ProtoMat 93s 

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Manual

English version

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PM93s-E(.DOC)

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1 Introduction

The LPKF ProtoMat 93s mill/drill unit is a circuit board plotter which can be used to produce prototype PCBs and gravure films, and for engraving aluminum or plastic.

Familiarity with the BoardMaster driver program of the LPKF ProtoMat 93s is essential for operation of the machine. Operation of the LPKF ProtoMat 93s with the LPKF93s.EXE machine driver is described in the LPKF ProtoMat 93s Driver Manual. The LPKF ProtoMat 93s is controlled from the serial port of a PC.

In order to make any guarantee claims, if necessary, it is absolutely vital to follow the instructions of this manual before putting the machine into operation. For machines exported to other countries of the European Community the guarantee conditions of the corresponding country apply.

1.1 Characteristics of the LPKF ProtoMat 93s

Voltage:	200-240V (or 100-120V)
Power consumption	200VA
Speed of high-speed spindle max.	Approximately 60000/min
Weight	ca. 40kg (88 Pounds)
Drilling performance:	max. 60 strokes/min
Resolution (smallest step):	0.0079375mm (0.0003125 Inch)

Operating data:

Humidity:	60% max.
Temperature:	15-25^{0}C (59^{o}-77^{o})

2 General Information

2.1 Scope of supply

1. 1 LPKF ProtoMat 93s machine unit with integrated electronics
2. 1 null modem cable (LPKF ProtoMat 93s control unit-computer), AT-Adapter 9/25-pol
3. 1 set of accessories (Drafting Tape, Allen wrenches, alignment pins, tweezers, brush, 7 mm wrench, 2 red two-pin strips)
4. 1 power cable
5. This manual

2.2 Optional accessories

The following accessories can be supplied for the LPKF ProtoMat 93s:

1. Vacuum system with fine filter (2 micron or better). The fine filter is essential when handling materials containing glass fiber such as for FR4 base material.
2. Machine table
3. Noise and dust guard hood
4. Pen holder
5. Solder and plated through hole dispenser unit LPKF DispoMat

2.3 Safety precautions

- **In order to be able to guarantee the safe operation of the system the user must have read this manual and especially the safety precautions printed in bold types!**
- **Never reach into the machine while it is running!**
- **Remember that the machine changes speed automatically during the process!**
- **Only change the tool when the mill/drill motor is not spinning!**
- **Insert the tool into the clamping device as far as it will go!**
- **Never operate the control PC simultaneously when working with the device!**
- **Operator with longer hair must wear a hair net!**
- **If you modify the equipment yourself, the equipment's safety can no longer be guaranteed and no guarantee claims can be accepted!**
- **Please take note that some materials may produce cancerogenous dust or hazardous gases. Ask your supplier of the materials.**
- **Always work with the vacuum device!**
- **When using chemicals please take note of the safety notes on the containers or separate security sheets delivered with them!**
- **Keep the workplace tidy.**

2.4 Air-borne sound

The continuous sound level at the work place during operation is 71 dB (A).
This value does not include the vacuum unit.

2.5 Installation

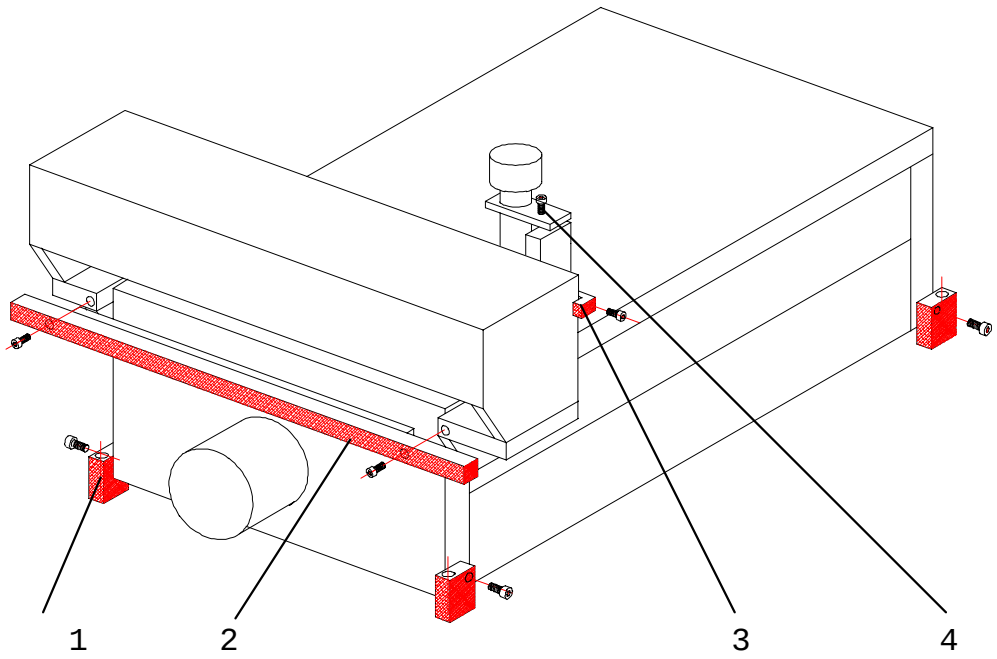
1. Unpack the LPKF ProtoMat 93s carefully (for detaching the security screws *see drawing on the next page*). Then loosen the *transport safety devices*. These devices are marked red and are located:

   Locking of the X-axis - wood panel above the X motor (safety device 2)

   Locking of the Y-axis - directly at the head to the left (safety device 3)

   Locking of the Z-axis - Phillips screw (safety device 4)

2. **Important! The equipment must stand on a flat and firm base in order to work properly!**
3. Set up the circuit board plotter so that the connecting cables to the electronic unit can move freely.
4. Connect the LPKF ProtoMat 93s to the computer with the null modem cable supplied with the system (COM1 or COM2).
5. Connect the LPKF ProtoMat 93s control unit power cord.
6. Fit the Vacuum to the adapter (suitable for stay tube no. 111124 of a Nilfisk industrial vacuum unit).



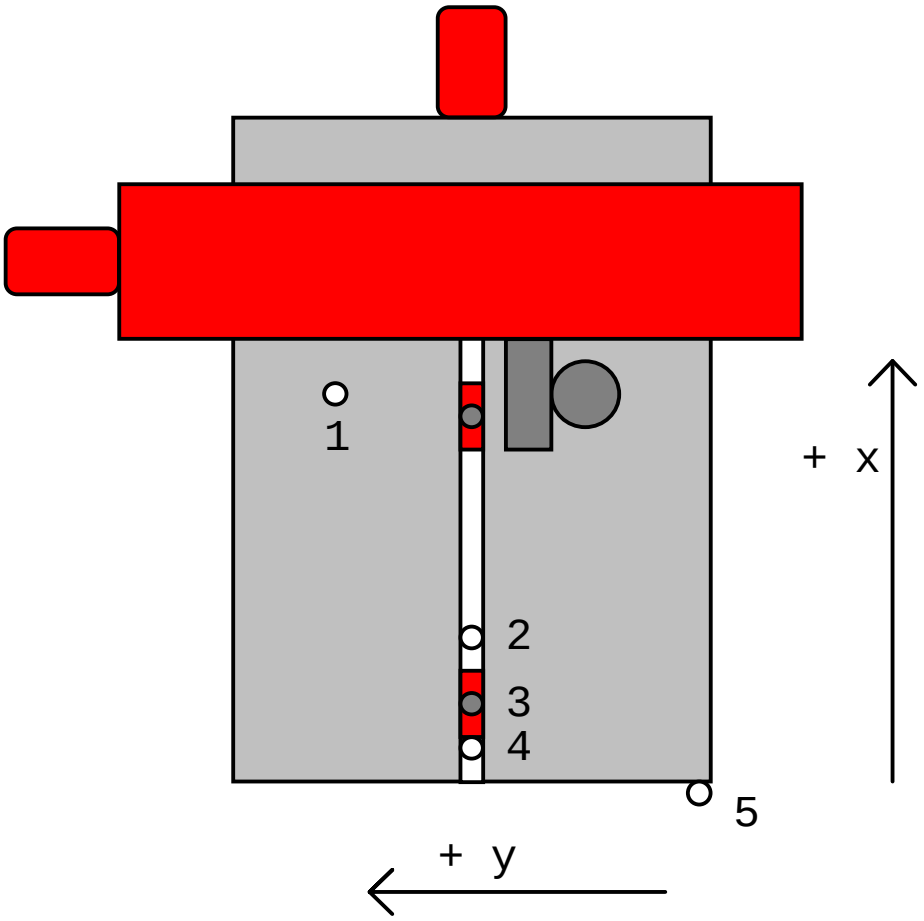
Transport safety devices of the LPKF ProtoMat 93s

Description of the transport safety devices

1. Safety device 1	Attaching the machine safely to the transport support
2. Safety device 2	Securing the X-axis
3. Safety device 3	Securing the Y-axis
4. Safety device 4	Securing the mill/drill head

Keep all transport safety device and mount them accordingly if the machine is to be shipped.

2.6 Machine orientation



LPKF ProtoMat 93s: the x-axis is the longer direction of movement

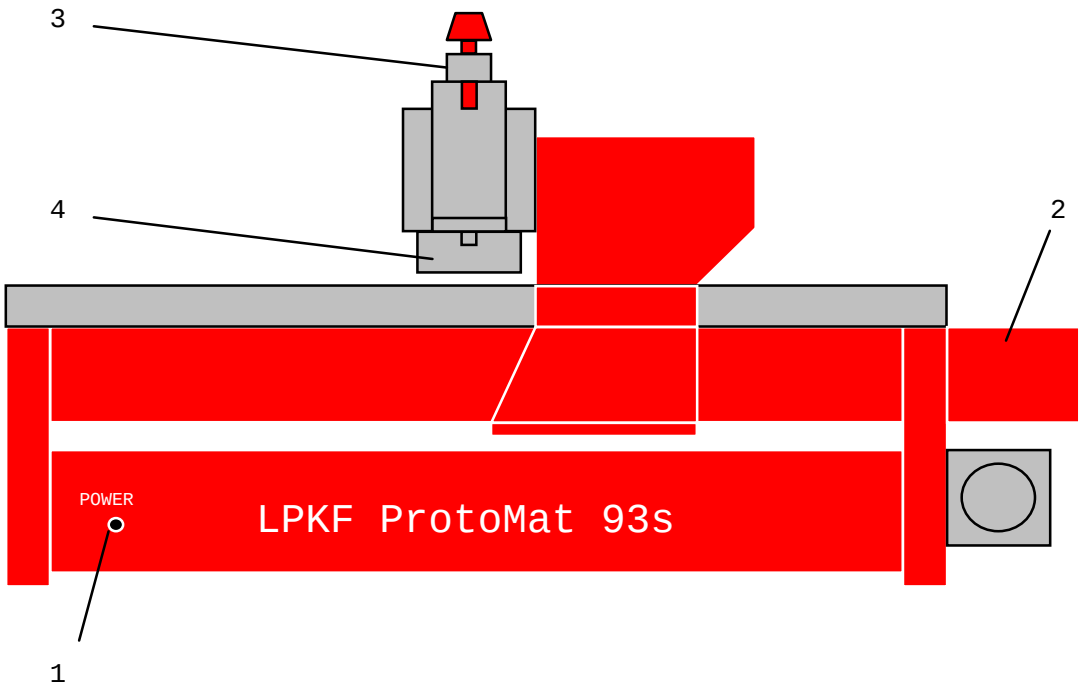
CAUTION! Keep fingers and any other items out the area of movement!

