Printed circuit board manufacturing – clear and brief

In the workflow overview you will see the simple steps to develop a finished printed circuit board using LPKF technology; process steps for galvanic or chemistry-free through-hole plating are shown. On the declared pages you will find detailed information about the appropriate steps of the production process.

Detailed information starting at page 96.
Placing an order? Need technical support? No problem!

Indicia

Price lists
Any price list inserted or attached to this catalog is not a part of this catalog. All prices subject to change. Contact your nearest Distributor for the most current prices.

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Process steps
The color-coded steps are only necessary for the production of multilayer boards.

Galvanic through-hole plating

<table>
<thead>
<tr>
<th>Data preparation</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milling inner layers (2+3 and 4+5)</td>
<td>99 &amp; 104</td>
</tr>
<tr>
<td>Bonding multilayer</td>
<td>106</td>
</tr>
<tr>
<td>Marking and drilling</td>
<td>108</td>
</tr>
<tr>
<td>Galvanic through-hole plating</td>
<td>110</td>
</tr>
<tr>
<td>Milling external layers (bonded multilayer)</td>
<td>99</td>
</tr>
<tr>
<td>Cutting the printed circuit board</td>
<td>108</td>
</tr>
<tr>
<td>Solder resist masks, legend printing</td>
<td>112</td>
</tr>
<tr>
<td>Solder paste printing</td>
<td>113</td>
</tr>
<tr>
<td>Assembling</td>
<td>114</td>
</tr>
<tr>
<td>Reflow soldering</td>
<td>115</td>
</tr>
</tbody>
</table>

Through-hole plating without chemicals

<table>
<thead>
<tr>
<th>Data preparation</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milling external layers (each layer done before bonding)</td>
<td>99 &amp; 104</td>
</tr>
<tr>
<td>Milling inner layers (2+3)</td>
<td>99 &amp; 104</td>
</tr>
<tr>
<td>Bonding multilayer</td>
<td>106</td>
</tr>
<tr>
<td>Marking and drilling</td>
<td>108</td>
</tr>
<tr>
<td>Through-hole conductivity without chemicals</td>
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</tr>
</tbody>
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Why in-house prototyping?
In-house PCB prototyping is simply the only way to stay ahead of competition with the lightning pace of today’s technology. In-house prototyping lets engineering and research groups build a prototype, test it, modify the design, and construct a new prototype – in a fraction of the time required by an outside prototyping house. Depending on the complexity of the prototype, a single shift might see several development cycles.

Security is also a huge factor, and in-house prototyping keeps all design work in the engineering lab where it belongs. No external vendors, no couriers, no one outside the lab sees the data.

In addition to speed and security, probably the simplest benefit to in-house prototyping is the convenience. There’s nothing to compare with the convenience of having a production-quality board manufacturing house right there in the middle of the engineering department or research lab. LPKF products create single layer boards, multilayer boards, power boards, RF and microwave boards, boards on solid substrate, boards on flexible substrate, and even non-PCB products, such as stencil masks, polyimide films, plastics and metals, and a variety of other applications – all on the desktop.

Company
With over thirty years of experience helping customers meet or exceed their engineering needs, LPKF remains a world leader in the field of Rapid PCB Prototyping. More than 300 employees maintain a worldwide distribution and service network.
Contents

Circuit Board Plotters

Introduction to rapid PCB structuring and drilling .......... 6
LPKF Plotters
  LPKF ProtoMat S100
    High-performance for RF and microwave applications ...... 7
  LPKF ProtoMat S62
    Advanced PCB prototyping for most applications .......... 11
  LPKF ProtoMat S42
    Rapid PCB prototyping in an entry-level package ........... 15
  LPKF ProtoMat H100
    High-performance PCB prototyping for all applications.. 19
  LPKF ProtoMat X60
    Reliable PCB prototyping for large working areas ........ 23
Feature comparison ........................................................... 27
Application review and compatibility grid ..................... 28
Accessories and options .................................................... 31
Tools .................................................................................. 35
Consumables ..................................................................... 39
Software ............................................................................ 43

Laser Circuit Structuring

LPKF ProtoLaser S
  Direct laser structuring of circuit boards ....................... 46
Efficient for all types of PCB material .............................. 47
Live test passed ................................................................. 51

Through-Hole Conductivity/Plating

Introduction to through-hole plating ............................... 52
LPKF ProConduct®
  In-house PCB through-hole conductivity without chemicals.................................................. 53
LPKF Contac RS and MiniContac RS
  Professional stand-alone electroplating tanks ............... 57
LPKF EasyContac
  Manual through-hole conductivity for two-layer PCBs........ 61
Comparison of through-hole conductivity solutions ........ 63
Multilayer Prototyping

Introduction to multilayer PCB production ......................... 64
LPKF MultiPress S
Bench-top hydraulic press for multilayer PCBs .................. 65
Special notes for multilayer board production .................. 67

Surface Mount Technology/Finishing

Introduction to SMT prototyping ........................................ 68
LPKF ProMask and ProLegend
In-house screenprinting and solder-resist masks .......... 69
LPKF ZelPrint LT300 and ZelPrint LT300 RP
SMT solder paste printer ................................................... 73
LPKF ProtoPlace
Pick & Place assembly system ........................................... 77
LPKF ProtoFlow and ProtoFlow N2
Lead-free reflow oven ideal for in-house rapid PCB prototyping .......... 81
Review of rapid PCB prototyping for SMT circuitry .... 85

Technical Guide

Basic knowledge printed circuit boards ............................. 93
Basic data to the selection of the correct machine and procedure ........................................ 95
PCB structuring with LPKF ProtoLaser S ............................ 97
Differences in the production of multilayer ....................... 98
Data preparation with LPKF software
LPKF CircuitCAM ........................................................... 100
LPKF BoardMaster ....................................................... 102
Milling .............................................................................. 104
Bonding multilayer ......................................................... 106
Marking and drilling ...................................................... 108
Cut out the printed circuit board ..................................... 108
Through-hole conductivity without chemicals .................. 109
Galvanic through-hole plating ........................................ 110
Solder-resist masks, legend printing ................................ 112
Solder paste printing ...................................................... 113
Assembling ....................................................................... 114
Lead-free and lead containing reflow soldering .......... 115
Applications ................................................................... 116

Other LPKF technical solutions ............................ 88
Cross Reference List ..................................................... 119
Glossary ........................................................................ 120
Catalog index ............................................................... 124
LPKF distributors worldwide ........................................ 126
Indicia ............................................................................ 127
LPKF circuit board plotters
for in-house manufacturing of prototype and small-batch printed circuit boards

Each LPKF circuit board plotter includes a comprehensive software package for importing data from any PCB CAD package and for controlling the plotter.
To me, using the LPKF circuit board plotter is the most useful, time-saving and flexible way to produce my prototypes and individual boards fast and with high precision. Together with a through-hole plating system this is really a most profitable investment.

Herbert Oppenborn, Manager Electronic Development
Doepke Schaltträger GmbH & Co KG, Germany

Contents

Introduction to rapid PCB structuring and drilling ........................................... 6
LPKF ProtoMat S100 .................................. 7
  High-performance for RF and microwave applications
LPKF ProtoMat S62 ............................ 11
  Advanced PCB prototyping for most applications
LPKF ProtoMat S42 ............................ 15
  Rapid PCB prototyping in an entry-level package
LPKF ProtoMat H100 ............................ 19
  High-performance PCB prototyping for all applications
LPKF ProtoMat X60 ............................ 23
  Reliable PCB prototyping for large working areas
Feature comparison .................................. 27
Application review and compatibility grid ........................................... 28
Accessories and options ................................ 31
Tools .................................................. 35
Consumables ...................................... 39
Software ........................................... 43

Key Features

The LPKF tool changer automatically replaces milling and drilling tools during board production. This reduces setup time and allows unattended operation.

