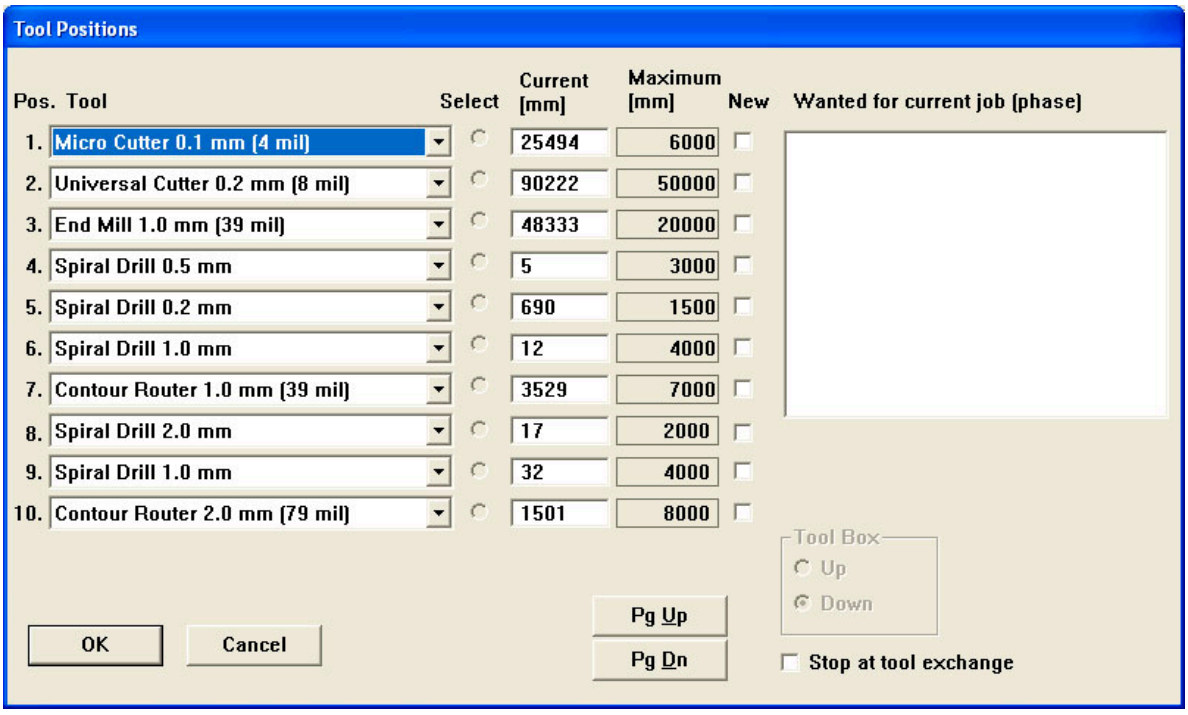
Danger:This instruction starts the circuit board plotter. Danger of pinching and crushing! Also observe safety precautions for changing tools in the circuit board plotter manual!

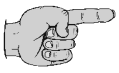
After changing the tool, and confirming the change by clicking **OK**, processing can be continued with the next control commands.

4.2.2 Automatical tool change

The following dialog box can only be called up when machines with automatic tool changing unit are used. (example *ProtoMat* 95s, H100 and so on). If you now open the **TOOL** list field on the function bar, only the thirty or seven tool positions with their corresponding tool assignment are displayed instead of a list of all tools as for circuit board plotters with manual tool change.

Fig 55: Tool position





Note: When the program is started for the first time, the tool <UNKNOWN> is assigned to each tool position, i.e. no tool entered. This is intended to cause the user to check the tools in the circuit board plotter magazines and assign the corresponding positions in the TOOL POSITIONS dialog box.

It is absolutely necessary to ensure that the tools in the tool box coincide exactly with those assigned in *BoardMaster* in order to prevent using the wrong tools and therefore malfunctions.

Open the **TOOL POSITIONS** dialog box by clicking the TOOL list field with the right-mouse button.

A tool can be assigned to the tool positions 1 to 30 by selecting the tool required for the production phase from the appropriate list field.

If a tool position is not assigned to a required tool, this dialog box is opened automatically when the production phase is started. It is possible to continue only after all tools have been assigned a position!

The tools required for the selected production phase are listed in the list field **WANTED FOR CURRENT JOB** (PHASE).