Description of the main machine positions:

1. PAUSE position. The machine will move to this point to load or turn the material to be machined.
2. HOME position. This is the relative 0.0 position and MUST lie on the machine mirror (X) axis (two-pin system) and serves as the reference X=0,Y=0 position for the machine driver (BoardMaster and LPKF ProtoMat 93s).
3. Two-pin slide with hole for alignment pin.
4. Reference pin for front two-pin strip.
5. Tool change position (absolute zero position). The tool is changed here.

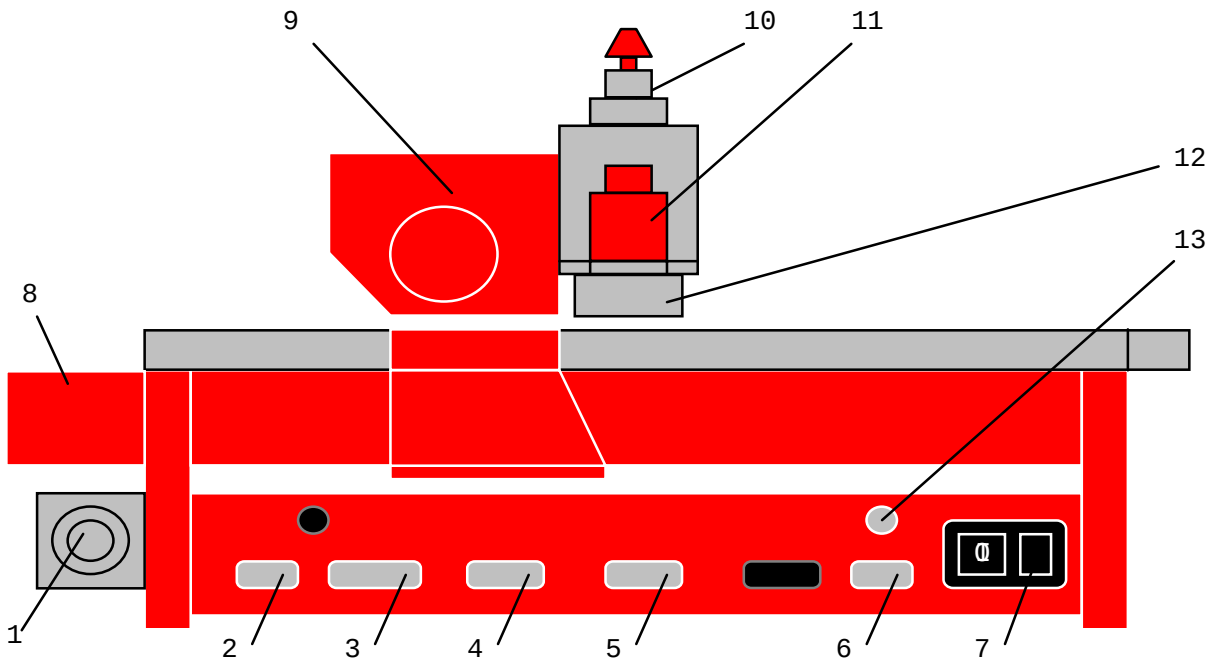
2.7 LPKF ProtoMat 93s displays and connections

Front LPKF ProtoMat 93s



Description of the front panel:

1. Operating display of the integrated machine control SMCU
2. X motor
3. High-speed spindle motor
4. Working depth limiter



Rear view of LPKF ProtoMat 93s

Description of the rear panel:

1. Vacuum connection
2. Output Serial interface (9-pole) for controlling optional equipment
3. Input Serial interface (25-pole) for connection to PC serial port
4. X motor connection
5. Y motor connection
6. Mill/Drill head connection
7. On/Off switch, power cord connector and fuses
8. X motor
9. Y motor
10. High-speed spindle motor
11. Y Axis solenoid
12. Working depth limiter
13. Spindle motor connection

2.8 Use of BoardMaster

Data required to drive the plotters are generated in CircuitCAM and are stored in files with HP-GL format or as LPKF binary files (LMD format). BoardMaster is used for reading the files, decoding plot commands and modifying them for the specific LPKF System being driven. The drivers use the HP-GL or LMD data and add important, machine specific functions such as scaling, motor control, etc. The LPKF ProtoMat 93s circuit board plotters respond to HP-GL commands. The drivers provide additional capability such as step and repeat, move, rotate, etc.

All LPKF circuit board plotters are driven via an asynchronous interface (RS232C). In the case of the LPKF ProtoMat 93s, it is operated at *9600 baud, 1 stop bit, 8 data bits, no parity and hardware handshake*. The serial interface of the computer must be configured using the DOS MODE commands in the case of the DOS driver and using the Windows Main/Control Panel/Port setup facility in the case of BoardMaster.

3 Setup

3.1 Before switching on

Be sure the voltage set at the machine corresponds with the line voltage: If not, continue at chapter 8.7 Electrical Fuses, Setting the device voltage.

Before switching on, all items are to be removed from the machine and its range of movement. Pilot pins must not project from the base material.

CAUTION! Never reach into the machine while it is running!

3.2 Turning the system on

The following switching on order is useful, but not essential:

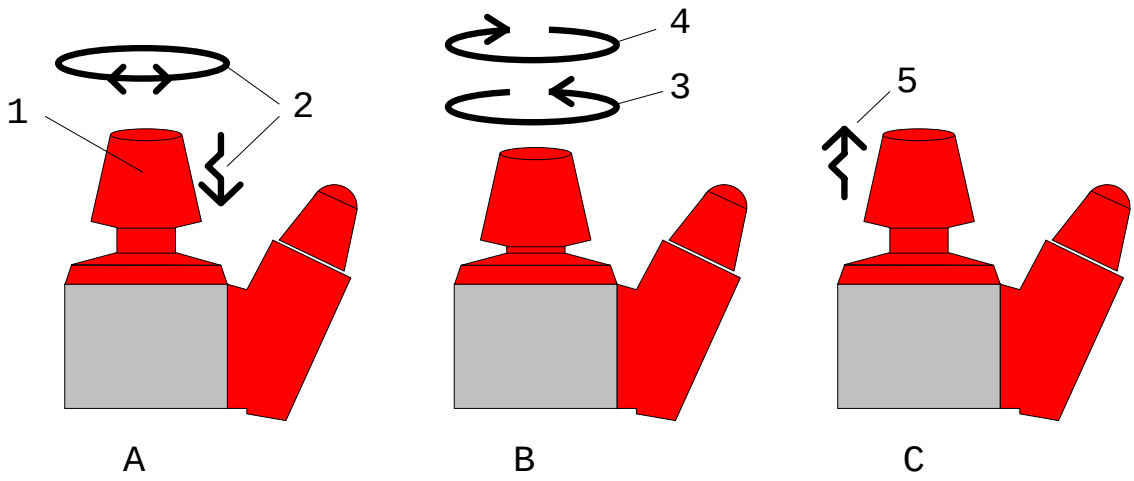
1. Computer
2. LPKF ProtoMat 93s
3. Start the BoardMaster program

If for some reason it should be necessary to switch the machine off and on again, then change to the Machine/Settings window of the BoardMaster program and click on OK. Thus all necessary initialization parameters like speed ranges, dwell times positions and so on are again transmitted to the machine.

3.3 Switch-on instructions for high-speed spindles

A tool must always be placed in the shaft of the high-speed spindle when the machine is switched on. The collet must always be closed and the knob of the high-speed spindle must be in its top position, otherwise the spindle is blocked and the motor driver can be overloaded.

Caution: The spindle can be damaged if it operated without a tool inserted!



Operating the collet of he high-speed spindle

A) Knob in normal position, spindle is running freely. Push the knob (1) down until it is engaged in order to open or close the collet. Hold the head up to avoid damaging the tool in the collet. . If necessary, turn the knob slightly to the right or to the left (2) when pushing it down.

B) Caution*: in this position collet and spindle are blocked and the drive electronics may be damaged if the motor is turned on.* In order to open the collet, turn the knob counter-clockwise (3). To close, turn the knob clockwise (4). Do not turn the knob too tightly.

C) Bring knob back to normal position (top) (5). The spindle can now run free again.

During set-up take note that the bearings of the high-speed spindle have to be run in first after a longer period of standstill (several months) or after transport. *During initial set-up the spindle should run at 10 000 rpm for several hours.*

Normal warm-up of 3 to 10 minutes (at 20 000 rpm) of the spindle is automatically controlled by BoardMaster. The duration of this warm-up depends on the length of time the system has been off. During warm-up no speeds exceeding 20,000 rpm will be allowed. Programmed speed above 20,000RPM will be allowed after the warm-up time.

3.4 After switching on

When it has been switched on, the equipment moves to limit switches -X and -Y, and the system then halts in the tool change position. It is then able to accept commands from the machine drivers. If the equipment does not move when it has been switched on, check the following:

1. Is the POWER LED on (is on only after successful initialization) ?

2. Are all cables properly inserted ?

3. If necessary, check the fuses at the input power connection!

3.5 Function test with BoardMaster

CAUTION! Make sure that nothing is in the machine operating area when the first functional test is taking place!

First check that the baud rate for the serial interface used is set to *9600 baud, 8 data bits, 1 stop bit, no parity bit and hardware handshake*. Also check that ***Channel*** and the correct interface have been selected in BoardMaster under ***Machine Connect...*** Consult the BoardMaster Manual if you need help.

Now using BoardMaster:

1. turn on the motor (first the motor will turn at a maximum of 20,000 rpm)
2. raise/lower the head
3. switch off the motor
4. move the head manually using the cursor keys on the BoardMaster function bar.
5. If the equipment does not move, check the interface configuration, the connecting cable as well as the PC interface.

3.6 HOME-Position and two-pin system

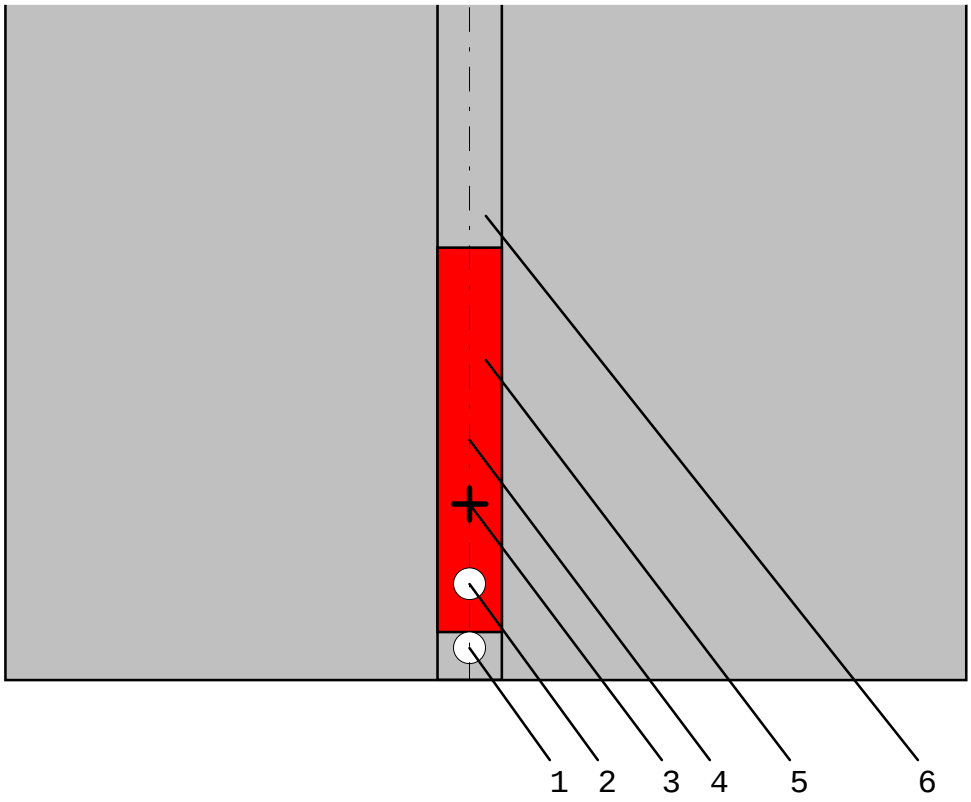
The HOME position must be on the machine's X axis (two-pin system) to guarantee alignment of a double sided board. The data for the bottom side of a PCB is mirrored around the X axis and therefore the board must also be rotated around the X axis to maintain registration. Inaccuracies in the HOME position result in a displacement during machining of double-sided boards after the rotation.