Increase the registration accuracy of most circuit board plotters by adding a fiducial recognition camera. The driver software integrates seamlessly with LPKF’s software suite and provides automatic recognition and alignment to existing fiducials in the circuit board.

The vacuum table option holds the work piece tightly against the work surface, eliminating any substrate irregularities such as twisting or warpage. The tabletop also prevents the board from slipping after it has been flipped for multi-sided milling or drilling.
Introduction to rapid PCB structuring and drilling

LPKF ProtoMat circuit board plotters feature unmatched precision, flexibility, and ease-of-use and play a key role in the rapid in-house production of printed circuit boards, from one-shot engineering projects to production level circuits. LPKF circuit board plotters reduce time-to-market for new designs by keeping fabrication work in-house – no more waiting days or even weeks for a complex prototype to come back from a fabrication house. With an LPKF circuit board plotter, a board can be produced, tested, improved, produced again, and tested several times in a single day. LPKF circuit board plotters are ideal for such applications as high power circuitry, analog circuitry, digital circuitry, RF and microwave circuitry. Warranted and backed by more than three decades of precision German engineering, LPKF ProtoMat circuit board plotters set the standard in printed circuit board milling, drilling, and routing equipment across the world.

Precision and Speed

All LPKF ProtoMat circuit board plotters feature high-speed spindle motors, ranging from 42,000 rpm to 100,000 rpm. The higher speeds mill and drill the precision geometries required by high frequency and microwave applications. LPKF circuit board plotters produce some of the highest quality and strongest repeatability in the industry, with system resolution as fine as 0.25 µm (0.01 mils). LPKF ProtoMat circuit board plotters are reliable high-speed performers for producing high quality printed circuit boards in-house.

Convenience and Security

LPKF ProtoMat circuit board plotters are universally simple to use. No alignment or calibration steps are necessary. Many LPKF ProtoMat models enjoy automatic tool change and other hands-off features, as well as acoustic cabinets and vacuum systems to reduce sound and environmental impact. ProtoMat circuit board plotters typically connect to a Windows® computer via a standard USB or RS-232 cable. Today's fierce market competition requires absolute security and nothing is more secure than keeping designs inside the prototyping lab. A ProtoMat can be unpacked, set up and fabricating a prototype in less time than a courier could deliver a design to a board house.

Multilayer Boards and Through-Hole Plating

LPKF ProtoMat circuit board plotters are especially well suited for multilayer rapid PCB prototyping. When combined with a multilayer press such as the MultiPress S and a through-hole conductivity solution such as ProConduct®, MiniContac RS or Contac RS, the ProtoMat circuit board plotters are the initial and key step in producing high quality multilayered printed circuit boards, especially during the critical development phase of any competitive, complex design.

Versatile Software

Every LPKF ProtoMat circuit board plotter ships with a comprehensive software suite, designed to increase productivity and throughput, while allowing for additional flexibility in design. CircuitCAM imports CAD and other image data from a variety of file formats and prepares it for transmission to the ProtoMat. Additionally, CircuitCAM offers unprecedented editing features for data – so modifications can be made closer to the production level. BoardMaster controls the ProtoMat and makes the full capabilities of LPKF’s most advanced hardware instantly available in an easy-to-learn WYSIWYG milling, drilling, and routing control application.

Other Applications

In addition to creating circuit boards in record time, the LPKF ProtoMat machines have proven their versatility time and time again with such varied applications as housing pockets, front panels, metal and plastics machining, depaneling pre-assembled circuit boards, cutting and engraving plastic foils, fabricating precision inspection templates, test adapters, and more.
LPKF ProtoMat S100
High-performance for RF and microwave applications

The ProtoMat S100 is one of LPKF’s top-of-the-line circuit board plotters, ideal for all in-house prototyping applications, including multilayer and RF applications. The ProtoMat S100 features the highest spindle speed possible – resulting in the precision circuit geometries today’s high-frequency and microwave applications demand – and a pneumatic working depth limiter, for the most surface-sensitive substrates. The ProtoMat S100 is an indispensable component of any development group where speed, precision, and simplicity are absolutely required.

Ideal for these applications
- Milling and drilling 1- and 2-sided circuit boards
- RF & microwave circuits
- Multilayer PCBs up to 8 layers
- Contour routing of circuit boards
- Flexible and rigid-flex circuit milling
- Front panels/sign engraving
- Machining cut-outs in front panels
- SMD stencil cutting
- Housing production
- Wave solder pallets
- Depanelization and rework
- Test adapter drilling
- Inspection templates

High travel speed
with max 150 mm/sec (6”/sec)
and resolution of 0.25 µm (0.01 mil).

- Ideal for RF and microwave circuitry on all substrates
- Superior milling speed, resolution, and accuracy
- Automatic tool change for unmatched ease-of-use and unattended operation
- Integrated acoustic cabinet for quiet operation
- Vacuum table and fiducial recognition available

www.lpkf.com See page 126 to locate an LPKF distributor near you.
The LPKF ProtoMat S100 circuit board plotter features:

**Automatic tool change**

Advanced features include a 10-position tool changer that automatically replaces milling and drilling tools while the board is being produced. This significantly reduces setup time, and allows for unattended operation.

**100,000 rpm spindle motor for precision**

The ProtoMat S100 delivers unmatched precision with system resolution as fine as 0.25 µm (0.01 mils). Each system is carefully calibrated at the factory for unsurpassed overall accuracy. As a result, the plotter mills and drills all types of PCBs with extremely fine traces, specializing in the precision trace geometries required by RF and microwave boards. Its milling head travel speed of 150 mm (6") per second and high-performance 100,000 rpm spindle motor make it a premiere high-speed performer.

**Non-contact working depth limiter for delicate substrates**

The ProtoMat S100 features a fully pneumatic working depth limiter. This allows the S100 to mill, drill, and depanel an entire circuit with nothing but the tools touching the work surface. The pneumatic working depth limiter is recommended for the delicate or surface-sensitive substrates found in many RF applications.

**2 1/2-dimensional operation with Z-axis drive**

With its unique motorized Z-axis drive, the ProtoMat S100 is ideal for machining instrument front panels and housings, as well as pockets in microwave boards. It can also mill around mounted PCB components, simplifying board rework and depanelization jobs.

**And many more, such as:**

**Convenience and easy handling**

The ProtoMat S100’s rich featureset and simple, automatic operation are quick and easy to master. Board production begins within minutes of switching on the machine. A standard USB or RS-232 cable connects the ProtoMat S100 to any Windows-compatible computer.

**Integrated head lighting**

Shadow-free illumination of the milling area from integrated head lighting makes direct quality control faster and easier.

**Acoustic cabinet**

An integrated acoustic cabinet reduces system sounds and acts as a protective cover. The circuit board plotter can safely operate in any work environment.

**CAM software included**

Each plotter comes with comprehensive LPKF CircuitCAM and BoardMaster software for importing PCB data from any CAD package and for controlling the operation of the circuit board plotter. This easy-to-use software, developed by LPKF, processes the same data that would be sent to a PCB manufacturer.

