

# Heidelberg Operation Manual

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The Heidelberg DWL66FS uses a laser exposure system with a 20mm write-head and a 2mm write-head. The time required for an exposure will vary from 1.5 hours to over 5 days, depending on the size of the design and the minimum feature size. Elementary operations may be done with design layers before conversion. Conversion and transfer times will also vary from 30 minutes to 10 hours. Multiple aligned exposures are also possible. Current billing rates are 55\$ per mask when written with the 20mm write-head, and not yet finalized for the 2mm write-head.

## Contents

<b>Design Conversion</b>	<b>1</b>
Conversion Parameters . . . . .	1
Conversion Options . . . . .	2
Final Steps . . . . .	3
<b>Design Transfer</b>	<b>3</b>
Automatic . . . . .	3
Manual . . . . .	3
<b>Exposure</b>	<b>3</b>
Exposure Map . . . . .	3
Make Job . . . . .	4
Run Job . . . . .	4
<b>Key Points to Remember</b>	<b>6</b>
<b>OS9 Reference</b>	<b>6</b>
cd . . . . .	6
mkdir . . . . .	6
rmdir . . . . .	6
dir . . . . .	6
<b>Linux Reference</b>	<b>6</b>
cd . . . . .	6
ls . . . . .	6
ftp . . . . .	6
pwd . . . . .	6
rm . . . . .	7
rmdir . . . . .	7
time . . . . .	7
<b>Mask Development and Etching</b>	<b>7</b>

run the conversion program. When the program loads it will appear as shown in figure 1.

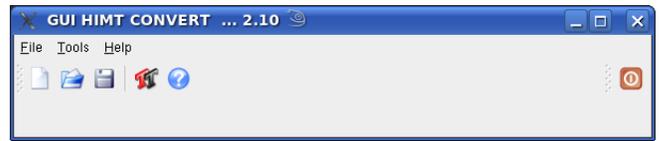


Figure 1. : Initial state of the conversion program.

## Conversion Parameters

Select the option to create a new job and give the job a name in the following format:  
**JobName\_WriteHead\_Day#\_month\_Year#.job**  
Do not use hyphens or spaces in the name. A new job should be made for each mask being written. Once a job name has been selected the program window will expand as shown in figure 2.



Figure 2. : New job window layout.

## Design Conversion

The first step in exposing a new mask is to convert the design from the native file format to the data files used by the Heidelberg system. The Heidelberg conversion program accepts the following design file formats: DXF, CIF, GDSII, Gerber, BMP, Ascii and STL. Please review the design requirements before submitting a design for conversion. The 20mm write-head may be used if the features are larger than 3µm or 5µm for critical features. This conversion process will take approximately half an hour. Conversion for a mask to be written with the 2mm write-head may take up to two hours. Double-click on the icon HIMT Convert from the desktop to

Click on the Add button in the Source File option group

and select the design file to be written. The window shown in figure 3 will be shown. By default, all the layers included in the file will be selected and will normally need to be unselected by clicking on the **Unselect All** button. Select the desired layer to write by checking the box next to the layer number as shown in figure 3. When the correct layer has been selected close the window by clicking the **Create Default** button.

The program will appear as shown in figure 4 when the design file has been loaded. The layer that has been selected may be previewed by selecting the **Preview** button in the **HIMT File** option group. If the wrong layer has been selected from the design file a new layer may be selected by clicking on the **Options** button in the **Source File** option group.

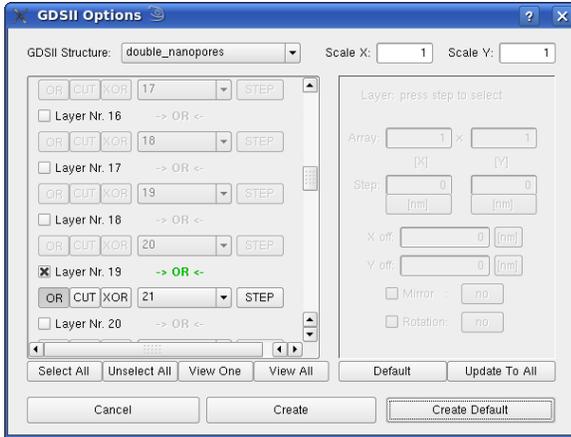


Figure 3. : Layer choice window.