Note:
The two-pin system is parallel only for the current position of the two-pin strips. The front two-pin slide must be placed against the pin in the groove (reference). If base material of different sizes is used, an additional hole must be drilled in the strip of the back for every format. To do this, move from the home position in direction of the rear strip, displace it to the desired position and drill an additional hole by hand, using the 3 mm drill. The position of the new holes should recorded or marked at the plotter. This will help when drilling the reference hole in various size material.

3.7 Programming the HOME position in BoardMaster

The home position needs to be programmed on new equipment and when the system has been moved.
The HOME position of the LPKF ProtoMat 93s must be precisely on the mirror (X) axis (the two-pin system with the red plastic slides) for machining double-sided PCBs. To do this, proceed as follows:

1. Start BoardMaster
2. Click ***Machine*** in the menu bar.
3. Now select ***Settings..***
4. Activate ***Unlock*** so that you can make entries in this window.
5. Check that ***SMCU*** is selected. If there is no cross in the relevant box, the box must be clicked.
6. Now ***Initialize*** must be clicked. The equipment travels to all four end positions, and then stops in the ZERO position (at the front, to the right). The movement range thus determined is displayed under ***Size*** and stored when the ***Machine Settings..***dialog box is left. For more detailed information see the BoardMaster Manual.
7. A two-pin system has already been set up at the factory. The HOME position x and y coordinates is delivered with the machine on the enclosed paper (see sticker of the driver diskette). They should now be entered under ***Home*** in BoardMaster.
8. If the coordinates are not known, the two-pin system must be drilled again. To do this, see the section entitled “Making a new two-pin system“.
9. When the ***Machine Settings..*** dialog box is closed and BoardMaster left, the new values are saved in a .INI file which is read each time BoardMaster is called and each time ***Machine Settings..*** called.



Front stripe of the two-pin system

1. reference pin, may be covered by two-pin stripe (5)
2. front alignment pin
3. HOME position, min. 10 mm distance to the alignment pin
4. mirror axis
5. two-pin stripe
6. two-pin groove

3.8 Making a new two-pin system

The alignment holes in the red two-pin strip become larger over time due to use and top to bottom alignment will suffer. You must then drill new holes in the slides. If after a certain time there are too many holes in the slides, the two-pin strips must be changed.

CAUTION! Take note that sharp tools are involved and that they may be hot. In order not to hurt yourself because of chips always work with the vacuum system switched on!

To make a new two-pin system, proceed as follows:

1. First press both two-pin strips into the machine groove, *with the front two-pin strip pushed against the reference pin to the front of the groove*. The distance between the two two-pin strips should be about the size of the base material in the X axis.
2. Fit a drill measuring 3 mm in diameter (better 2.95 mm) so that the distance between the base plate and the drill point is about 0.5 mm. This is the only time a tool is not inserted into the collet as far as it will go.
3. Adjust the working depth limiter to the top using the knurled screw, in order to increase the drill stroke.
4. Move the mill/drill head to HOME and then to the front two-pin strip. Then manually drill a hole about 4 mm deep in the approximate center by pressing down the drill head. *Afterwards, do not move the mill/drill head position in the Y axis*.
5. Move the mill/drill head an exact, known distance (25 mm or 1 inch for example) the +X direction and define this position as the new HOME position (***Set Home***). Knowing this dimension is important because you need to know the exact distance between the pins to prepare material later.
6. Move in the X axis a known amount to the second, rear two-pin strip and drill a hole about 4 mm deep there too. Remember the distance between the two holes because this will be the dimension you need when drilling holes in the backing material and the copper clad. *By no means move in the Y-direction.*
7. Now position the drill tool in the drill chuck as far as it will go.
8. Move the mill/drill head to the side. Insert two alignment pins in the holes now made in the two-pin strip. Check that the pins are firmly inserted as any play affects alignment accuracy.
9. Mark old holes with a felt pen so they cannot be confused with the new ones.
10. Position the previously drilled base material and drilling base over the alignment pins. The holes in the base material and the copper clad should have been drilled using the system and at the same distance apart as the alignment pins so the plastic strips do not have to be moved.
11. Now fix the base material thus positioned with adhesive tape on all four sides.

3.9 Checking and correcting the HOME position

1. Make alignment holes in double-sided base material.
2. Fix the material and the drilling base (2 mm) on the base plate with the help of the alignment pins (see too the section on fixing the PCB on the machine bed).
3. Drill a hole at the HOME position with a 0.7 mm drill.
4. Move the mill/drill head to the PAUSE position.
5. Turn the PCB material around the X axis.
6. Move to the HOME position, move to the tool change position and insert a universal milling cutter. When the tool has been changed, the mill/drill head automatically returns to the HOME position.
7. Mill a channel over the hole manually in the X direction, without moving in the Y direction.
8. Check visually that the milled channel passes precisely through the center point of the hole.
9. If the milled line does not run exactly through the center point, the HOME position must be corrected by half the difference. This can be done directly by changing the home position in ***Machine Settings..*** dialog box.
10. After making a correction, the movement should be repeated as a check.

4 The LPKF ProtoMat 93s operating displays

POWER (green): control operating display. This only comes on when the system has been initialized (limit switch reached).

5 Computer-controlled functions of the LPKF ProtoMat 93s

5.1 Connection to a PC

The LPKF ProtoMat 93s has two serial interfaces. The first (SERIAL 1) is the INPUT to the system and is used for connection to the controlling computer (PC).

The second interface (SERIAL 2) is an OUTPUT and is provided for future applications.

The LPKF ProtoMat 93s control unit's SERIAL 1 is connected to a serial interface on the computer with the RS232 cable supplied.

The RS232 cable (null modem) for the LPKF ProtoMat 93s circuit board plotter is wired as follows:

25-pole port PC(COMx)				25-pole port circuit board plotter (SERIAL1)
1	-		-	1
2	-	TXD	-	3
3	-	RXD	-	2
4	-		-	5
5	-		-	4
7	-	GND	-	7
8	-		-	20
15,17	-		-	24
20	-		-	8
24	-		-	15,17

The cable shield ground is connected only on the PC side (port).

The following parameters must be observed:

baud rate	9600 (default setting, others upon request)
parity	none
data bit	8
stop bit	1
hardware handshake	

If the DOS driver is used the PC's serial interface is initialized with the DOS command ***Mode Com1:96,N,8,1.*** If BoardMaster is used, the port must be initialized under Windows using Main/Control Panel/Ports.

5.2 The LPKF ProtoMat 93s Commands

5.2.1 Command structure

The SMCU (Signal Processor Control Unit) control unit of the machine interprets the HP-GL commands described below and converts them into set reactions.

The *resolution of the machine is 0.0079375mm*. This is a different resolution than that of standard HP-GL-plotters. Therefore the output is scaled down when original commands are used.

The syntax:

Symbol	Meaning
{...}	The contents can be repeated any number of times.
()	The command parameters are between these brackets.
[]	The content of these brackets is optional and does not have to be included.

The SMCU expects a separator between the command parameters which is not any of the figures or upper case letters. A new command can follow a parameter without a separator. The last character in a command file which is sent must be a semicolon or a line feed symbol (0A hex.).

Unknown commands are ignored by the control unit, but their parameters can lead to unwanted plot absolute or plot relative commands.

5.2.2 HP-GL standard commands

AA (x,y,a{,ß}){;}
Arc Absolute
Draws an arc around the absolute coordinate (x,y) starting from the current position with the arc angle a=[degree]. With a negative arc angle a, it is drawn clockwise, but otherwise counterclockwise.

AR(x,y,a{,ß}){;}
Arc Relative
Draws an arc around the relative coordinate (x,y) starting from the current position with the arc angle a=[degree]. With a negative arc angle a, it is drawn clockwise, but otherwise counterclockwise.

CI (r{,ß}){;}
Circle
Draws a complete circle around the current position with radius r. Resolution ß is ignored as the maximum resolution is always used when drawing.

EA (x,y){;}

Edge rectangle absolute

Draws a rectangle defined by two corner points lying diagonally to each other. The first corner point is determined by the current position and the second by the absolute coordinate (x,y).

ER (x,y){;}

Edge rectangle relative

Draws a rectangle defined by two corner points lying diagonally to each other. The first corner point is determined by the current position and the second by the relative coordinate (x,y).

IN {;}

Initialize

Changes the control unit to the same status as after switching on. This restores all default settings.

IW (x0,y0,x1,y1){;}

Input window

Restricts the working area on the XY axis to a window with the given corner coordinates.

OH {;}

Output hard clip limits

The control unit automatically determines its maximum travel range within the limit switches and send the coordinates determined in this way as an ASCII string in the form ("W Xmin,Ymin,Zmin,Xmax,Ymax,Zmax<cr>") to the PC.

OS {;}

Output status

The control unit sends its status line as ASCII hex ("S xxxx <cr>") to the PC.

PA (x1,y1{,...xn,yn}){;}

Plot absolute

Draws a line from the current position to the absolute coordinates listed one after the other. The commands PU and PD can be given between the pairs of coordinates as parameters. If additional pairs of coordinates are sent, the command word PA is not necessary. All pairs of coordinates without a command word are taken to relate to the last PA or PR commands sent and are carried out accordingly.

PD {;}
Pen down
Lowers the tool.

PR (x1,y1{,...xn,yn}){;}
Plot relative
Draws a line from the current position to the relative coordinates listed one after the other. The commands PU and PD can be given between the pairs of coordinates as parameters. If additional pairs of coordinates are sent, the command word PA is not necessary. All pairs of coordinates without a command word are taken to relate to the last PA or PR commands sent and are carried out accordingly.

PU {;}
Pen up
Lifts the tool.

VS (v{,n}){;}
Velocity select
Defines the track speed in the XY level v=[µm/s] with the tool lowered and allocates this speed to the tool with number n.

5.2.3 Special commands

All special commands begin with the symbol "!" and their syntax is otherwise like that for HP-GL standard commands.

!AS (a){;}
Acceleration Set
Defines a new acceleration constant a=mm/s². The valid value range is 10...50000.

!CC {;}
Close channel
Ends a data transmission introduced with !OC.

!CM (n){;}
Change mode
Switches between the drill (n=0) and mill (n=1) working modes.

!CT (n){;}
Command counter
Switches between echo mode (n=1) and non-echo mode (n=0). In echo mode, the machine acknowledges every correctly completed command with the message "C<cr>".

!EM (n){;}
External motor
Switches the mill/drill motor on (n=1) or off (n=0).

!ES (n){;}
Enable stop
Release (n=1) and block (n=0) the external stop function. After switching on, the external stop function is blocked.

!FP {;}
Full power
Switches the motors of the XYZ axis to full power.

!HP {;}
Half power
Switches the motors of the XYZ axis to half power.

!OC {;}
Open channel
Opens a direct data transmission from serial data channel SER1 to serial data channel SER2. All characters received on data channel SER1 are sent to data channel SER2 until the character string !CC is received.