The ProtoMat S100 ships with a Multimedia Training CD!
Applications

The LPKF ProtoMat S100 is ideal for the following applications:

RF and microwave circuits
The ProtoMat S100 is ideal for reproducing the precision geometry required by RF and microwave prototyping. Custom-designed carbide tools create straight sidewalls and reduce penetration into the substrate by the tool.

High quality printed circuit boards
The ProtoMat S100 is also useful for producing high quality professional printed circuit boards from two- to six-layer prototypes.

Housings
In addition to flat circuit boards and signs, LPKF ProtoMat circuit board plotters are useful in a prototyping laboratory when routing out and machining three-dimensional objects, such as housings and pockets in such material as aluminum or plastic.

Additional application for the ProtoMat S100:

<table>
<thead>
<tr>
<th>Application Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milling and drilling 1- &amp; 2-sided circuit boards</td>
</tr>
<tr>
<td>RF and microwave circuits</td>
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<tr>
<td>Multilayer PCBs up to 8 layers</td>
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<td>Front panels/sign engraving</td>
</tr>
<tr>
<td>Machining cut-outs in front panels</td>
</tr>
<tr>
<td>SMD stencil cutting</td>
</tr>
<tr>
<td>Housing production</td>
</tr>
<tr>
<td>Wave solder pallets</td>
</tr>
<tr>
<td>Depanelization and rework</td>
</tr>
<tr>
<td>Test adapter drilling</td>
</tr>
<tr>
<td>Inspection templates</td>
</tr>
</tbody>
</table>

Application Notes

LPKF recommends the optional Fiducial Recognition Camera.

This application requires the optional vacuum table.

Options

Fiducial recognition camera
Use the fiducial recognition camera to align a board for double or multilayer production quickly and accurately. Requires USB 2.0.

Vacuum tabletop
The vacuum tabletop holds the work piece tightly against the work surface, eliminating any substrate irregularities such as twisting or warpage.
Accessories, software, tools and consumables

**Dust extraction**
- Keeps the work area free of debris of all sizes.

**Compressor**
- A clean source of compressed air.

**Measuring microscope**
- 60x magnification for proper alignment.

**StatusLight**
- Indicates the status of the machine.

**Brush head**
- Removes debris from the work area when working in 2 1/2-dimensional mode.

**Tools**

**Conical milling tools**
- Sturdy tooling for all purposes.

**Cylindrical milling tools**
- Ideal for RF structuring.

**Drilling/routing tools**
- Drilling and depaneling bits.

**Specifications table**

<table>
<thead>
<tr>
<th>Part #</th>
<th>LPKF ProtoMat S100</th>
</tr>
</thead>
<tbody>
<tr>
<td>Working area (X/Y/Z)</td>
<td>116664</td>
</tr>
<tr>
<td>Working area with vacuum table (X/Y/Z)</td>
<td>229 x 305 x 38 mm (9” x 12” x 1.5”)</td>
</tr>
<tr>
<td>Resolution (X/Y)</td>
<td>229 x 305 x 25 mm (9” x 12” x 1&quot;)</td>
</tr>
<tr>
<td>Repeatability</td>
<td>0.25 µm (0.01 mil)</td>
</tr>
<tr>
<td>Precision of front-to-back alignment</td>
<td>±0.001 mm (±0.04 mil)</td>
</tr>
<tr>
<td>Milling motor</td>
<td>±0.02 mm (±0.8 mil)</td>
</tr>
<tr>
<td>Tool change</td>
<td>Max. 100,000 rpm, software controlled</td>
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<tr>
<td>Tool collet</td>
<td>Automatic, 10 positions</td>
</tr>
<tr>
<td>Drilling speed</td>
<td>3.175 mm (1/8&quot;), pneumatic release collet</td>
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<tr>
<td>Travel speed (max)</td>
<td>150 strokes/min</td>
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<tr>
<td>X/Y positioning system</td>
<td>Max. 150 mm/sec (6&quot;/sec)</td>
</tr>
<tr>
<td>Z drive</td>
<td>3-phase stepper motors</td>
</tr>
<tr>
<td>Dimensions (W/H/D)</td>
<td>Stepper motor</td>
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<tr>
<td>Weight</td>
<td>670 x 540 x 760 mm (26.4” x 21.3” x 29.9”)</td>
</tr>
<tr>
<td>Power supply</td>
<td>55 kg (121 lbs)</td>
</tr>
<tr>
<td>Compressed air supply</td>
<td>115/230 V, 50–60 Hz, 274 W</td>
</tr>
<tr>
<td></td>
<td>6 bar (87 psi), 100 l/min (3.528 cfm)</td>
</tr>
</tbody>
</table>

Specifications subject to change.

Size of tracks and gaps depends on materials and tools. 100 µm tracks and gaps possible with LPKF MicroCutter on FR4 18/18 µm Cu. More information on materials page 93 and tools page 35.
LPKF ProtoMat S62
Advanced PCB prototyping for most applications

Ideal for these applications
- Milling and drilling 1- and 2-sided circuit boards
- Multilayer PCBs up to 8 layers
- Contour routing of circuit boards
- Front panels/sign engraving
- Machining cut-outs in front panels
- SMD stencil cutting
- Housing production
- Depanelization and rework
- Test adapter drilling
- Inspection templates

High travel speed
with max 150 mm/sec (6”/sec) and resolution of 0.25 µm (0.01 mil).

The ProtoMat S62 is a state-of-the-art circuit board plotter, ideal for most in-house prototyping applications where speed and security are essential, including multilayer and RF applications. The S62 features a high speed spindle motor, ideal for many applications requiring more precise circuit geometry, as well as a host of other features that make it an ideal addition to any development environment.

This compact high-speed circuit board plotter provides unequalled precision and performance for quickly and easily milling and drilling circuit board prototypes in a single day. Production delays and the high cost of outside vendors can be eliminated, reducing a product’s development time and time-to-market dramatically. Design data also remains securely in-house and under control.

- Excellent milling speed, resolution, and accuracy
- Automatic tool change for unmatched ease-of-use
- Integrated acoustic cabinet for quiet operation
- Vacuum table and fiducial recognition available

The ProtoMat S62 was voted Best of 2005 by the Readers of Electronic Design.

www.lpkf.com    See page 126 to locate an LPKF distributor near you.
The LPKF ProtoMat S62 circuit board plotter features:

**Automatic tool change**

Advanced features include a 10-position tool changer that automatically replaces milling and drilling tools while the board is being produced. This significantly reduces setup time, and allows for unattended operation.

**62,000 rpm spindle motor for precision and speed**

The ProtoMat S62 delivers unmatched precision with system resolution as fine as 0.25 µm (0.01 mils). Each system is carefully calibrated at the factory for unsurpassed overall accuracy. As a result, the circuit board plotter can mill and drill all types of PCBs with extremely fine traces, including most RF and microwave boards. Its milling head travel speed of 150 mm (6") per second and high-performance 62,000 rpm spindle motor makes it a premiere high-speed performer for producing quality PCBs in-house.

**2 1/2-dimensional operation with Z-axis drive**

With its unique motorized Z-axis drive, the ProtoMat S62 is ideal for machining instrument front panels and housings. It can also mill around mounted PCB components, simplifying board rework and depanelization jobs.

**Convenience and easy handling**

The ProtoMat S62’s rich featureset and simple, automatic operation are quick and easy to master. Board production begins within minutes of switching on the machine, and requires no external air compressors. A standard USB or RS-232 cable connects the ProtoMat S62 to any compatible Windows® computer.