### Conversion Options

Unless there are multiple layers to overlay or use as boolean operator selections, there are only a few options that need to be reviewed before the design may be converted. The most important option is the selection of the write-head that will be used. There are three options: 20mm, 2mm, and 2mmHQ. The 20mm write-head reliably exposes features down to 5 $\mu$ m. The 2mm write-head has two separate modes: normal and high quality. While both the normal and high quality modes should be able to achieve feature sizes of 600nm, the high quality mode is used to achieve smoother results on features placed at angles. Automatic centering should be selected when only one design will be written to the mask. This will ensure that the center of the design will be aligned to the center of the mask (or exposure field).

The other major options that need to be reviewed affect the way the design itself is written. If the design file was drawn from the perspective of looking at the mask with the chrome side down, the design will need to be mirrored. To do this, check the **Mirror** button in the **Place** group. Sometimes the design will need to be inverted to write the mask in the correct polarity. The polarity may be verified in the preview window. Click on the **Fill** button in the preview control window to toggle between filled and outline views. Wherever the design is black will be exposed to the laser. This means that where the design is black the mask will *NOT* have chrome. The option to invert the design in the converted files is found by clicking on the **Expose Options** button, then choosing **Inverted** option from the **Exposure Mode** drop-down menu. The exposure options are shown in figure 5.

There are a number of more advanced operations that may be done to a design. These operations include X and Y offsets and scaling, rotation, and cropping. Other operations may be done between layers, such as **CUT**, **OR**, and **XOR**. For such functions please see the Heidelberg Conversion Job Manager document.

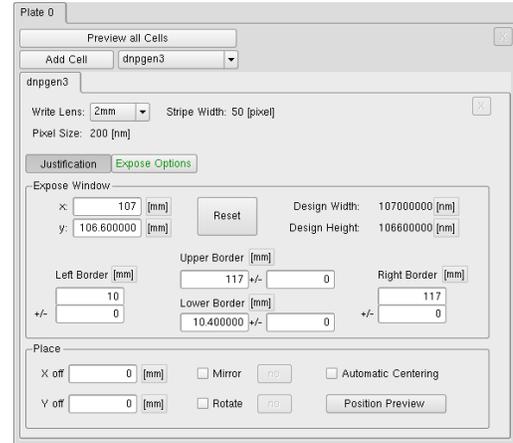


Figure 4. : Conversion window with design loaded.

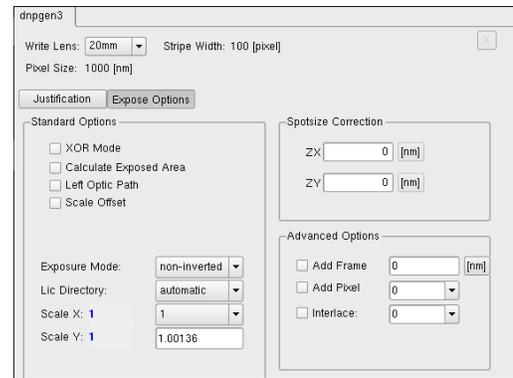
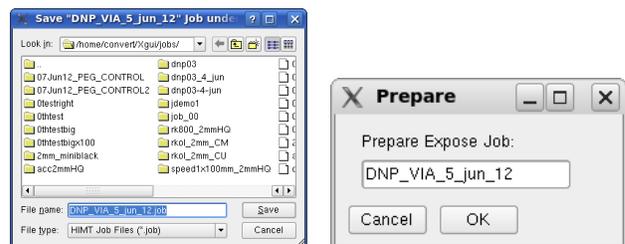


Figure 5. : Additional options for exposure.

When the design conversion options have been selected and verified in the preview window, click on the **Complete Tasks** button. The window shown in figure 6a will appear and the job should be saved with the name chosen when the new job was created. After saving the job the prompt shown in figure 6b will appear. Click on the **OK** button to continue.