!ON (a){;}

Output nominal position

The control unit sends the nominal position (target position) of the motor axis addressed with parameter a. The following addresses are attributed to the motor axes:

0 = X,Y,Z axis
1 = X axis
2 = Y axis
3 = Z axis

!RD (a){;}

Read port

Effects the reading of the input port with the address a=<0..15>. The data is output via the serial interface from the which the command came, as an ASCII figure.

!RS (r){;}

Resolution set

Gives the control unit the step size (r=µm/step) of the machine. The valid value range is 1...32000.

!TA (x,y,z){;}

Plot three-D absolute

Carries out a physical movement from the current position to the absolute coordinate (x,y,z).

!TD (t1,t2,t3,t4){;}

Time for drilling

Sets new drill times t=[ms].

!TM (t1,t2,t3,t4){;}

Time for milling

Sets new mill times t=[ms].

!TR (x,y,z){;}
Plot three-D relative
Carries out a physical movement from the current position to the relative coordinate (x,y,z).

!TS (t){;}
Time to stabilize
Sets a stabilization time t=[ms] between the individual commands.

!TW (t){;}
Time to wait
The following command is only carried out after a wait t=[ms].

!VU (v){;}
Velocity if pen up
Defines the track speed v=[µm/s] of the movement in XY plane when the tool is raised.

!VZ (v){;}
Velocity Z axis
Defines the speed v=[µm/s] of the movement in the Z axis.

!WR (a,d{,m}){;}
Write port
Effects an output of the data word d on the port address a=<0..15>, whereby a bit mask can be given.

!ZA (z){;}
Plot Z axis absolute
Moves the Z axis from the current position to the absolute coordinate (z).

!ZR (z){;}
Plot Z axis relative
Moves the Z axis from the current position to the relative coordinate (z).

5.2.4 Special command for the high-speed spindle

Before communicating with the high-speed spindle, send the command for opening the SERIAL2 (!OC;), then the serial interface SERIAL2“ must be closed again (!CC;)

!RM (r){;}
Revolutions Motor, r=0...60.
Sets the speed (r)*1000 of the high-speed spindle.

5.2.5 Direct commands

Direct commands are special commands which, once they have been interpreted, are carried out via the command buffer.

!CB{;}
Clear buffer
Deletes all commands from the command buffer.

!GO{;}
Go on
Removes the stop command and continues the command implementation.

!RC{;}
Repeat command
Repeats the last command carried out.

!ST{;}
Stop
Interrupts command processing when the current command is completed.

The command set implemented is a subset of the HP-GL. If the equipment is to be driven by any CAD system, with HP-GL commands, it must be ensured that the step size is substantially lower than with normal pen plotters.

The step size is 7.9375 µm/step (0.0003125 inch/step).

5.3 Producing a PCB with BoardMaster

The job to be carried out must already be loaded or prepared in BoardMaster. For example, the data from the CircuitCAM tutorial can be used.

A further requirement is that the HOME position was programmed precisely as described above.

1. **Attention! Take care when handling the tools! Danger of cutting! Do not forget to switch on the vacuum system during machining!**
2. Move to the PAUSE position using BoardMaster (***Machine, Pause***).
3. Fix the base material using alignment pins as described in the section entitled "Securing the PCB on the machine bed".
4. Using BoardMaster, move to the bottom left corner (-x, -y) of the base material so that the working depth limiter does not quite touch the adhesive tape.
5. This corner must be programmed under ***Material*** with ***Set X,Y min***.
6. In the same way, move to the top right corner (+x, +y) of the material and program (***Material, Set X, Y max***).
7. The material must be visible in BoardMaster as light gray on the dark gray machine surface.
8. If applicable, move the project by means of ***Placement*** so that the graphics data is completely on the material.
9. Select the first machining phase i.e. ***DrillingPlated*** .
10. Drill data is selected with ***All+***. Selected data is shown brighter.
11. Switch on ***Auto-Motor-On*** (motor key on right in BoardMaster).
12. Press ***Start*** .
13. BoardMaster requests the tool needed for the machining phase by traveling to the tool change position and then switching the motor off automatically.
14. After opening the collet , the tool can be removed from the motor shaft using the tweezers supplied.
15. Insert the appropriate tool *as far as it will go* and tighten the collet.
16. Acknowledge the tool change with ***OK***.
17. The motor switches on and the first hole diameter of the drill phase is carried out.
18. Once the holes of the current diameter have been made, the next tool is requested and changed in the same way.

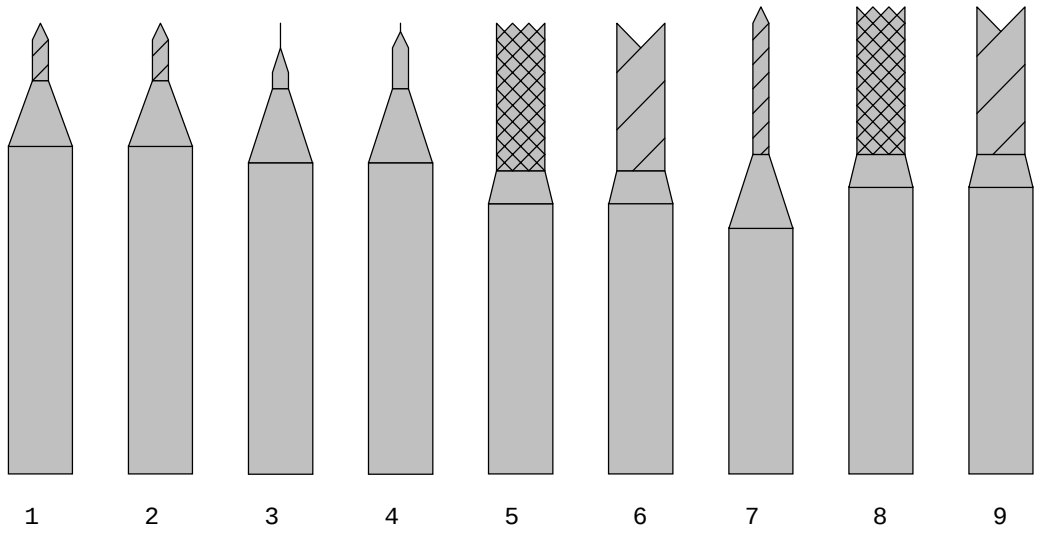
19. When the drill phase is complete, mill phase ***MillingCompSide*** is selected after any through-plating.
20. The milling depth should now be set. To do this, click ***1Unimill*** in the tool combo box. The head travels to the tool change position. Insert the universal milling cutter and, with the arrow keys, move over the base material, but not over the project, in BoardMaster.
21. Set the step size using **Machine Settings..** to some small step (0.1 inch or 0.2 mm). Go into mill mode, switch on the motor, lower the head and move with the arrow keys. Set the milling depth. See too the section entitled "How the mechanical working depth limiter works".
22. The mill data for the component side is now selected with ***ALL+.*** Machining is started with ***Start***.
23. If all of the top or component side operations are finished, then move to the pause position and turn the material.
24. Select and carry out the ***MillingSoldSide*** mill phase.
25. If required, select the ***Cutting*** mill phase and machine with a contour milling cutter.
26. Move to the pause position, remove the PCB and proceed as described in the section entitled "Cleaning the PCB".

6 Tools and accessories

6.1 Tools

The tools for the LPKF ProtoMat 93s come in two different lengths. Tools used to machine the material surface (milling and engraving) are 30 mm long for 3 mm collets or 1.42 inch long for 1/8 inch collets, and tools used for drilling or contour milling are 32 mm long for 3 mm collets or 1.5 inch long for 1/8 inch collets. The following tools are available.

.



LPKF tools for circuit board plotters

1. Universal LPKF milling cutter and drill, for milling isolation channels and for front panel engraving from 0.2 to 0.5 mm (depending on depth set), 30 mm and 1.42 inch long
2. LPKF Micro-cutter, for milling isolation channels of 0.1 - 0.2mm (depending on the depth setting), length 30mm
3. LPKF HF-cutter, produces rectangular isolation channels of 0.25mm width.
4. Film milling cutter, 0.3 mm, for making typons, 30 mm long. This tool is not available for 1/8 inch collets.
5. Contour miller for engraving wider isolation channels.
6. Double chamfered cutter (0.8; 1; 2 mm) for front panel engraving, 30 mm long.
7. Spiral drill, various diameters for drilling in PCB material, 32 mm long.
8. Contour milling cutter, for milling out gaps in PCB material, 32 mm long.
9. Double-edged cutter (0.8; 1; 2 mm) for milling of open spaces on aluminum, length 32 mm.

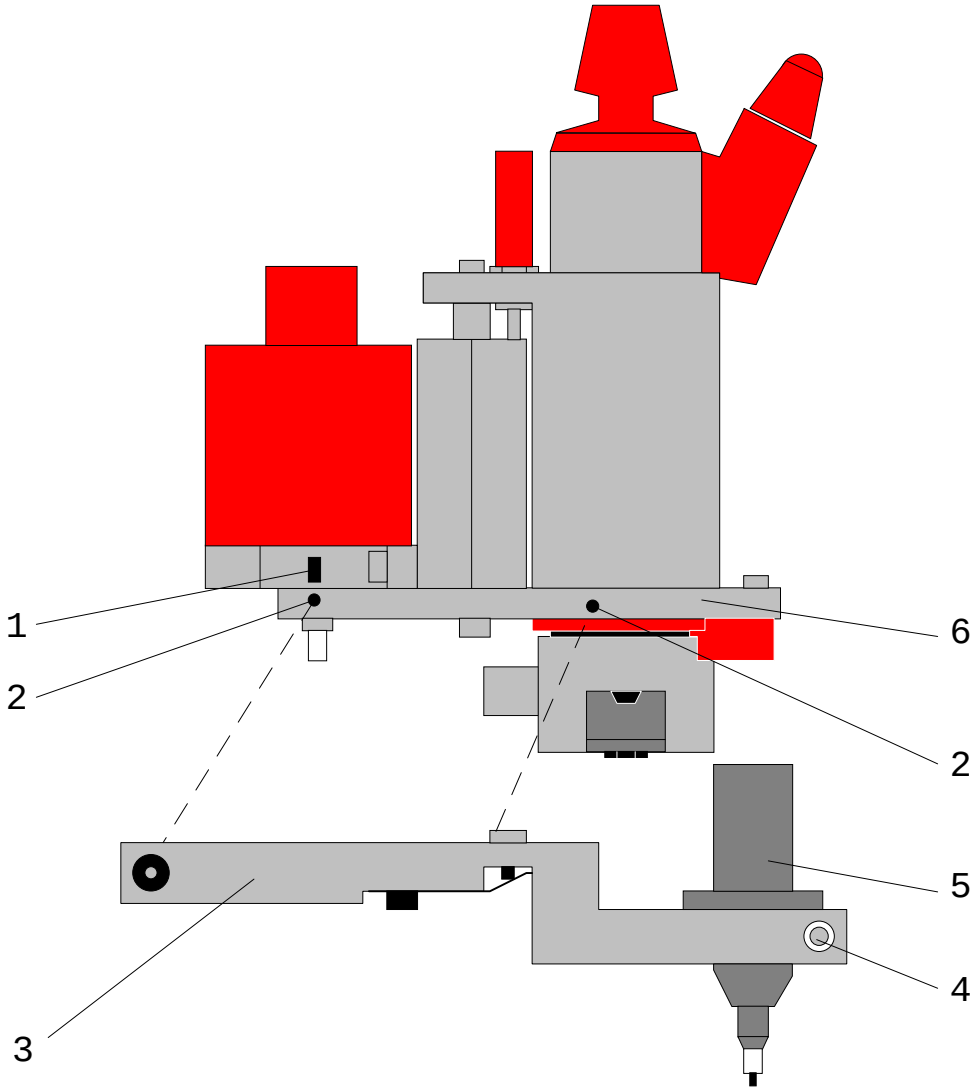
Attention! Execute a tool change only in defined positions!