**Acoustic cabinet**

An integrated acoustic cabinet reduces system sounds and acts as a protective cover. The circuit board plotter can safely operate in any work environment.

**Integrated head lighting for illumination of milling area**

Shadow-free illumination of the milling area from integrated head lighting makes direct quality control faster and easier.

**CAM software included**

Each circuit board plotter comes with comprehensive LPKF CircuitCAM and BoardMaster software for importing PCB data from any CAD package and for controlling the operation of the circuit board plotter. This easy-to-use software, developed by LPKF, processes the same data that would be sent to a PCB manufacturer.

**The ProtoMat S62 ships with a Multimedia Training CD!**
Applications

Although the LPKF ProtoMat S62 is an excellent tool for a wide variety of applications, it is particularly well-suited for:

**Multilayer circuit boards**
The ProtoMat S62 is a key component to any application requiring multilayer circuit boards. Fabricate multilayer prototypes using the S62 circuit board plotter with a through-hole conductivity system such as the MiniContac RS and a board press such as the MultiPress S.

**Front panels and sign production**
The S62 engraves and routes front panels and signs with extraordinary precision, on such varied surfaces as plastics, Plexiglas®, aluminum, brass, and more.

**Housings**
In addition to flat circuit boards and signs, the S62 is even more useful in a prototyping laboratory when used to rout out and machine dimensional objects, such as housings and pockets in material.

**Routing slots, cut outs and board profiles**
Even with complex shapes, the S62 easily routes out circuit board contours, or depanelizes populated boards from existing frames.

**Additional applications for the LPKF ProtoMat S62:**

- Milling and drilling 1- & 2-sided circuit boards
- RF and microwave circuits
- Multilayer PCBs up to 8 layers
- Contour routing of circuit boards
- Flexible and rigid-flex circuit milling
- Front panels/sign engraving
- Machining cut-outs in front panels
- SMD stencil cutting
- Housing production
- Wave solder pallets
- Depanelization and rework
- Test adapter drilling
- Inspection templates

**Application Notes**

- LPKF recommends the optional Fiducial Recognition Camera.
- This application requires the optional vacuum table.

**Options**

**Fiducial recognition camera**
Use the fiducial recognition camera to align a board for double or multilayer production quickly and accurately. Requires USB 2.0.

**Vacuum tabletop**
The vacuum tabletop holds the work piece tightly against the work surface, eliminating substrate irregularities.
Accessories, software, tools and consumables

**Accessories**

- **Dust extraction**
  Keeps the work area free of debris of all sizes.

- **Measuring microscope**
  60x magnification for proper alignment.

- **StatusLight**
  Indicates the status of the machine.

- **Brush head**
  Removes debris from the work area when working in 2 1/2-dimensional mode.

**Tools**

- **Conical milling tools**
  Sturdy tooling for all purposes.

- **Cylindrical milling tools**
  Ideal for RF structuring and big rubouts.

- **Drilling/routing tools**
  Drilling and depaneling bits.

**Software**

- **LPKF CircuitCAM PCB**
  A complete workstation for the ProtoMat S62.

- **LPKF BoardMaster**
  Versatile control software for all ProtoMat models.

**Consumables**

- **Starter Set**
  Contains high-quality tools and consumable material.

- **Multilayer Start-Set**
  Everything needed to start making multilayer boards.

- **Base materials**
  A collection of copper clad FR4 substrates.

**Specification table**

<table>
<thead>
<tr>
<th>LPKF ProtoMat S62</th>
<th>115788</th>
</tr>
</thead>
<tbody>
<tr>
<td>Part #</td>
<td></td>
</tr>
<tr>
<td>Working area (X/Y/Z)</td>
<td>229 x 305 x 38 mm (9” x 12” x 1.5”)</td>
</tr>
<tr>
<td>Working area with vacuum table (X/Y/Z)</td>
<td>229 x 305 x 25 mm (9” x 12” x 1”)</td>
</tr>
<tr>
<td>Resolution (X/Y)</td>
<td>0.25 µm (0.01 mil)</td>
</tr>
<tr>
<td>Repeatability</td>
<td>±0.001 mm (±0.04 mil)</td>
</tr>
<tr>
<td>Precision of front-to-back alignment</td>
<td>±0.02 mm (±0.8 mil)</td>
</tr>
<tr>
<td>Milling motor</td>
<td>Max. 62,000 rpm, software controlled</td>
</tr>
<tr>
<td>Tool change</td>
<td>Automatic, 10 positions</td>
</tr>
<tr>
<td>Tool collet</td>
<td>3.175 mm (1/8”)</td>
</tr>
<tr>
<td>Drilling speed</td>
<td>150 strokes/min</td>
</tr>
<tr>
<td>Travel speed (max)</td>
<td>Max. 150 mm/sec (6”/sec)</td>
</tr>
<tr>
<td>X/Y positioning system</td>
<td>3-phase stepper motors</td>
</tr>
<tr>
<td>Z drive</td>
<td>Stepper motor</td>
</tr>
<tr>
<td>Dimensions (W/H/D)</td>
<td>670 x 540 x 760 mm (26.4” x 21.3” x 29.9”)</td>
</tr>
<tr>
<td>Weight</td>
<td>55 kg (121 lbs)</td>
</tr>
<tr>
<td>Power supply</td>
<td>115/230 V, 50–60 Hz, 225 W</td>
</tr>
<tr>
<td>Compressed air supply</td>
<td>Not required</td>
</tr>
</tbody>
</table>

Specifications subject to change.

Size of tracks and gaps depends on materials and tools. 100 µm tracks and gaps possible with LPKF MicroCutter on FR4 18/18 µm Cu. More information on materials page 93 and tools page 35.
The LPKF ProtoMat S42 introduces a new entry-level circuit board plotter for in-house rapid PCB prototyping. This compact system provides precision and performance for quickly and easily milling and drilling circuit board prototypes in a single day. In-house PCB prototyping eliminates production delays and the high cost of outside vendors, reducing a product's development time and time-to-market dramatically. Design data also remains securely in-house and under control. The S42 in particular is a perfect entry-level tool for educational and other settings where economy is a critical issue.

- **Entry level system for precision prototypes**
- **Easy operation with quick-release tool change**
- **Vacuum table, fiducial recognition and acoustic cabinet available**

**Ideal for these applications**
- Milling and drilling 1- and 2-sided circuit boards
- Front panels/sign engraving
- SMD stencil cutting
The LPKF ProtoMat S42 circuit board plotter features:

42,000 rpm high-performance spindle motor

Each ProtoMat S42 is carefully calibrated at the factory for unsurpassed overall accuracy. As a result, the circuit board plotter can mill and drill all types of PCBs with fine traces, using reliable, well-tested technology. Its milling head travel speed of 50 mm (approx. 2”) per second and high-performance 42,000 rpm spindle motor makes it an excellent entry-level performer for producing quality PCBs in-house.

Integrated head lighting for illumination of milling area

Shadow-free illumination of the milling area from integrated head lighting makes direct quality control faster and easier.

And many more, such as:

Convenience and easy handling
The ProtoMat S42’s simple operation is quick and easy to master. Board production begins within minutes of switching on the machine, and it requires no external air compressors or other products. A standard USB or RS-232 cable connects the ProtoMat S42 to any compatible Windows® computer.

CAM software included
Each ProtoMat S42 includes LPKF CircuitCAM Lite and BoardMaster software for importing PCB data from any CAD package and for controlling the operation of the circuit board plotter. This easy-to-use software, developed by LPKF, processes the same data sent to PCB manufacturers.