(a) Prompt to save current (b) Confirmation dialog to prepare job data.

Figure 6. : Save and prepare job dialogs.

## Final Steps

The conversion process should start and the status window will appear as shown in figure 7. This process will take 2–3 minutes for a conversion for the 20mm write-head, or around 1.5 hours for the 2mm write-head conversion. Click on the **Finish** button to close the conversion window. If the conversion process encountered errors in the design then they will be shown in the main status window.

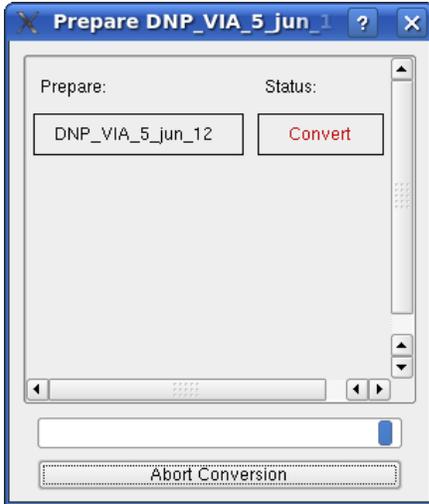


Figure 7. : Conversion status window.

In order to write the converted design to a mask the files will need to be transferred to the Heidelberg control computer. When the conversion process is finished the status indicator will show **Done!**. Click on the **Finish** button at the bottom of the dialog to bring up the FTP Transfer window shown in figure 8.

## Design Transfer

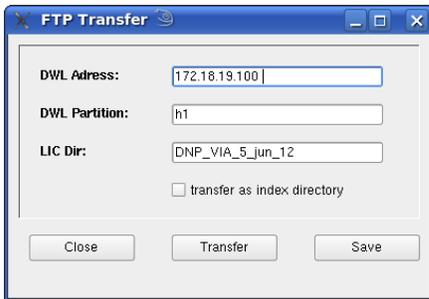


Figure 8. : FTP Transfer Window.

There are two ways to transfer the converted design files to the system control computer. Designs that are converted for use with the 20mm write-head should be simple enough to trust to the default FTP Transfer dialog shown in figure 8. Designs that are converted for the 2mm write-head may need to be transferred by a manual FTP session.

## Automatic

Verify that the FTP Transfer window has the parameters set as shown in table 1. When the **Transfer** button is clicked it will grey out and the program will not respond. For a standard 5 inch mask the transfer should be done in less than ten

minutes. Large or complicated designs may take up to ten hours.

DWL Address:	172.18.19.100
DWL Partition:	h1
LIC Dir:	JobName_WriteHead_Day#_month_Year#.job

Table 1  
: FTP transfer parameters

## Manual

Large designs will cause the transfer to fail when the default transfer method provided by the HIMT Convert program is used.

Run the following code on the (Linux) convert station from a terminal:

```

1 cd JobName_WriteHead_Day#_month_Year#
2 ftp dwl@172.18.19.100
3 cd /h1
4 mkdir JobName_WriteHead_Day#_month_Year#
5 cd JobName_WriteHead_Day#_month_Year#
6 prompt
7 ascii
8 mput c*
9 mput *.cfg
10 binary
11 mput *.lic

```

## Exposure

Once the design files have been transferred the exposure may be configured. When there is no current process the windows machine should appear as shown in figure 10. There is a red-bordered window (shown in figure 9) if the machine is currently exposing a design. The control program may be run by finding the HIMT Controller icon on the desktop.

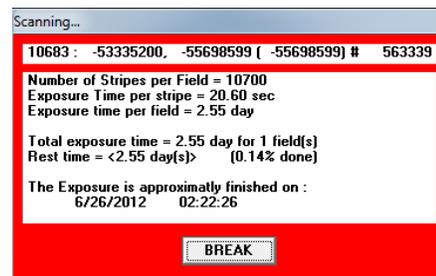


Figure 9. : Exposure window.

## Exposure Map

The exposure map is the way that the machine divides the substrate into a grid when multiple designs are to be exposed to the same mask. The number of fields, rows, columns, and number of fields in each row may be customized. The field size may also be set as well as the field that should be aligned with the zero coordinate of the substrate. The exposure map may be chosen from a list of saved maps or designed by choosing the corresponding option under the **Setup** menu item. Please see the Heidelberg User Manual for information on setting up and using Exposure Maps.