The tools must always be inserted in the tool fixture as far as they will go. Otherwise the working depth will be incorrect. In certain circumstances, this can even result in damage to the machine base plate.

Tweezers are supplied for tool insertion and removal.

6.2 Pen holder (optional)

With the pen holder, the circuit board plotter can be used as a pen plotter.



Assembly of pen holder

The pen holder is fitted as follows:

1. Insert the aluminum part (3) of the pen holder into the borings (2) at the motor support plate (5) and fix them using the Allen screw (1).
2. Insert the pin into the boring and fix it using the Allen screw. (4).
3. Set the working depth limiter so that the ink pen just comes in contact with the paper.

6.3 Materials used for machining

In general all base materials supplied by LPKF can be used for machining. You are free to machine all other materials at your own risk. Take into consideration the notes of the manufacturers.

Material supplied by LPKF and suitable for machining:

FR3-material:	engraving, drilling, milling
FR4-material :	engraving, drilling, milling
Aluminum:	engraving, milling only special alloys, e.g. AlCuMg1
Engraving film:	engraving

Material suitable for machining but not yet supplied by LPKF:

Teflon:	engraving, drilling **CAUTION! Keep from overheating, hazardous gases may be produced!**

When working with materials containing glass fibers there might be produced cancerogenous dusts. Therefore only work with vacuum system switched on!
When working with unknown materials cancerogenous dusts or hazardous gases may be produced. Ask your supplier or the manufacturer before starting with the machining.

7 Milling and drilling with the LPKF ProtoMat 93s

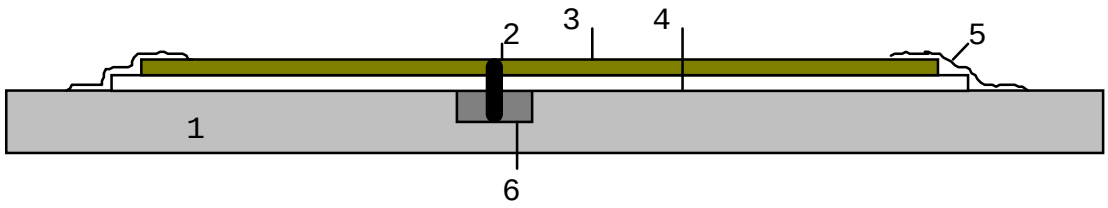
7.1 Securing the PCB on the machine bed

Make 3.0 mm alignment holes in the base material and backing material spaced the same distance as the alignment pins. This can also be done with any upright drilling machine. Take into consideration that the diameter decreases during galvanic through-plating process so do not plate these holes.

Move the mill/drill head to the PAUSE position. Insert alignment pins in the front and rear two-pin strips but, even so, check that the front two-pin strip is pushed forwards against the reference pin in the machine groove.

Position the pre-drilled base material and drilling base over the alignment pins. The format of the base material should be selected in a way that the two-pin slides do not have to be moved by more than 10 mm, as otherwise the two-pin system precision decreases.

Now secure the base material in position with drafting tape (masking tape is not recommended because it leaves a residue) on all sides. This prevents the corners of the PCB turning upwards.



Securing the PCB

1. Machine bed (aluminum base plate)
2. Alignment pins, 3 mm in diameter
3. Base material, approx. 1.6 mm thick
4. Drilling base, 2 mm thick
5. Drafting tape
6. Two-pin strip

The alignment pins hold the PCB in position. This is essential particularly for contour milling. They are also the reference when turning double-sided PCBs. The masking tape holds the PCB down at the edges.

Attention! Switch on the vacuum system! Take into consideration that the vacuum filter might need to be changed!

It is important that there is no dirt (adhesive tape remains, drilling or milling chips) between the individual layers so that the base material can be laid absolutely flat. Small particles under the base material would adversely affect milling depth uniformity.

7.2 The mechanical working depth limiter

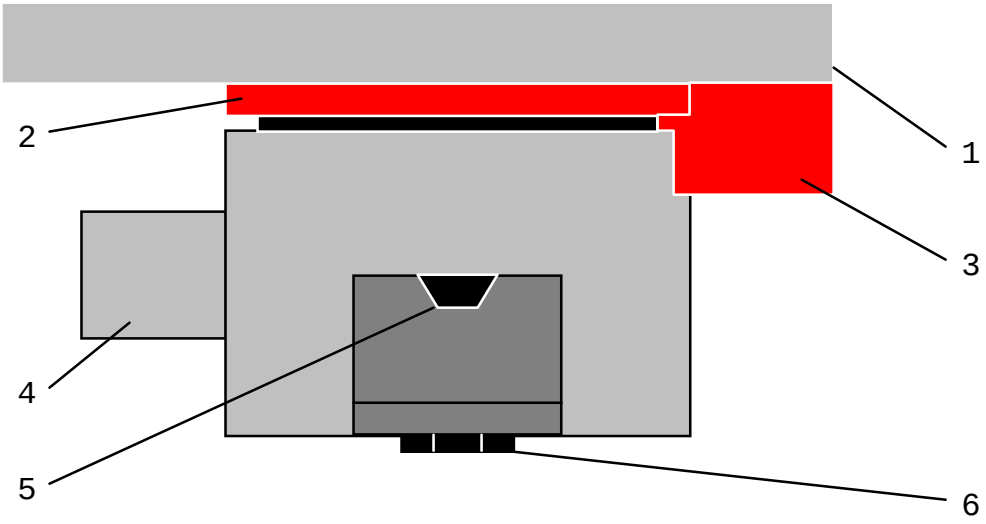
Attention! Keep your fingers away from the movement area of the machine during operation!

When milling isolation channels in PCB materials, it is extremely important to keep a constant milling depth. With the LPKF ProtoMat 93s, this done by the mechanical working depth limiter.

This provides the following benefits:

1. The depth limiter rides on the surface of the material. The working depth limiter follows warped PCBs.
2. The material is held down within certain limits by the working depth limiter.

The head is lowered with a solenoid and raised with a spring.

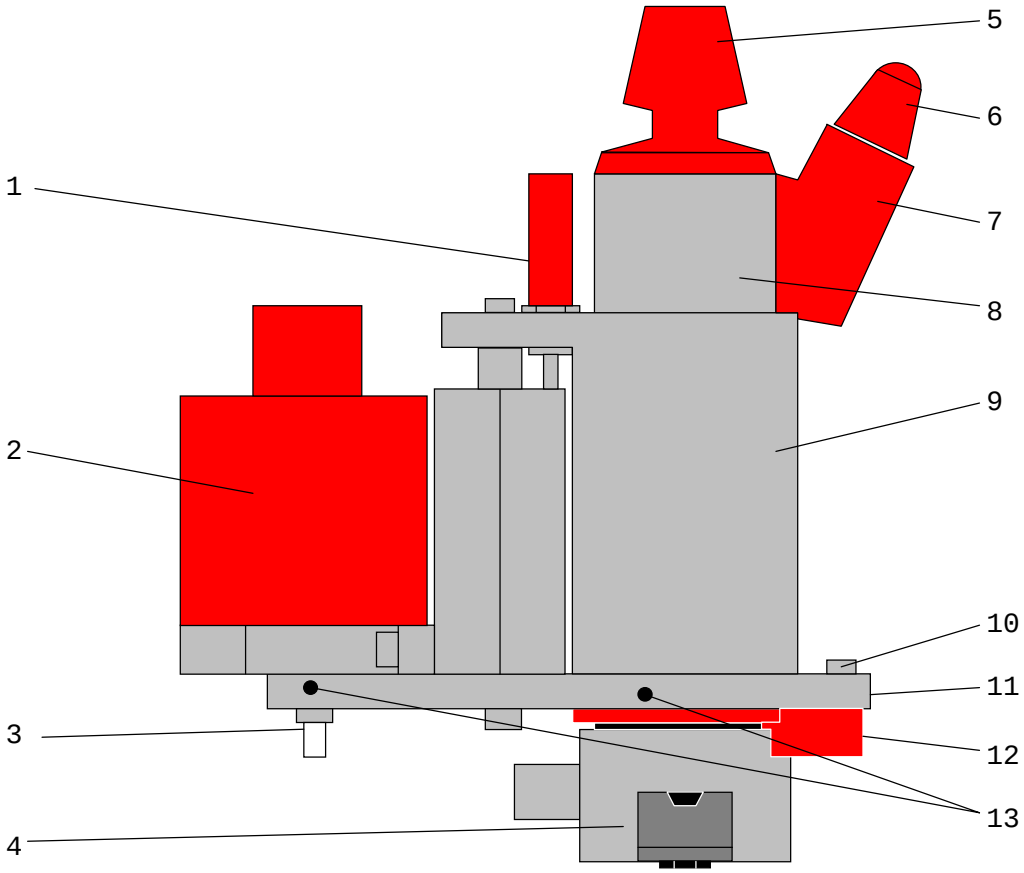


The LPKF ProtoMat 93s working depth limiter

1. Holding plate
2. Knurled nut used to set milling depth
3. Holding block for working depth limiter
4. Suction nozzle
5. Tool fixture (collet for manual clamping)
6. Scanning ring in the working depth limiter

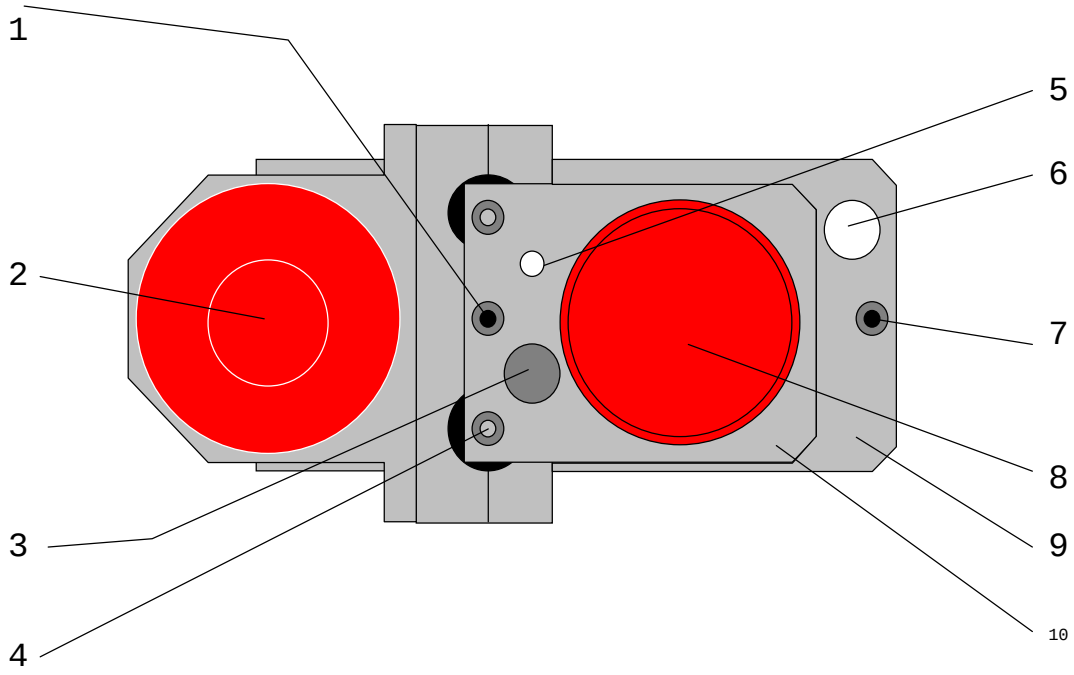
Milling depth is set by adjusting the knurled nut (2) on the working depth limiter. When the wheel is turned clockwise, the milling depth is increased, while it is reduced when turned counterclockwise. The milling depth is altered by about 4 µm (0.0008 inch) per step. Turning the knurled knob in counter-clockwise direction is difficult when the head is lowered.