Ideal for colleges and technical schools
LPKF ProtoMat S42 is an optimal system for educational facilities. The system is very compact and therefore fits easily in a lab setting without any modification work. Since it works entirely chemical-free, environmental regulations do not need to be considered, nor special safety measures for handling with chemicals is necessary.

For Mr. Dipl.-Ing.-Päd. Roald Blei of the Berufskolleg at Olsberg the LPKF ProtoMat S42 is the ideal system to collect practical experiences in parallel to theoretical contents: “The first big point is an attractive price. The acquisition of the ProtoMat S42 did not charge our budget extraordinary. The handling is extremely simply and easy to learn, so that the practical conversion and not the machine handling are the center of attention. The students can manufacture high-quality printed circuit boards on their own. In particular the system is extremely valuable in correspondence with the layout of printed circuit boards. Since the designed CAD data is converted very fast and economically into a printed circuit board, the beginning technicians have the opportunity to produce errors and in consequence independently recognize their faults. This is substantially more instructive and more memorable than a purely theoretical reprocessing. In summary I can say that the ProtoMat S42 opens us completely new perspectives to arrange project-oriented and professionally applicable training economical and lasting.”
Applications

Although the LPKF ProtoMat S42 is an excellent tool for a wide variety of applications, it is particularly well-suited for:

1- and 2-sided circuit boards on different materials
The most common use for the LPKF ProtoMat S42 is the production of high-quality professional printed circuit boards on FR4 in a prototyping environment. This system reproduces a prototype accurately from the original design data.

Additional applications for the LPKF ProtoMat S42:

<table>
<thead>
<tr>
<th>Application</th>
<th>Application Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milling and drilling 1- &amp; 2-sided circuit boards</td>
<td>✓</td>
</tr>
<tr>
<td>RF and microwave circuits</td>
<td>–</td>
</tr>
<tr>
<td>Multilayer PCBs up to 8 layers</td>
<td>✓</td>
</tr>
<tr>
<td>Contour routing of circuit boards</td>
<td>✓</td>
</tr>
<tr>
<td>Flexible and rigid-flex circuit milling</td>
<td>–</td>
</tr>
<tr>
<td>Front panels/sign engraving</td>
<td>✓</td>
</tr>
<tr>
<td>Machining cut-outs in front panels</td>
<td>–</td>
</tr>
<tr>
<td>SMD stencil cutting</td>
<td>✓</td>
</tr>
<tr>
<td>Housing production</td>
<td>–</td>
</tr>
<tr>
<td>Wave solder pallets</td>
<td>–</td>
</tr>
<tr>
<td>Depanelization and rework</td>
<td>–</td>
</tr>
<tr>
<td>Test adapter drilling</td>
<td>–</td>
</tr>
<tr>
<td>Inspection templates</td>
<td>–</td>
</tr>
</tbody>
</table>

Application Notes

- LPKF recommends the S62, S100, or H100 for RF/microwave applications.
- LPKF recommends the S100, S62 or H100 for multilayer boards.
- LPKF recommends the use of the S100, S62, H100 or X60.
- LPKF recommends the S100 or S62 with optional vacuum table, or the H100.
- LPKF recommends the S100 or S62 for routing aluminum front panels.
- LPKF recommends the S100 or S62 with optional vacuum table, or the H100.
- LPKF recommends the S100 or S62 for high clearances.
- LPKF recommends the stepper driven depth controlled S100 or S62.
- LPKF recommends the stepper driven depth controlled S100 or S62.
- LPKF recommends an S100 or H100 to avoid melting template plastic.

Options

Acoustic cabinet
LPKF acoustic cabinets reduce noise and dust emissions, perfect for CAD offices and electronics prototyping labs.

Fiducial recognition camera
Use the fiducial recognition camera to align a board for double or multilayer production quickly and accurately. Requires USB 2.0.

Vacuum tabletop
The vacuum tabletop holds the work piece tightly against the work surface, eliminating substrate irregularities.
Accessories, software, tools and consumables

**Accessories**
- Dust extraction (33)
  Keeps the work area free of debris of all sizes.
- Measuring microscope (33)
  60x magnification for proper alignment.

**Software** (included)
- LPKF CircuitCAM Lite (44)
  CAM workstation specially for the S42.
- LPKF BoardMaster (45)
  Versatile control software for all ProtoMat models.

**Tools**
- Conical milling tools (36)
  Sturdy tooling for all purposes.
- Cylindrical milling tools (36)
  Ideal for big rubouts.
- Drilling/routing tools (37)
  Drilling and depaneling bits.

**Consumables**
- Starter Set (40)
  Contains high-quality tools and consumable material.
- Multilayer Start-Set (41)
  Everything needed to start making multilayer boards.
- Base materials (42)
  A collection of copper clad FR4 substrates.

**Specification table**

<table>
<thead>
<tr>
<th>LPKF ProtoMat S42</th>
<th>117468</th>
</tr>
</thead>
<tbody>
<tr>
<td>Part #</td>
<td></td>
</tr>
<tr>
<td>Working area (X/Y/Z)</td>
<td>229 x 305 x 5 mm (9&quot; x 12&quot; x 0.2&quot;)</td>
</tr>
<tr>
<td>Resolution (X/Y)</td>
<td>1 µm (0.04 mil)</td>
</tr>
<tr>
<td>Repeatability</td>
<td>±0.005 mm (±0.2 mil)</td>
</tr>
<tr>
<td>Precision of front-to-back alignment</td>
<td>±0.02 mm (±0.8 mil)</td>
</tr>
<tr>
<td>Milling motor</td>
<td>Max. 42,000 rpm, software controlled</td>
</tr>
<tr>
<td>Tool change</td>
<td>Manual, quick-release</td>
</tr>
<tr>
<td>Tool collet</td>
<td>3.175 mm (1/8&quot;)</td>
</tr>
<tr>
<td>Drilling speed</td>
<td>90 strokes/min</td>
</tr>
<tr>
<td>Travel speed (max.)</td>
<td>Max. 50 mm/sec (1.97&quot;/sec)</td>
</tr>
<tr>
<td>X/Y positioning system</td>
<td>2-phase stepper motors</td>
</tr>
<tr>
<td>Z drive</td>
<td>Electromagnetic, 5 mm (0.2&quot;) stroke</td>
</tr>
<tr>
<td>Dimensions (W/H/D)</td>
<td>580 x 480 x 620 mm (22.8&quot; x 18.9&quot; x 24.4&quot;)</td>
</tr>
<tr>
<td>Weight</td>
<td>43 kg (95 lbs)</td>
</tr>
<tr>
<td>Power supply</td>
<td>115/230 V, 50–60 Hz, 200 W</td>
</tr>
<tr>
<td>Compressed air supply</td>
<td>Not required</td>
</tr>
</tbody>
</table>

Specifications subject to change.

Size of tracks and gaps depends on materials and tools. 100 µm tracks and gaps possible with LPKF MicroCutter on FR4 18/18 µm Cu. More information on materials page 93 and tools page 35.
LPKF ProtoMat H100
High-performance PCB prototyping for all applications

The ProtoMat H100 is LPKF’s top-of-the-line circuit board plotter, ideal for all in-house prototyping applications, including multilayer and RF applications. The fully automated ProtoMat H100 features the highest spindle speed possible – resulting in the precision circuit geometries today’s high-frequency and microwave applications demand – and a pneumatic working depth limiter, for surface-sensitive substrates.