The option **SELECT** indicates the tool momentarily located in the machining head.

The **CURRENT** life cycle and the **MAXIMUM** life cycle are indicated following each tool.

It is necessary for the **NEW** check box to be switched on when a used tool is replaced by a new tool in the tool box. The current life cycle is then reset to 0.

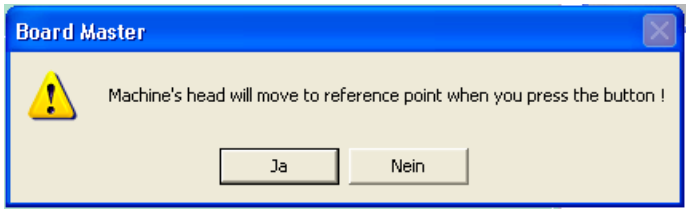
When exiting *BoardMaster*, the tool assignment in *BoardMaster* are stored under the name extension *.TLS and automatically reloaded each time *BoardMaster* is started.

4.3 Switch off

When switching off the circuit board plotter, first quit *BoardMaster* before switching off the machine. In the opposite sequence, recurring error messages are possible, which can be cancelled only by repeatedly actuating the **Yes** button. (Error message: Do you really want to cancel the current process...)

Before *BoardMaster* is actually switched off, a menu is displayed asking where the machining head is to be displaced to:

Fig 56: Go to reference point menu



› Click on **YES** to move the drill/mill head to the reference point, respectively move to zero position.

4.4 Home position and reference hole system

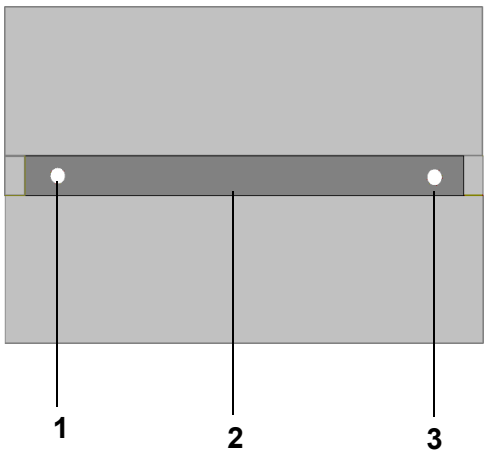
The **HOME** position is a reference point programmed in the software. *BoardMaster* use this point as a reference position for orientation on the machine base plate. The circuit board plotter can be controlled correctly by *BoardMaster* only when this point is adjusted correctly. The **HOME** position must be located on the reflection axis (reference hole system) of the machine for production of circuit boards coated on both sides. The base material is turned around this reflection axis. Inaccuracies in the **HOME** position lead to an offset in processing the base material after turning.

Note: The HOME position is set at the factory and its position for a *ProtoMat* S62 is different from the position of the rest of the *ProtoMat* types.

Note: The parallelism of the reference hole system is ensured only for the current position of the reference hole strips. The front reference hole strip must be pushed against the reference pin in the reference hole groove (referenced). If you use base material of different sizes later, it will be necessary to drill an additional reference hole in the !rear! reference hole strip for each format. The position of the pusher for the various holes should be noted or marked on the circuit board plotter. This ensures parallelism for the various formats and eliminates the possibility of mix-ups.

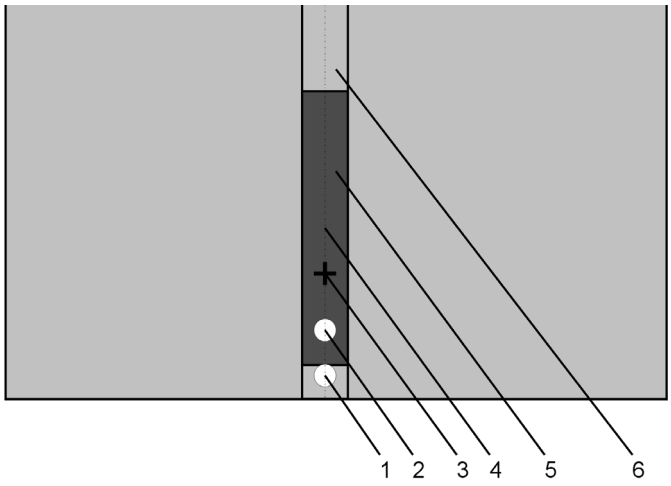
It is only necessary to reprogram the **HOME** position in exceptional cases (offset on double-sided circuit boards) or possibly after transport of the machine or loss of the individual .INI file.