7.3 Functional elements on the mill/drill head



Mill/drill head front view

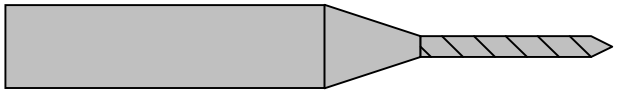
1. Shock absorber
2. Solenoid
3. Adjustment bottom head stop **(Attention! Do not move!)**
4. Working depth limiter
5. Knob for manual clamping
6. Connector for high-speed spindle
7. Socket for high-speed spindle
8. High-speed spindle
9. Holding block
10. Adjustment screw for working depth limiter
11. Base plate
12. Setting screw for knurled nut **(Attention! Do not move!)**
13. Mounting holes for holding accessories.



Mill/drill head, view from above

1. Adjusting nut for head stop, top
2. Solenoid
3. Hole for transport safety devices and options
4. Z Axis guide
5. Shock absorber
6. High-speed spindle
7. Fixing screw for working depth limiter
8. Knob for high-speed spindle
9. Base plate
10. Bracket for high-speed spindle

7.4 Drilling

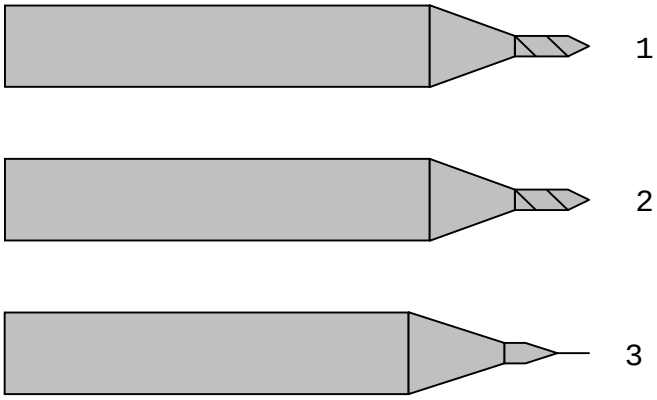


Attention! Before drilling make sure that the PCB is positioned tightly. Switch on the vacuum cleaner!

You must check the PCBs are drilled with special PCB drills. It is important always to lower the head at a constant speed. This is achieved by setting the tool as close as possible to the material to be drilled. A setting nut can be used to make this adjustment. An excessive lowering speed can result in burrs, particularly where holes have a small diameter.

Only one PCB can be drilled at a time. It is not possible to stack PCBs one on top of the other. No drill cover plate is needed. All drills are 32 mm long for 3 mm collets and 1.5 inches long for 1/8 inch collets. For further notes see chapter "Practical tips".

7.5 Isolation milling



LPKF universal- (1), micro- (2) and HF-cutter (3)

Attention! Before milling make sure that the PCB is positioned tightly! Switch on the vacuum system!

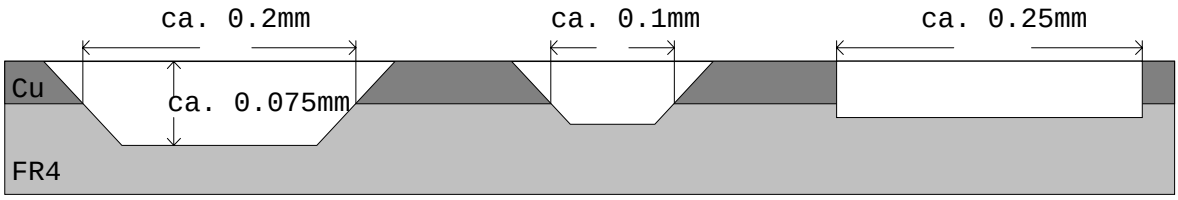
Before milling, it must be ensured that sufficiently sharp LPKF universal milling cutters (30 mm long or 1.42 inches long) are used. The milling width is set to between 0.2 and 0.5 mm or 0.008 and 0.020 inches depending on component thickness.

It is advisable to degrease the base material with cleaner spray before machining (degreaser for electronic components), so that milling dust can be removed more easily by the extractor.

The milling depth must be set as large (deep) as possible in all cases. If only the extreme milling cutter tip (<0.2 mm isolation) is used, the tool wears more quickly than with deeper drilling.

The LPKF micro-cutters can be used to produce even smaller isolation channels, but their service life is about 10% less than that of the above-mentioned universal cutters. Attention: do not confuse micro-cutters and universal cutters - both of them can only be recognized using a microscope.

A cutter has been specially designed for HF-technology. It produces a rectangular cross section.



Milling channel of LPKF universal, micro- and HF-cutters

.

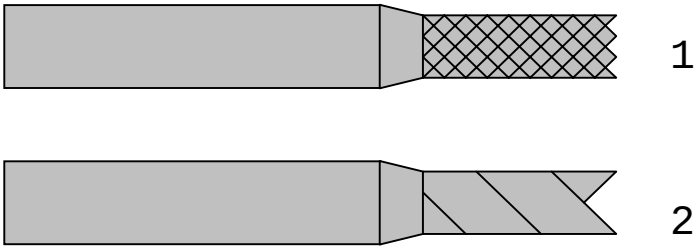
For further notes see chapter "Practical tips".

For the advantages and disadvantages of various materials, see the section entitled "Base material".

After machining, the PCB has to be cleaned. This can be carried out either in a brush machine or alternatively manually with board cleaners (LPKF accessories). In either case, the PCB must be rinsed thoroughly with water to remove any copper dust produced by brushing.

After rinsing, the PCB must be dried thoroughly (air drier) and then protected against oxidation by a solder varnish.

7.6 Contour milling in PCB material



Contour cutter (top) and two-edged cutter (bottom)

The speed of movement has to be lowered for contour milling. This may differ from material to material. Only use special contour milling cutters (32 mm or 1.5 inch long): if possible 1 or 2 mm.

The 1 mm contour milling cutter should only be used for internal holes (smaller internal radius). It breaks relatively easily so set the feed speed to minimum (2mm/sec. or 0.1 inch/sec).

The 2 mm contour milling cutter is substantially more robust, but does not remove as much material as the 3 mm milling cutter. Many LPKF software postprocessors are calculated for the 2 mm milling cutter (e.g. CUTTING).

With contour milling using a 3 mm milling cutter, a large quantity of material is removed. Moreover, the high-speed spindle can be overloaded if the speed of movement is too fast.

Caution! All speed ranges and feed rates given in BoardMaster refer to FR4 material. When other material is used, it is advised to work with reduced feed rates at first.

Attention! Take into consideration that cancerogenous dusts (due to glass fibers) might be produced when FR4 material is machined. Therefore always work with the dust exhaustor switched on. Always use the superfine filter.

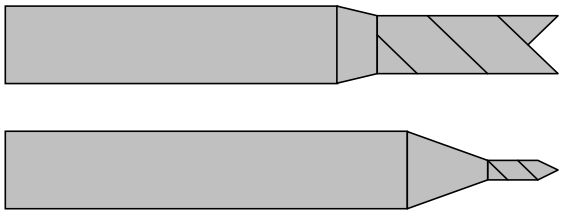
Attention! When machining some materials (e.g. teflon) hazardous gases might be produced!

7.7 Milling wide isolation channels

Wide isolation channels can be made with a 30 mm long contour milling cutter. Various diameters are available.

The milling depth must be set such that when the copper is removed, only minimal burring results. The 3 mm contour milling cutter is particularly well suited for milling very wide isolation channels (VDE regulations).

7.8 Front plate engraving



For engraving, set the speed of movement as appropriate for the engraving depth and the material. Use an LPKF universal milling cutter or LPKF double chamfered cutter.

Attention! Use extractor when engraving, too!

Aluminum front panels can be milled through with the LPKF ProtoMat 93s circuit board plotter.

7.9 Milling layout films

Secure the film base (sheet of perspex or glass) on the machine table with masking tape.

Lay the film material on the base with the coated (matte) side facing upwards.

Now smooth the film material firmly and level on the film support until the air has been completely expelled.

Now stick down the film on all four sides with transparent adhesive tape (which must not stretch) to form an air seal. There must not be any air bubbles between the film and the base. The milling depth can now be set at the film edge. It can be checked by milling a frame around the film area (manual movement).

The speed of movement should be reduced to about 15 mm/sec.

Switch on extractor, but only to half power, by extracting "secondary air" on the suction nozzle or, if there is one, reducing the power on the electronic extractor control. The film milling program can now be started.

Film material comes in DIN A3 and A4 formats (special sizes available upon request).

Important: the film coating is easily scratched and is water soluble, so do not let it come into contact with water. The film can be recopied with a coloring device upon request. For further notes see chapter entitled "Practical tips".

7.9.1 Correction agents

Gravure films can be corrected with Duroscal Korrekturschicht rot, which is easy to use. Paint in the problem areas with it, leave to dry for about 5 minutes and then further process the gravure film in the normal way.

The corrected areas can only have their coating removed with a quick acting coating remover.

Attention! Follow the safety instructions on the correction agent container!

7.9.2 Coloring milled films

For milled negative films, there is Duroscal Einfärber schwarz, with which positives can be made. The fully milled gravure film is colored with Duroscal Einfärber by pouring the liquid onto a SAFIR pad and spreading it evenly over the whole film. Excess color must be wiped off with cellulose wadding. The stained film must be held against the light to check it and to find poorly covered areas so that they can be re-colored. Then immediately remove the coating. The color must not dry.

Attention! Follow the instructions on the color container! Important: the liquid must not get onto the back of the film as it cannot then be removed from it. The color is also difficult to remove from other surfaces (fabrics, skin) (wear apron and rubber gloves)!

7.9.3 Coating removal

Follow the safety instructions on the quick-acting coating remover container!

When removing coatings, only treat one film per container to prevent any damage of the second film by contact between the back of it and a surface wet with color.

There are two options when it comes to coating removal:

1. Quick coating removal. Pour the quick-acting coating remover onto the film and immediately wipe the dissolved protective coating with cellulose applying slight pressure. Then dry the film with cellulose wadding, blotting paper or a cloth.
2. Removal with water. For this method, the film must be placed in a bowl of hand-hot water (to which a small amount of washing-up liquid has been added). The protective layer dissolves after about 30 minutes. Any coating remains must be removed with a fine hand brush. This method is cheaper and more environmentally friendly. The film can be left in the water bath as long as you want.

7.10 Basis material

Technically, it is possible to process all base materials.

However, the most basic phenol resin qualities (FR 2) can adversely affect milling quality.

Glass fiber reinforced epoxy material (FR 4 or G 10) can be a health hazard due to the milling dust produced (allergies, risk of cancer). Tool service life is also substantially reduced.

Attention ! Never work without extractor!

We recommend epoxy material without glass fiber (FR 3). With top milling quality and a high tool service life, no disadvantages with regard to FR 4 are known other than a slightly reduced mechanical strength (breakage). This drawback should not be of any significant importance for prototype boards unless particularly heavy components are to be mounted. The adhesive quality of the copper on the base material is slightly reduced which might lead to the removal of smaller pads.