The ProtoMat H100 is specially designed to handle larger working surfaces, 380 mm x 365 mm (15” x 14.4”). The ProtoMat H100 is an indispensable component of any development group where speed, precision, and simplicity are absolutely required.

Ideal for these applications

- Milling and drilling 1- and 2-sided circuit boards
- RF and microwave substrates
- Multilayer PCBs up to 8 layers
- Contour routing of circuit boards
- Flexible and rigid-flex circuit milling
- Front panels/sign engraving
- Machining cut-outs in front panels
- SMD stencil cutting
- Inspection templates

Ideal for large substrates.

- 380 mm (15”)
- 365 mm (14.4”)

Ideal for all applications

- Greatest speed, accuracy and resolution
- Automatic tool change
- Fully automated machine
- Integrated fiducial recognition camera
- Automated depth sensor
- Integrated vacuum table top
The LPKF ProtoMat H100 circuit board plotter features:

- **Automatic depth control sensing**
  The ProtoMat H100 automatically senses the work surface as it operates, precisely automating a task that normally requires careful manual operation.

- **Fully automatic tool change**
  Advanced features include a 30-position tool changer that automatically replaces milling and drilling tools while the board is being produced. This reduces setup time, and allows for unattended operation.

- **Fiducial recognition camera**
  The ProtoMat H100 includes a fiducial recognition camera, increasing accuracy and making it ideal for multilayer applications.

- **Vacuum tabletop**
  Holds the workpiece tightly against the work surface and eliminates substrate irregularities, such as twisting or warpage.

- **Non-contact working depth limiter**
  The ProtoMat H100 features a pneumatic working depth limiter. This allows the H100 to mill, drill, and depanel an entire circuit with nothing but the tools touching the work surface.

- **100,000 rpm spindle motor**
  The ProtoMat H100’s milling head travel speed of 150 mm (6”) per second and high-performance 100,000 rpm spindle motor makes it a premiere high-speed performer for producing quality printed circuit boards.

- **Workstation cabinet**
  The H100 includes an acoustic cabinet. This reduces system sounds and acts as a protective cover. The plotter operates safely in any work environment.

- **Integrated head lighting**
  Shadow-free illumination of the milling area from integrated head lighting makes direct quality control faster and easier.

- **Dust extraction**
  The LPKF dust extraction system, complete with a HEPA absolute filter, is especially well-suited for keeping the work area clean and free of debris of all sizes, from drill shavings to microscopic dust.

- **CAM software included**
  Each circuit board plotter comes with comprehensive LPKF CircuitCAM and BoardMaster software for importing PCB data from any CAD package and for controlling the operation of the circuit board plotter. This software, developed by LPKF, processes the same data that would be sent to a PCB manufacturer.

- **Fully equipped**
  No options necessary. The ProtoMat H100 is fully equipped. (The dust extraction unit can be placed behind the acoustic cabinet.)

And many more, such as:

- **Fully automatic tool change**
  Advanced features include a 30-position tool changer that automatically replaces milling and drilling tools while the board is being produced. This reduces setup time, and allows for unattended operation.

- **Non-contact working depth limiter**
  The ProtoMat H100 features a pneumatic working depth limiter. This allows the H100 to mill, drill, and depanel an entire circuit with nothing but the tools touching the work surface.

- **100,000 rpm spindle motor**
  The ProtoMat H100’s milling head travel speed of 150 mm (6”) per second and high-performance 100,000 rpm spindle motor makes it a premiere high-speed performer for producing quality printed circuit boards.

- **Workstation cabinet**
  The H100 includes an acoustic cabinet. This reduces system sounds and acts as a protective cover. The plotter operates safely in any work environment.

- **Integrated head lighting**
  Shadow-free illumination of the milling area from integrated head lighting makes direct quality control faster and easier.

- **Dust extraction**
  The LPKF dust extraction system, complete with a HEPA absolute filter, is especially well-suited for keeping the work area clean and free of debris of all sizes, from drill shavings to microscopic dust.

- **CAM software included**
  Each circuit board plotter comes with comprehensive LPKF CircuitCAM and BoardMaster software for importing PCB data from any CAD package and for controlling the operation of the circuit board plotter. This software, developed by LPKF, processes the same data that would be sent to a PCB manufacturer.
Applications

The LPKF ProtoMat H100 is ideal for the following applications:

RF and microwave circuits
RF and microwave prototyping requires a variety of special substrates, including PTFE based and ceramic filled (RO4000®) substrates, and extremely precise trace geometries. The H100 produces exactly this kind of precise cut, with unmatched accuracy.

Flexible and rigid-flex circuit boards
With its non-contact working depth limiter and integrated vacuum tabletop, the H100 easily processes a wide range of flexible circuit material. LPKF circuit board plotters consistently excel at producing rigid-flex circuit boards. In small batch production as well as prototyping, circuit board plotters with non-contact working depth limiters produce the best results in these technologically challenging situations.

Ultra-fine printed circuit boards
The most common application is the production of high quality professional printed circuit boards in a prototyping environment.

Additional applications for the ProtoMat H100:

<table>
<thead>
<tr>
<th>Application</th>
<th>Application Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milling and drilling 1- &amp; 2-sided circuit boards</td>
<td>✓</td>
</tr>
<tr>
<td>RF and microwave circuits</td>
<td>✓</td>
</tr>
<tr>
<td>Multilayer PCBs up to 8 layers</td>
<td>✓</td>
</tr>
<tr>
<td>Contour routing of circuit boards</td>
<td>✓</td>
</tr>
<tr>
<td>Flexible and rigid-flex circuit milling</td>
<td>✓</td>
</tr>
<tr>
<td>Front panels/sign engraving</td>
<td>✓</td>
</tr>
<tr>
<td>Machining cut-outs in front panels</td>
<td>✓</td>
</tr>
<tr>
<td>SMD stencil cutting</td>
<td>✓</td>
</tr>
<tr>
<td>Housing production</td>
<td>– LPKF recommends the S100 or S62 for high clearances.</td>
</tr>
<tr>
<td>Wave solder pallets</td>
<td>– LPKF recommends the stepper driven depth controlled S100 or S62.</td>
</tr>
<tr>
<td>Depanelization and rework</td>
<td>– For depaneling of populated boards, LPKF recommends the S100 or S62.</td>
</tr>
<tr>
<td>Test adapter drilling</td>
<td>✓</td>
</tr>
<tr>
<td>Inspection templates</td>
<td>✓</td>
</tr>
</tbody>
</table>

Options

No options necessary: Fully equipped!
For detailed information on options and accessories, please see page 31.
Accessories, software, tools and consumables

**Accessories**

More details on page

- **Compressor**
  A clean source of compressed air.

- **Measuring microscope**
  60x magnification for proper alignment.

- **StatusLight**
  Indicates the status of the machine.

**Software (included)**

More details on page

- **LPKF CircuitCAM PCB**
  A complete workstation for the ProtoMat H100.

- **LPKF BoardMaster**
  Versatile control software for all ProtoMat models.

**Tools**

More details on page

- **Conical milling tools**
  Sturdy tooling for all purposes

- **Cylindrical milling tools**
  Ideal for RF structuring.

- **Drilling/routing tools**
  Drilling and depaneling bits.

**Consumables**

More details on page

- **Starter Set**
  Contains high-quality tools and consumable material.

- **Multilayer Start-Set**
  Everything needed to start making multilayer boards.