Fig 57: Reference hole ProtoMat S-series



1- HOME position
2- Reference hole notch
3- PAUSE position

Abbildung 58: Reference hole system other ProtoMat types



1- Reference pin
2- Front pilot pin
3- HOME position, (distance depending on machine types)
4- axis of reflection
5- reference strip
6- Reference hole notch

4.5 Camera functions

Note: Only for *ProtoMat* S62/100 with camera option.

Set Focus
Use the arrow keys to move the dril/mill head with camera until the image is focussed. Then press this key to have the current Z value stored in the INI file as focus position.

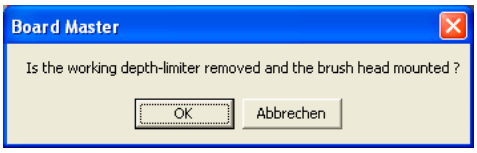
Focus
Click this button to have the camera moved back to the focus position when it the camera or drill/mill head is currently in a different position.

Stop
Click this button stops ongoing reading processes of the camera, e.g. when fiducials are being read in.

4.6 2.5D mode

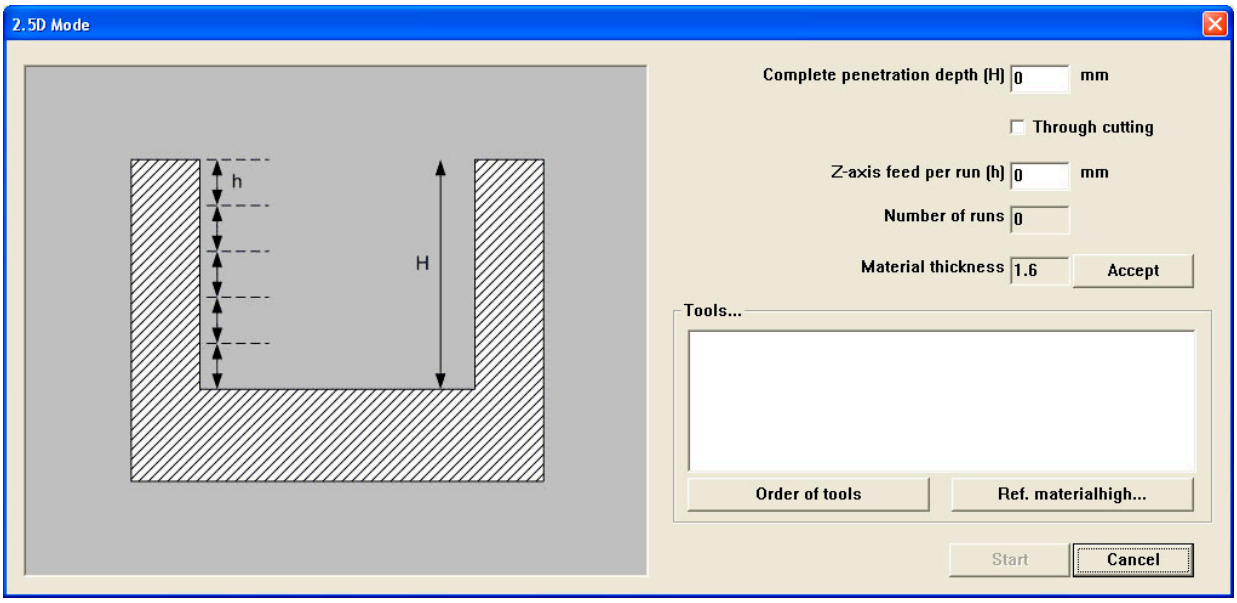
By activating the 2.5-D-Mode checkbox in the function bar the following dialog box will be opened:

Fig 59: 2.5-D-Mode dialog box



In 2.5-D-Mode the working depth limiter is of no use, instead you should mount a brush. If the dialog is terminated with escape then the whole process is cancelled. By clicking **OK** the following dialog box will be opened:

Fig 60: 2.5-D-Mode

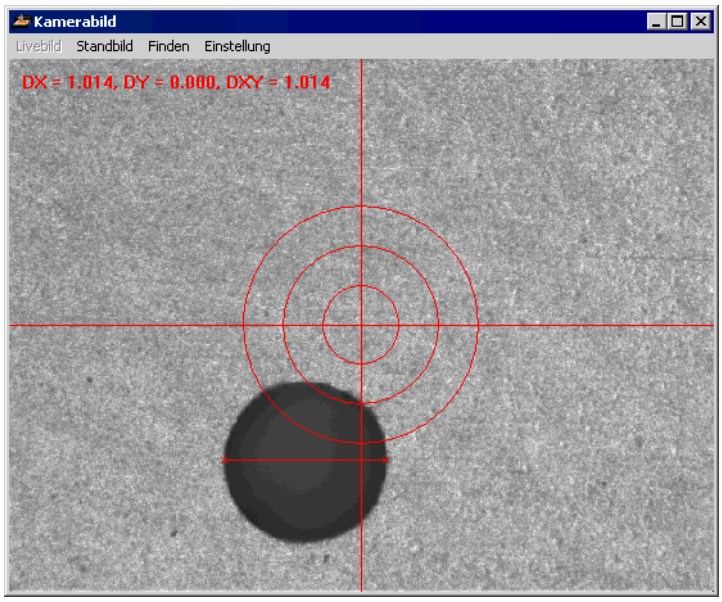


The material thickness is divided into various processing layers. The number of layers depends on the depth with which the tool penetrates the material. The penetration depth must be individually adapted to each tool. The settings that are made can be stored in the job.

4.7 Camera image fiducial detection

Note: Only for *ProtoMat* S62/100 with camera option.

Fig 61: Camera view



Note: This image can only be seen when the phase for fiducial recognition is selected.

When the camera is successfully calibrated, a live image like the figure above can be seen.

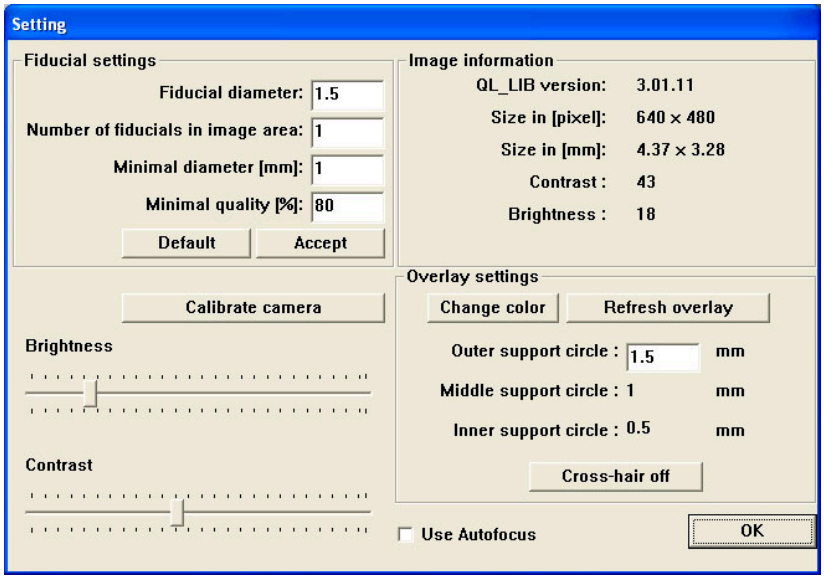
Freeze image
The image is „frozen“ and the menu item **LIVE** becomes visible, so that it is possible to switch between the two modes.

Live image
The image is again represented in real time and the menu item **FREEZE** becomes visible. Thus it is possible to switch between the two modes.

Find
When the menu item **FIND** is activated, a standard fiducial is searched in the image area. The result is shown in a message as quality and stance to the image center.

Settings
After activation of this menu item the following dialog is opened:

Fig 62: Camera settings



Fiducial setting
Changing the settings for fiducial detection.

Standard
Use default settings.

Transfer
Use actual edit settings.

Camera calibration
Camera adjustment with selected values.

Brightness
Adjust the camera brightness.

Contrast
Adjust the camera contrast.

Image information
Display of the actual camera settings.

Overlay settings
Changing the colour, switch ON/OFF the crosslines and changing the dimensions of the substitute circles.

Note: A detailed describtion of the camera calibration will be find in the machine manual (*ProtoMat* S62 or *ProtoMat* S100).

5 Troubleshooting

We refere to the particular machine manuals, for example user manual *ProtoMat* S62, to get detailed troubleshooting information.

The following informations are notes and tips and the first steps for troubleshooting when the system run out of function.