Normally, a total thickness of 1.5 mm and a Cu thickness of 35 µm are used. With 17 µm material even fine milling channels can be engraved at a higher density. For galvanically through-hole-plated, double-sided PCBs, 5 - 17 µm Cu thickness is used to prevent an excessively thick copper layer after galvanic copper application.

With 70 µm material, compromises must be made when setting milling depth. I.e. a deeper milling depth results in wider milling channels of 0.5 to 0.7 mm.

Special base materials with a thicker copper layer of up to 300 µm can no longer be machined with the LPKF universal milling cutter. Contour milling cutters or special tools are needed for this. In these cases, we would ask that you consult us and send sample material so that tests can be carried out if appropriate.

Teflon materials can be machined, but the following points must be borne in mind:

1. As the material is very soft and therefore often extremely uneven, a constant milling width often cannot be maintained unless the material is smoothed first.
2. Because the material is so soft, it is not possible to mill such as isolation tracks as in epoxy material.

Attention! Machining Teflon might produce hazardous gases ! Protect Teflon from overheating!

The following material has proved particularly successful as material for HF and microwave applications: RT/Duroid types 5870, 0310 diel and 001 10 oz electro-deposited copper 2 sides.

A drilling base is indispensable for all machining processes on PCB material. With it, PCBs cannot be drilled through without damaging the machine. The drilling base can be made simply of cardboard and should be 2 mm thick.

7.11 Cleaning the PCB

Before components are mounted, the finished PCB must be thoroughly cleaned. This can be carried out manually or in PCB brushing machines.

If cleaning by hand, the PCB is placed on a flat support. The board is brushed in the direction of the conductor paths with wet board cleaner (e.g. LPKF board cleaner PAD). The purpose of the brushing is on the one hand to remove the layer of oxidation and on the other to remove swarf in the isolation channels. After brushing, the PCB must be free of any metal particles. From now on, the board should only be held by its edges and with gloves. The board should now be rinsed under running water and then dried with an air drier. Important: never use compressed air as the oil particles it contains can cause problems later on. After drying, both sides of the board are coated with solderable lacquer.

7.12 Practical tips

- Set the milling depth such that *engraving is too deep* rather than too shallow. Insufficient depth when engraving promotes milling tool wear.
- There can be a number of causes of *uneven milling width (depth)*. It is important that the *machine bed is clean.* Residues of adhesive tape or such like can adversely affect milling depth quite considerably. Also, milling swarf between the machine bed, drilling support and PCB can reduce precision. Greatly *distorted materials* bend such that the sag shows underneath; in this case, secure the edges well with adhesive tape. Another important point for precise milling depth is the *removal* of milling and drilling chips.
- Hooks can occur between the milling channels if the incorrect milling direction was specified , in particular with circles. If a circle is to be milled with a tool which rotates clockwise, *fine hooks* can arise between the copper areas if the milling tracks should overlap. The reason for this is that the cutting speed on the outer edges is reduced.

  The solution lies in selecting the right milling direction. When isolating conductor paths with LPKF isolate, the solder side should be mirrored before isolating as the isolation algorithm itself works in a clockwise direction. The standard postprocessing is already designed for this. CircuitCAM allows the user to select the direction of the milling tool and therefor mirroring prior to isolation is not necessary.
- *Milling burrs* can be caused by blunt tools or incorrect speeds of movement. If possible with the structure to be milled, deeper settings can be the answer. Otherwise, change the tool.
- *Burrs* when contour milling or *cut edges which are not clean* occur either due to a blunt tool or incorrect advance speed.
- With some materials, the *color of the milled channel* gives some indication of the state of the tool. With epoxy materials, dark isolation paths indicate a sharp tool, while lighter ones indicate a blunter tool.
- *Drilling burrs* occur either because the tool is blunt or the head lowering speed is excessive. In the first case, change the tool. In the second case, the tool height over the material must be reduced.

- *Drill deflection* occurs in particular with thin tools which are no longer absolutely sharp. However, this also depends on the surface structure of the material. If, for example the glass fiber structure of FR4 materials penetrates the copper, drill deflection cannot be avoided even with a sharp tool.

  For materials with additional, removable copper film (FR4 material with 18 µm or 9 µm

  Cu coating), drill deflection is very slight.

- *Vitrification of the drilled hole* occurs where the drill stays in the hole too long once the hole has been made. These holes then cause problems at feedthrough stage. Reduce drilling times as appropriate.

- *Drills break* where the drilling base has already been used a number of times. The drilling base should be changed for every new PCB. It is not really possible to prevent breakage if a drill comes into contact with the edge of an existing hole in the base. Broken tools must be removed from the PCB and the drilling base. Drills can also break if the tool is too high above the material.

- In film milling, milled channels are uneven if there is still air under the film. If the *film* is secured with *elastic adhesive tape*, waves may form in the film after a while. It is particularly important here that the milling base should be level (LPKF film engraving base).

- *Burrs* are produced when milling films either because the tool is blunt or milling was too deep.

- *Misalignment* of the solder and component sides occurs where the HOME position is not accurately programmed.

8 Appendix

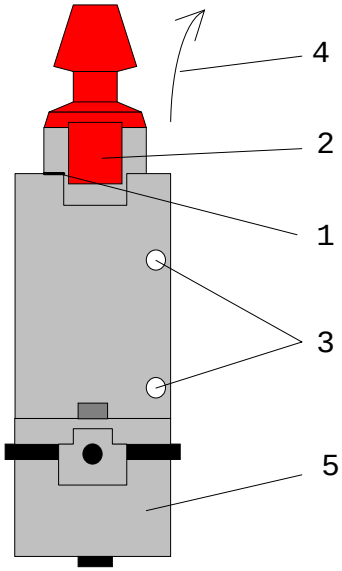
8.1 Maintenance

Keep spindles clean. In rooms with a high air humidity, wipe down with a lightly oiled cloth from time to time. Keep transport spindles oiled and clean.

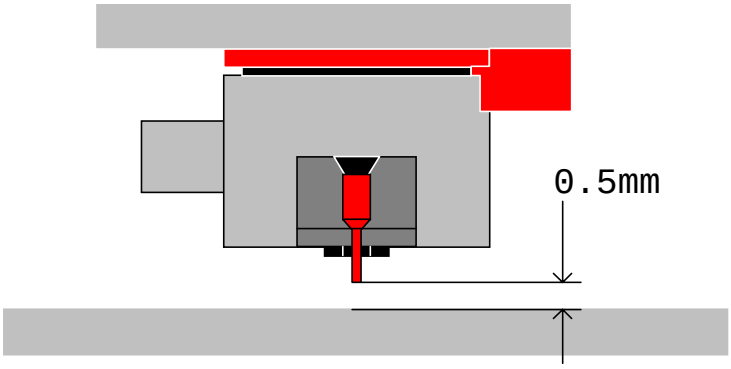
Important! Do not oil bearings!

Strip and clean working depth limiters at regular intervals. To do this, first switch the device off, then proceed as follows:

1. Mark the insertion depth of the spindle (1).
2. Remove connector from the spindle (2).
3. Release Allen screw with which the high-speed spindle is clamped to the holding block (3).
4. Spindle can now be pulled out towards the top (4). If necessary, turn it slightly to the left or to the right.
5. The working depth limiter (5) can now be removed toward the side for cleaning .
6. Clean both parts of the working depth limiter using the brush provided.
7. *Attention! Only lightly lubricate the thread of the working depth limiter with graphite or Teflon!*
8. After cleaning the *working depth limiter* is refitted following the procedure in reverse. The spindle is inserted into the holding block. Observe the insertion mark*!*



9. Check the correct insertion depth of the spindle before setting it into operation. The distance between the drill tip and the machine plate must be 0.5 mm when the head is in its lower position.
10. *Caution! The machine plate can be damaged during drilling when this distance is too small.* At an insufficient distance the device can no longer drill through the workpiece.
11. At last tighten the screws again (3) and put the connector again on the spindle.



Check the distance when mounting the high-speed spindle

8.2 Serial port SERIAL 1

The serial data channel SERIAL 1 is an RS 232-C standard interface with photo diode decoupling and is used for communication between the control unit and a PC. The DCD signal input on the control means that the control unit can be STOPPED quickly when the signal level changes from low to high. In this way, it is possible to stop the machine directly from the PC by activating the DTR signal. The SERIAL 1 transmission speed is programmed with DIL switches 1 and 2.

Switch 1	Switch 2	Baud rate
OFF	OFF	4800 baud
ON	OFF	9600 baud
OFF	ON	19200 baud
ON	ON	-

SERIAL 1 settings:

Pin	Signal	Meaning
2	TXD	Transmit data
3	RXD	Receive data
4	RTS	Request to send
5	CTS	Clear to send
7	GND-I	Ground (isolated)
8	DCD	Data carrier detect
20	DTR	Data terminal ready

All signals are electrically decoupled; all contacts not mentioned are not used.

8.3 Serial port SERIAL 2

The serial data channel SERIAL 2 is an RS 232-C standard interface and can be used for communication between the control unit and another system. The transmission speed of SERIAL 2 is programmed with DIL switches 3 and 4.

Switch 3	Switch 4	Baud rate
OFF	OFF	4600 baud
ON	OFF	9600 baud
OFF	ON	19200 baud
ON	ON	-

SERIAL 2 settings:

PIN		Signal	Meaning
3	6	TXD	Transmit data
2	4	RXD	Receive data
7	5	RTS	Request to send
8	7	CTS	Clear to send
5	10	GND	Ground

All contacts not mentioned are not used.

8.4 Motor connection

The stepping motors are connected per axis via a 15-pole SUB-D plug. If the limit switch is actuated, any further axis movement in the direction of the limit switch is immediately blocked. The position of the sockets is described in the section entitled "LPKF ProtoMat 93s displays and connections". Another 5-pole cable is used to supply the high-speed spindle with power.

Important: never confuse the stepper motor and the mill/drill head cables!!!

8.5 Mill head connection

The mill/drill head is connected to the control unit with a 15-pole socket. The socket position is described in the section entitled "LPKF ProtoMat 93s displays and connections".

Important: never confuse the stepper motor and the mill/drill head cables!!!

8.6 EPROMs

The software for the control unit is in 2 EPROMs. If the EPROMs need to be replaced (updates), the LPKF ProtoMat 93s has to be partially dismantled, so follow the procedure described in the section entitled "Fuses" and change the EPROMs, ensuring that the EPROMs are correctly aligned and positioned.

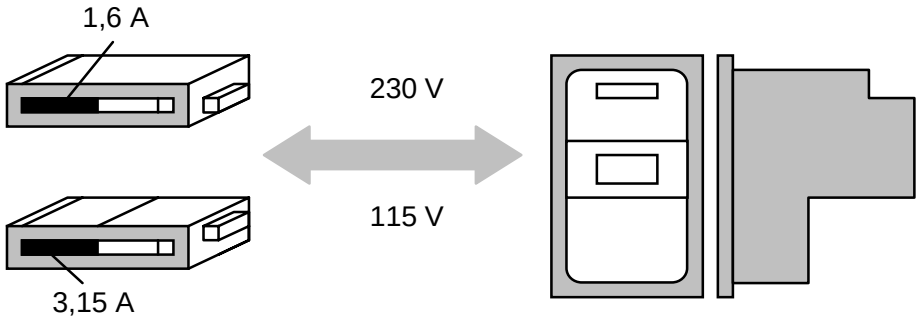
Use only an IC extractor to remove the EPROMs as otherwise the contacts of the mounting might be damaged. When inserting new EPROMs support the PCB from the bottom in order to avoid bending of the board. Take care that the orientation of the EPROMs is correct.

8.7 Fuses, commuting the device voltage

CAUTION! Before working on the fuses or opening the device, make sure that the power cord is removed!