- **Base materials**
  A collection of copper clad FR4 substrates.

**Specification table**

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>LPKF ProtoMat H100</strong></td>
<td><strong>111424</strong></td>
</tr>
<tr>
<td>Working area (X/Y/Z)</td>
<td>380 x 365 x 14 mm (15” x 14.4” x 0.55”)</td>
</tr>
<tr>
<td>Resolution (X/Y)</td>
<td>0.25 µm (0.01 mil)</td>
</tr>
<tr>
<td>Repeatability</td>
<td>±0.001 mm (±0.04 mil)</td>
</tr>
<tr>
<td>Precision of front-to-back alignment</td>
<td>±0.02 mm (±0.8 mil)</td>
</tr>
<tr>
<td>Milling motor</td>
<td>Max. 100,000 rpm, software controlled</td>
</tr>
<tr>
<td>Tool change</td>
<td>Automatic, 30 tools</td>
</tr>
<tr>
<td>Tool collet</td>
<td>3.175 mm (1/8”), pneumatic release collet</td>
</tr>
<tr>
<td>Drilling speed</td>
<td>120 strokes/min</td>
</tr>
<tr>
<td>Travel speed</td>
<td>Max. 150 mm/sec (6”/sec)</td>
</tr>
<tr>
<td>X/Y positioning system</td>
<td>3-phase stepper motors</td>
</tr>
<tr>
<td>Z drive</td>
<td>Pneumatic, 14 mm (0.55”)</td>
</tr>
<tr>
<td>Dimensions (W/H/D)</td>
<td>650 x 430 x 750 mm (25.6” x 17” x 29.5”)</td>
</tr>
<tr>
<td>Weight</td>
<td>50 kg (110 lbs)</td>
</tr>
<tr>
<td>Power supply</td>
<td>115/230 V, 50–60 Hz, 300 W</td>
</tr>
<tr>
<td>Compressed air supply</td>
<td>6 bar (87 psi), 100 l/min (3.528 cfm)</td>
</tr>
</tbody>
</table>

Specifications subject to change.

Size of tracks and gaps depends on materials and tools. 100 µm tracks and gaps possible with LPKF MicroCutter on FR4 18/18 µm Cu. More information on materials page 93 and tools page 35.
LPKF ProtoMat X60
Reliable PCB prototyping for large working areas

Ideal for these applications
- Milling and drilling 1- and 2-sided circuit boards
- Multilayer PCBs up to 8 layers
- Contour routing of circuit boards
- Front panels/sign engraving
- Machining cut-outs in front panels
- SMD stencil cutting
- Depanelization
- Inspection templates

The LPKF ProtoMat X60 combine rapid PCB prototyping with reliable, robust technology in a package designed for large-scale substrates and applications.

The LPKF ProtoMat X60 is a specially designed circuit board plotter, ideal for most in-house prototyping applications where speed and security are essential, including multilayer and RF applications. This circuit board plotter feature particularly large working areas, perfect for antennas, sensors, sign engraving, depaneling, and large circuit board substrates.

- Large working areas
- Fiducial recognition available
- Reliable, robust technology
The LPKF ProtoMat X60 circuit board plotter features:

The ProtoMat X60 offers an even larger work area of 650 x 530 mm (25.6” x 20.8”), ideal for large circuits, antennas, and depaneling operations, as well as engraving on plastics and soft metals. The engraving and routing of 19” front panels is easily done with the ProtoMat X60.

The ProtoMat X60 deliver excellent precision with system resolution as fine as 1 µm (0.04 mils) for the ProtoMat X60 and 7.5 µm (0.3 mil). This circuit board plotter can mill and drill all types of PCBs with fine traces, including RF and microwave boards. The high-performance 60,000 rpm spindle motors make this ProtoMat circuit board plotters premiere high-speed performers for producing large-scale, high-quality PCBs in-house.

And many more, such as:

**Convenience and easy handling**
The ProtoMat X60’s rich featureset and simple operation are quick and easy to master. Board production can begin within minutes of switching on the machine. A standard USB or RS-232 cable connects the circuit board plotters to any compatible Windows® computer.

**CAM software included**
Each circuit board plotter ships with comprehensive LPKF CircuitCAM and BoardMaster software for importing PCB data from any CAD package and for controlling the operation of the circuit board plotter. This easy-to-use software, developed by LPKF, processes the same data that would be sent to a PCB manufacturer.

**Non-contact working depth limiter**
The ProtoMat X60 features a pneumatic working depth limiter. This allows the X60 to mill, drill and depanel an entire circuit with nothing but the tools touching the work surface. The pneumatic working depth limiter is recommended for delicate and surface-sensitive substrates.

**Brush head**
The ProtoMat X60 is equipped with a brush head, used during rework procedures to help protect placed components, while maintaining a sufficient low-pressure region for the vacuum system to remove debris from the work area.
Applications

The LPKF ProtoMat X60 is ideal for the following applications:

Front panels and sign engraving
The ProtoMat X60 is the ideal tool for engraving and routing of 19” front panels and signs on various materials such as plastic, aluminum, brass and more.

Routing slots, cut-outs and board profile
Even with complex shapes, the X60 easily rout out circuit board contours. Slots, cut-outs, and other features are also simple to program and cut.

Depaneling
The ProtoMat X60 is a cost-effective addition to congested production lines pasticular for the depaneling of unpopulated boards.

Further applications for the LPKF ProtoMat X60 are:

<table>
<thead>
<tr>
<th>Application</th>
<th>Application Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milling and drilling 1- &amp; 2-sided circuit boards</td>
<td>✓</td>
</tr>
<tr>
<td>RF and microwave circuits</td>
<td>✓</td>
</tr>
<tr>
<td>Multilayer PCBs up to 8 layers</td>
<td>✓</td>
</tr>
<tr>
<td>Contour routing of circuit boards</td>
<td>✓</td>
</tr>
<tr>
<td>Flexible and rigid-flex circuit milling</td>
<td>✓</td>
</tr>
<tr>
<td>Front panels/sign engraving</td>
<td>✓</td>
</tr>
<tr>
<td>Machining cut-outs in front panels</td>
<td>✓</td>
</tr>
<tr>
<td>SMD stencil cutting</td>
<td>✓</td>
</tr>
<tr>
<td>Housing production</td>
<td>–</td>
</tr>
<tr>
<td>Wave solder pallets</td>
<td>–</td>
</tr>
<tr>
<td>Depanelization and rework</td>
<td>✓</td>
</tr>
<tr>
<td>Test adapter drilling</td>
<td>–</td>
</tr>
<tr>
<td>Inspection templates</td>
<td>✓</td>
</tr>
</tbody>
</table>

Application Notes

- LPKF recommends the S100 or H100 for RF/microwave work.
- Fiducial recognition camera recommended for this application.
- LPKF recommends the S100 or S62 with optional vacuum table, or the H100.
- LPKF recommends the S100 or S62 with optional vacuum table, or the H100.
- LPKF recommends the stepper driven depth controlled S100 or S62.
- Only for depaneling unpopulated PCBs.
- LPKF recommends the stepper driven depth controlled S100 or S62.

Options

Fiducial recognition camera
Use the fiducial recognition camera to align a board for double or multilayer production quickly and accurately. Requires USB 2.0.