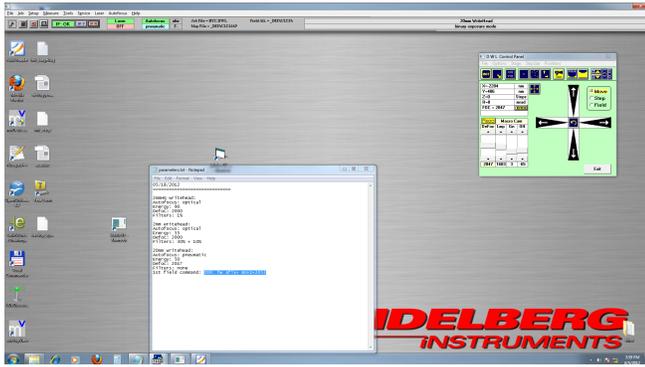


Figure 10. : Windows machine without exposure running.

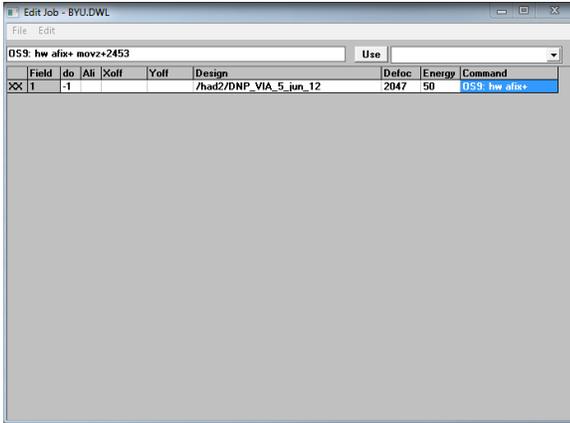


Figure 11. : Job parameter window. Each field may be set with different values, and multiple lines represent different fields in the exposure map.

### Make Job

After choosing or creating the exposure map go to the Job menu and select the Make Job item. The Edit Job (figure 11) and Map - `_default.job` windows will appear. Lines in the Edit Job window correspond to the boxes in the Map - `_default.job` window. Click on the fields in the Edit Job to edit the exposure parameters for the corresponding field shown in the exposure map. The images shown correspond to an exposure map with only one field.

If the path to the design files is known then it may be entered in the Design field of the Edit Job window. To show the list of designs on the control computer click on the File menu of the main program and then on the Designs option. The window shown in figure 12 will appear. If the design to be written does not show up in the list of designs then the list may need to be refreshed. Click the Refresh List button to retrieve a fresh list from the control computer. The design also may be in a different position in the list than anticipated because the list is sorted with numbers first, then capital letters, then lowercase letters. Click on the field in the Edit Job window and then click on the corresponding job name in the Designs window. Click the To Job button to copy the path of the design to the Edit Job window.

### Run Job

Once all the parameters have been set for the exposure open the Expose window (figure 13) by clicking on the Run Job option under the Job menu in the main program. The

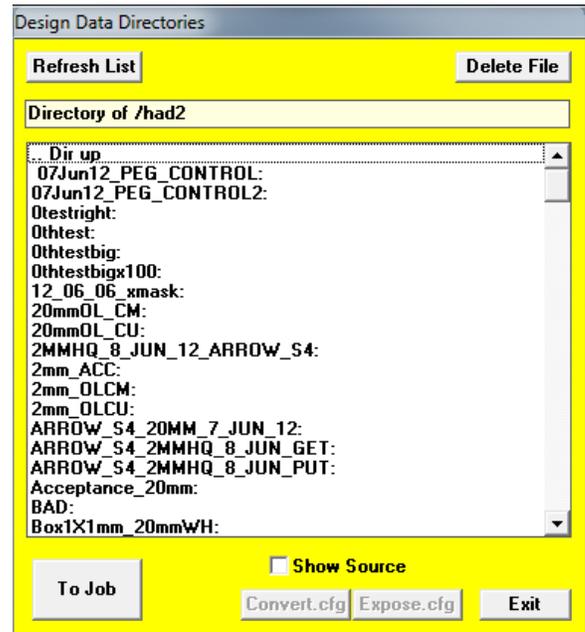


Figure 12. : List of designs on the control computer.

rest of the exposure can be run from this window. Clicking on the Load button will move the stage in the machine to a more accessible position. Load the mask, or substrate, and vacuum it down with the green knob at the front of the stage. Click on the dialog to move the stage back to the original position.