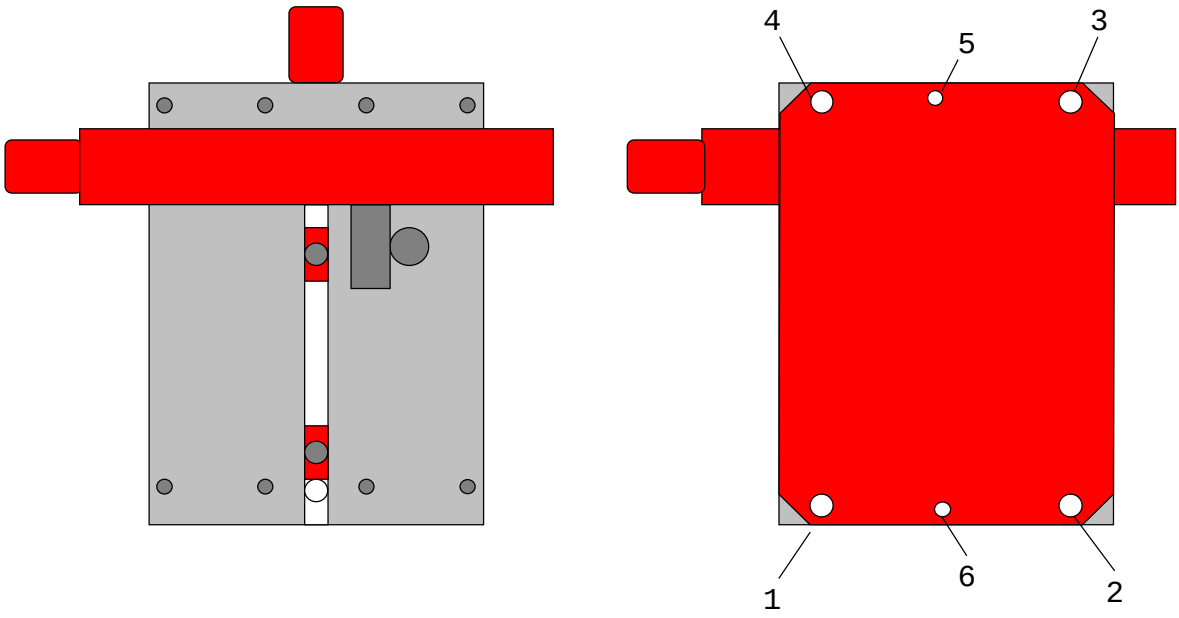
In the LPKF ProtoMat 93s, the primary and secondary voltages are fused. The main fuses (primary) are in the power connection of the control unit and are accessible from the outside.

Caution! When switching to another line voltage make sure that *both* fuses are exchanged. Both fuses must be of the *same* value.



Voltage setting and fuses

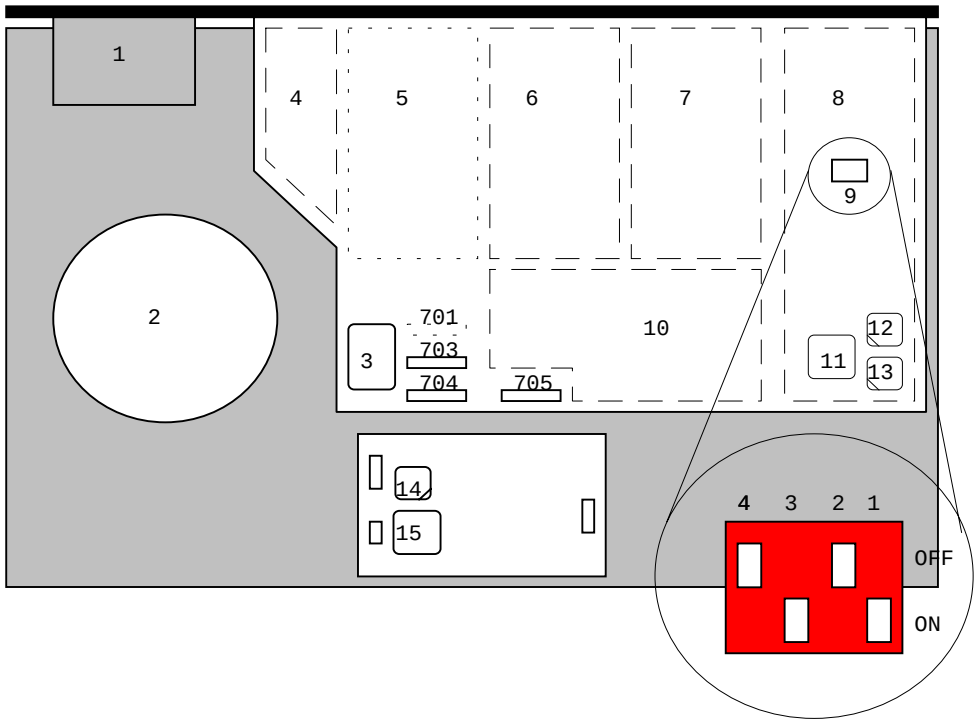
The secondary fuses are inside the control unit. The control unit must first be removed from the mechanical part to replace the fuses. To do this, loosen screws 1, 2, 3 and 4 and the M4 screws 5 and 6 at the bottom of the device and then remove the cable connections between the mechanical part and the control unit.



Position of screws for removing the electronics from the mechanical part of an LPKF ProtoMat 93s

CAUTION! Be sure the power cable is removed!

Remove the cover with the x limit switches. The control unit thus released is constructed as follows:



View of the PCB of the LPKF ProtoMat 93s PCB

1. Power filter
2. Transformer
3. Transformer connection
4. Power pack for mill/drill head
5. Power pack, Z axis (not used)
6. Power pack, Y axis
7. Power pack, X axis
8. Processor section
9. DIL switches for baud rate setting (with default setting)
10. Power packs
11. Processor
12. EPROM L
13. EPROM H
14. EPROM of the high-speed spindle
15. Processor of the high-speed spindles

701-705 Various fuses (see below)

The secondary current circuits are protected with fine-wire fuses as follows:

Fuse	Type	Power circuit
F701	3.15 A	Power high level
F703	3.15 A	+24 V at I/O-interface
F704	2.00 A	+5V and VREF
F705	0.50 A	RS 232 C/SER 1

The units are mounted in the opposite sequence to that described above for dismantling.

Important: never confuse the stepper motor and the mill/drill head cables!!!

Before switching on, always check that the head and motor cables are in the correct place.

The fuses in the primary current circuit are in the power switch, which also contains the mains filter and the power selector (e.g. 230 V/115 V). The fuses should be medium -time lag:

230V fused with 1.6A

115V fused with 3.15A

8.8 Inventory of available tools

Tools shaded gray cannot be used for the LPKF ProtoMat 93s.

Name	Diameter	Length		Delivery
	in mm	30 mm	32 mm	L = in stock
Universal milling cutter	0.2 - 0.4	*		L
micro milling cutter	0.1 - 0.2	*		L
HF cutter	0.25	*		L
Film milling cutter	0.3	*		L
Contour milling cutters	1.0	*	*	L
	1.5	*	*	L
	2.0	*	*	L
	2.5	*	*	L
	3.0	*	*	L
Double chamfered cutters	0.8	*		L
	1.0	*		L
	2.0	*		L
	3.0	*		L
Drills	0.5		*	L
	0.55		*	
	0.6		*	L
	0.65		*	
	0.7	*	*	L
	0.75	*	*	
	0.8	*	*	L
	0.85	*	*	L
	0.9	*	*	L
	0.95	*	*	
	1.0	*	*	L
	1.05	*	*	L
	1.1	*	*	L
	1.15	*	*	
	1.2	*	*	L
	1.25	*	*	L
	1.3	*	*	L
	1.35	*	*	
	1.4	*	*	L
	1.45	*	*	
	1.5	*	*	L
	1.55	*	*	
	1.6	*	*	L
	1.65	*	*	
	1.7	*	*	L
	1.75	*	*	
	1.8	*	*	L

	1.85	*	*	
	1.9	*	*	L
	1.95	*	*	
	2.0	*	*	L
	2.05	*	*	
	2.1	*	*	L
	2.15	*	*	
	2.2	*	*	L
	2.25	*	*	
	2.3	*	*	L
	2.35	*	*	
	2.4	*	*	L
	2.45	*	*	L
	2.5	*	*	L
	2.55	*	*	
	2.6	*	*	L
	2.65	*	*	
	2.7	*	*	L
	2.75	*	*	
	2.8	*	*	L
	2.85	*	*	
	2.9	*	*	L
	2.95	*	*	
	3.0	*	*	L
	3.05	*	*	

8.9 Spare parts for the LPKF ProtoMat 93s

Spare part	*Machine*	*Order number*
SMCU complete with casing for ProtoMat	93s	3039500008
SMCU board: SMCU941 for:	93s	3019500009
Spindle controller: HFAMP943	93s	3039500010
Transformer for ProtoMat	93s	3039500001
Mains filter		3009500001
Set of fuses for ProtoMat	93s	4009504002
Zero modem-cable		3009500002
Head cable	92s/93s	3039500011
Head cable high-speed spindle	93s	3039500012
Helix cable for high-speed spindle	93s	3039500013
Limit switch for x-axis		3009500003
Limit switch board		3009500004
High-speed spindle	93s	3039500022
Manual clamping collet for high-speed spindle	3mm	3039500014
Manual clamping collet for high-speed spindle	1/8 inch	3039500015
Step motor with transport spindle 92s/93s	x-axis	3039500016
Step motor with transport spindle 92s/93s	y-axis	3039500017
Spindle nut for transport spindle (helix)		3009500010
Working depth limiter	93s	3039500018
Linear bearing for z-axis		3009500005
Solenoid		3009500006
Return stroke spring for solenoid	93s	3039500018
Shock absorber for z-axis		3009500007
Two-pin alignment system	front	3009500008
Two-pin alignment system	back	3009500009
Pilot pins (M3x8)		3009500011
Extraction tube	92s/93s	3039500019
Protection hood for y-axis	92s/93s	3039500020
Cable chain	93s	3039500021

When ordering spare parts or making inquiries always state the number of the machine. This machine number is engraved at the bottom of the base plate.

8.10 Concluding remarks

As a rule the machine recommendations 93 / 44 of the European Community, dated June 14, 1993 applies to this manual. If an EC recommendation has not been taken into consideration in one of the chapters, these recommendations are hereby referred to and any claims concerning completeness and liability are excluded. Furthermore, we hereby point out to remaining risks unknown to the manufacturer which might occur due to inexpert handling of the machine. LPKF is not responsible for damage following the operation and handling of the LPKF ProtoMat 93s. This also applies to the case of these damage having been referred to.

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10 Declaration of conformity for LPKF ProtoMat 93s

1. Manufacturer of the machine designated LPKF ProtoMat 93s is company:

   LPKF
   CAD / CAM Systeme GmbH
   Osteriede 7
   D-30827 Garbsen
   Germany

2. The machine designated as LPKF ProtoMat 93s is a circuit board plotter, suitable for the production of circuit boards-prototypes and engraving films, as well as for the engraving of aluminum or plastics. The series number of the above-mentioned machine is 1C..... (see also bottom plate). Further details of the LPKF ProtoMat 93s can be seen in the enclosed manual.

3. The LPKF ProtoMat 93s corresponds to the provisions of the EC recommendation 93/44 dated June 14,1993 (see also Appendix I of the recommendation).

4. Existing DIN regulations have also been applied for the production of the LPKF ProtoMat 93s.

5. Authorized signatory is

   Mr. Bernd Hackmann

   Technical Manager LPKF

   Osteriede 7

   D-30827 Garbsen/Germany

Bernd Hackmann