5.1 Circuit board plotter initialisation

Danger! The following instructions starts the circuit board plotter motor!

Take care that no person be in the process area of the circuit board plotter-Risk of crush!

Adhere the safety instruction of the machine manual!

› Click on **CONFIGURATION>SETTINGS.**

› Click on **UNLOCK** (password protected) to change the machine parameter.

› Click on **INITIALIZE** to start the initialisation process.

During the initialization process, the machining head moves to the limit switches in all four directions of motion, thereby transmitting the values measured to *BoardMaster*. These values are displayed in the text fields **ZERO POINT** (Xmin/Ymin, always 0/0) and **SIZE** (Xmax/Ymax). These entries cannot be edited, they can only be reset by initializing.

The values in the text field **PAUSE** are identical to the values in the text field **SIZE**. However, they can be edited to move the Pause position to any desired position.

Note: The values in the text field HOME (data origin) are set to Xmin and Ymax/2 as default. The HOME values determined in this manner are not the exact values leading to coincidence of the top and bottom during production of double-sided circuit boards. For this purpose, it is necessary for the HOME position to be located precisely on the plotter reflection axis.

To reset the **HOME** position precisely on the circuit board plotter reflection axis, it is necessary to drill new reference holes. For this purpose, first remove the base material and drilling panel as well as the reference hole pins. If no more space is present on the old reference hole strips, use new strips.

Then follow the following instructions:

› After the circuit board plotter has come to a stop at the tool change position after initialization, select Spiral Drill Ref. 2.95 from the Tool list and clamp it in so that an interval of 0.5 mm is present between the base plate and tip of the drill (a 0.5 mm thick plate can be placed beneath as an aid).

The machine moves to the tool change position and the message "Continue after tool change" appears".

After inserting the tool acknowledge the message with **OK**.

› Move the machining head to the **HOME** position defined by initialization by clicking Go to in the menu and then **HOME** position.

› Move the machining head in the positive X direction with the arrow keys (not in Y direction under any circumstances) approx. 15 mm.

› Move the machining head with the arrow keys to the middle of the front reference hole strip (this time X and Y axes). For this purpose, set the increment to 0.05 mm.

› Move in the positive X direction to find a free point on the reference hole strip (if necessary, change increment setting).

› Click on  to switch on the motor of the drill/mill head. Click on  to drill a hole. Wait until the drill/mill head has lowered completely into the material and click on  again to lift the drill/mill head.

› Click on  to switch off the motor of the drill/mill head.

› Move the drill/mill head 30 mm in the positive X direction from the new reference hole (not in Y direction under any circumstance), because the **HOME** position should always be 30 mm away from the reference hole.

› Go to **CONFIGURATION>SETTINGS** on the menu bar. Click on **UNLOCK** and then **SETHOME**. The data for the current machining head position are read in as the new **HOME** position and can be saved by clicking the **OK** button.

› Move the drill/mill head along the X axis to the rear reference hole strip and then drill the rear hole as described above by performing the concrete steps for drilling a hole (do not change anything in the menu Configuration again).

We recommend noting the values for the **HOME** position to prevent having to setup the circuit board plotter again if they are changed by mistake. However, after a new initialization run, it is always necessary to readjust the **HOME** position.

6 Appendix

6.1 From pen plotter to circuit board plotter

Conventional pen plotters, such as are used for printout of large graphics and drawings, have a paper transport for moving the paper back and forth along one axis (X axis). The print head containing various pins of different sizes and colors, can be moved along the second axis (Y axis). The print head can therefore be moved to any position on the paper. The print head is then lowered while the head/paper is moving so that the plotter can draw. It must be possible for the plotter to change the pins in order to draw lines of different thicknesses and colors.

The circuit board plotter operates according to the same principle with a few differences:

The base material, here the copper-coated circuit board material, is not transported; it is held tightly on a machine base plate.
Instead of drawing, milling and drilling operations are accomplished.
Some terms used in the *BoardMaster* software may be irritating because they are taken over from the old pen plotter technology.

For this reason, we have listed the basic terms in a comparative list for better understanding:

Pen Plotter	Circuit Board Plotter
Pen (thick, thin, black, red)	Tools (drill, milling cutter, ...)
Drawing paper as processing material	Circuit board base material as processing material
Pen change (thick, thin, ...)	Tool change (universal cutter, end mills,...)

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