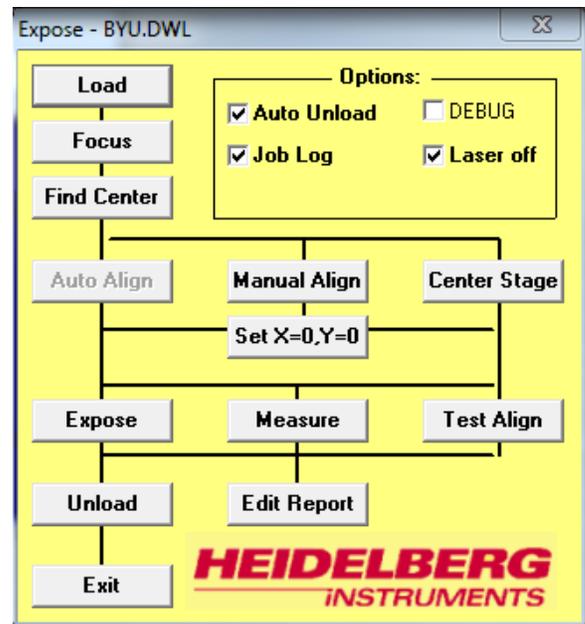


Figure 13. : Expose job dialog.

After the mask is loaded the optics may be focused. Make sure to set the autofocus to the proper setting: pneumatic for the 20mm write-head and optical for the 2mm write-head. Click on the Focus button to start the procedure. The window shown in figure 14 will be displayed. Caution must be taken that the write-head does not crash into the substrate! Do not let the Z value go lower than about -4700 for the 2mm write-head, or -5000 for the 20mm write-head. Click

the **Cancel** button if the Z value does not slow down when it approaches the approximate values given previously.

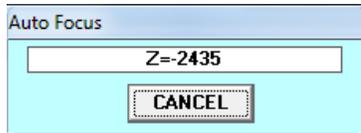


Figure 14. : Focus adjustment dialog.

After the optics have been focused the stage should be centered. This process is automated, and should take less than five minutes. Click on the **Find Center** button, then the **Start** button in the window shown in figure 15. Close the window after the process finishes.

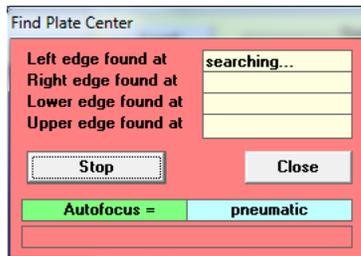


Figure 15. : Find plate center dialog.

Before starting the exposure please review the options in the **Expose** window. Make sure that the **Laser Off** box is checked. This option will automatically turn off the laser after the exposure is finished. The **Auto Unload** box will move the stage into the Load/Unload position after finishing the exposure.

## Appendix A Key Points to Remember

1. Use the same job name set in the beginning to set the FTP directory
2. Turn the laser off after the exposure
3. Take care to not let the write-head crash during focus
4. Use N<sub>2</sub> to blow dust off the mask before loading it
5. Turn off the vacuum with the green knob after removing the mask
6. *ALWAYS* wear gloves when reaching beyond the access window
7. Gloves, goggles, and a lab coat should be worn when mask is being developed and etched

Write-Head	Convert	Transfer	Setup	Expose
20mm	5 min	10 min	10 min	1.5 hr
2mm	30 min	4 hr	10 min	3 days
2mmHQ	2 hr	10 hr	10 min	5 days

Table A1

: Standard timetable for new mask jobs.

## Appendix B OS9 Reference

The computer that controls the operation of the write-head, object stage, and the laser controller is running an OS9 operating system. The only access to the system is through FTP and telnet. The FTP connection is used primarily in transferring files from the conversion station as described in Appendix C. The telnet connection may be accessed from the Windows machine through the TerraTerm program. The connection options that load when the program starts should connect to the OS9 computer by default.

The OS9 system seems to be case-insensitive. Directories and commands may be typed in either case without repercussions.

### *chd*

The *chd* command changes the directory. The *chd* command may be given a relative or absolute directory as an argument. The file structure on the OS9 system is a forest, rather than tree structure; each device is represented as a root. The designs are kept in the */had2* device. This is equivalent to the */h1* partition that is used in the FTP Transfer dialog shown in figure 8.

### *mkdir*

This command is similar to the command in Linux and DOS. The name directly following it is created as a folder.

### *rmdir*

This command is similar to the command in Linux and DOS. The name of the folder directly following it is removed if it exists.

### *dir*

This command is similar to the command in Linux and DOS, but has some glaring limitations that need to be handled frequently. The *-e* argument displays the contents of the current directory in a list format with attributes shown.

The command will throw a stack overflow error if there are more than about 1328 files in the directory. In order to remove this error the *#1024* argument may be passed to the command to increase the default size of the stack.

## Appendix C Linux Reference

The syntax for Linux commands is generally accepted in this manner: [COMMAND] [OPTIONS] [FILE/DIRECTORY]. Many commands have options that may be stacked, for example: *ls -al*.

### *cd*

*cd* is the command to change directories. Linux has a tree file structure, with all files, folders *and devices* being rooted at */*. The *cd* command may be given a relative or absolute directory as an argument. Example: If the current directory is */home/convert* the commands *cd /home/convert/myjob* and *cd myjob* are identical.

### *ls*

The *ls* command lists the contents of a directory. There are many options that may be used, but only 3 of the most common are included here.

<i>-a</i>	Lists all the files and folders, even the hidden ones.
<i>-l</i>	Displays folder contents in list format, one item per line with attributes.
<i>FILENAME.EXT</i>	Shows only the file <i>FILENAME.EXT</i> , if it exists in the current folder.

### *ftp*

The *ftp* command is the way designated by HIMT to transfer files from the Linux conversion station to the OS9 control computer. For the purposes of this system, the command is entered as *ftp -i dwl@172.18.19.100*. The FTP session will require a password and then will display a prompt. Switching directories is done with the *cd* command, and listing their contents is done with the *dir* command. When a manual transfer of files is necessitated, an FTP session should be started from the directory (on the Linux machine) that contains the files to transfer. Once the session has been started change the directory to */h1* and make a new directory by running *mkdir DESIGNNAME*. This name should be the same as the design name selected when the job was converted. Change directories to the one just created. The *pwd* command should confirm the current directory. Change the transfer mode by entering *ascii* and the start transferring the design configuration files by entering *mput c\**, and then *mput \*.cfg*. These files are small and should take less than a minute. The design files must be transferred in a different mode, so change the mode with the *binary* command. Start the transfer by entering *mput \*.lic*. This operation may take up to ten hours to complete. Once the operation finishes, type *exit* to end the session.

### *pwd*

Print working directory. Shows the absolute path of the current directory.

*rm*

Remove command. May only be used with files, not folders.

*rmdir*

Remove directory command. Only used on folders, not files.

*time*

Displays the time taken by a command to execute. Time is displayed in minutes. Syntax is `time COMMAND`. Frequently used with the `ftp` command (see `ftp`) to calculate total transfer time.

## Appendix D Mask Development and Etching

The times needed to properly develop the mask after exposure depends on the age of the developer, if the mask is clear or dark field, and the concentration of the developer. The approximate times are summarized in table D1.

Mask Type	Development	Etch
Clear Field	30 seconds	140 seconds
Dark Field	15 seconds	100 seconds

Table D1

: Approximate development and etch times for a standard five-inch mask. Development is for 4:1 H<sub>2</sub>O:AZ400K. Etch times are given for CEP 200 etchant at room temperature.