More information on options on page 31.

www.lpkf.com    See page 126 to locate an LPKF distributor near you.
Accessories, software, tools and consumables

### Accessories

More details on page 34

**Compressor**
A clean source of compressed air.

**Dust extraction**
For keeping the work area clean and free of debris.

**Measuring microscope**
60x magnification for proper alignment.

### Software (included)

More details on page 44

**LPKF CircuitCAM PCB**
A complete workstation for the ProtoMat X60.

**LPKF BoardMaster**
Versatile control software for all ProtoMat models.

### Tools

More details on page 36

**Conical milling tools**
Sturdy tooling for all purposes

**Cylindrical milling tools**
Ideal for big rubouts.

**Drilling/routing tools**
Drilling and depaneling bits.

### Consumables

More details on page 40

**Starter Set**
Contains high-quality tools and consumable material.

**Multilayer Start-Set**
Everything needed to start making multilayer boards.

**Base materials**
A collection of copper clad FR4 substrates.

### Specification table

<table>
<thead>
<tr>
<th>Specification</th>
<th>LPKF ProtoMat X60</th>
</tr>
</thead>
<tbody>
<tr>
<td>Part #</td>
<td>109643</td>
</tr>
<tr>
<td>Working area (X/Y/Z)</td>
<td>650 x 530 x 14 mm (25.6” x 20.8” x 0.55”)</td>
</tr>
<tr>
<td>Resolution (X/Y)</td>
<td>1 µm (0.04 mil)</td>
</tr>
<tr>
<td>Repeatability</td>
<td>±0.001 mm (±0.04 mil)</td>
</tr>
<tr>
<td>Precision of front-to-back alignment</td>
<td>±0.02 mm (±0.8 mil)</td>
</tr>
<tr>
<td>Milling motor</td>
<td>Max. 60,000 rpm, software controlled</td>
</tr>
<tr>
<td>Tool change</td>
<td>Manual, quick-release</td>
</tr>
<tr>
<td>Tool collet</td>
<td>3.175 mm (1/8”)</td>
</tr>
<tr>
<td>Drilling speed</td>
<td>120 strokes/min</td>
</tr>
<tr>
<td>Travel speed (max.)</td>
<td>100 mm/sec (3.94”/sec)</td>
</tr>
<tr>
<td>X/Y positioning system</td>
<td>3-phase stepper motors</td>
</tr>
<tr>
<td>Z drive</td>
<td>Pneumatic, 14 mm (0.55”)</td>
</tr>
<tr>
<td>Machine table base</td>
<td>Precision milled aluminum bed</td>
</tr>
<tr>
<td>Dimensions (W/H/D)</td>
<td>750 x 420 x 900 mm (29.5” x 16.5” x 35.4”)</td>
</tr>
<tr>
<td>Weight</td>
<td>69 kg (152 lbs)</td>
</tr>
<tr>
<td>Power supply</td>
<td>115/230 V, 50–60 Hz, 300 W</td>
</tr>
<tr>
<td>Compressed air supply</td>
<td>6 bar (87 psi), 100 l/min (3.528 cfm)</td>
</tr>
</tbody>
</table>

Specifications subject to change.

Size of tracks and gaps depends on materials and tools. 100 µm tracks and gaps possible with LPKF MicroCutter on FR4 18/18 µm Cu. More information on materials page 93 and tools page 35.
Feature comparison of LPKF ProtoMat circuit board plotters

<table>
<thead>
<tr>
<th>Feature</th>
<th>LPKF ProtoMat</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>S100</td>
</tr>
<tr>
<td>Working area (X/Y)</td>
<td>Page 7</td>
</tr>
<tr>
<td>mm</td>
<td>229 x 305</td>
</tr>
<tr>
<td>inch</td>
<td>9” x 12”</td>
</tr>
<tr>
<td>Working area (Z)</td>
<td>38</td>
</tr>
<tr>
<td>mm</td>
<td>1.5</td>
</tr>
<tr>
<td>inch</td>
<td></td>
</tr>
<tr>
<td>Spindle speed (x1,000 rpm)</td>
<td>100</td>
</tr>
<tr>
<td>Head speed * (mm/sec)</td>
<td>150</td>
</tr>
<tr>
<td>Aluminum cutting</td>
<td>●</td>
</tr>
<tr>
<td>Front panel engraving</td>
<td>●</td>
</tr>
<tr>
<td>BoardMaster software version</td>
<td>CircuitCAM PCB</td>
</tr>
<tr>
<td>Tool count</td>
<td>10</td>
</tr>
<tr>
<td>Automatic tool change</td>
<td>●</td>
</tr>
<tr>
<td>Vacuum table option</td>
<td>+</td>
</tr>
<tr>
<td>Fiducial recognition option</td>
<td>+</td>
</tr>
<tr>
<td>Brush head option</td>
<td>+</td>
</tr>
<tr>
<td>Acoustic cabinet</td>
<td>●</td>
</tr>
<tr>
<td>Automatic depth control sensing</td>
<td>–</td>
</tr>
<tr>
<td>Working depth limiter</td>
<td>Pneumatic</td>
</tr>
<tr>
<td>Footprint (W/D)</td>
<td>650 x 800</td>
</tr>
<tr>
<td>mm</td>
<td>25.6” x 31.5”</td>
</tr>
<tr>
<td>inch</td>
<td></td>
</tr>
<tr>
<td>Weight</td>
<td>55 kg</td>
</tr>
<tr>
<td></td>
<td>121 lbs</td>
</tr>
</tbody>
</table>

* Head speed is the speed of the head travelling freely. Milling speed depends on the density of the working material and the spindle speed.

● standard
+ optional
– not available
Application review and compatibility grid

LPKF ProtoMat circuit board plotters enjoy a broad range of applications. They work with a variety of material – flexible, rigid, dense, soft, etc. In all applications, LPKF ProtoMat circuit board plotters perform flawlessly, creating production-quality work in a fraction of the usual time.

1. **Milling and drilling single- and double-sided circuit boards**
The most common application is the production of high quality professional printed circuit boards in a prototyping environment. LPKF ProtoMat circuit board plotters mill tracks and gaps as small as 100 µm (4 mil) and drill holes as small as 150 µm (6 mil). This reproduces a prototype accurately from the original design data, including the precise geometry needed for BGA, fine-pitch SMT, RF, and other applications.

2. **RF and microwave circuits**
RF and microwave prototyping requires a variety of special substrates, such as ceramic filled (RO4000®) substrates, and extremely precise trace geometries. LPKF ProtoMat printed circuit board plotters with high speed spindle motors produce exactly this kind of precise cut, with unmatched accuracy. Custom-designed carbide tools create straight sidewalls and reduce penetration into the substrate by the milling head.

### Multilayer PCBs up to 6 layers
LPKF circuit board plotters are key components to any application requiring multilayered circuit boards. Fabricate prototypes as complex as six layers using a combination of an LPKF ProtoMat circuit board plotter with a through-hole conductivity system such as the Contac RS and a board press such as the MultiPress S.

### Contour routing of circuit boards
LPKF ProtoMat printed circuit board plotters can rout any shape from a substrate – straight lines, curves, whatever. If the CAD software can describe it, a ProtoMat can cut it.

### Flexible and rigid-flex circuit milling
Process a wide range of flexible and rigid-flexible circuit material using LPKF ProtoMat models equipped with a patented non-contact air bearing foot, such as the S100 and the H100. These models produce the finest results for these technologically challenging substrate combinations.

<table>
<thead>
<tr>
<th>Application</th>
<th>S100</th>
<th>S62</th>
<th>S42</th>
<th>H100</th>
<th>X60</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milling and drilling single- and double-sided circuit boards</td>
<td>✔</td>
<td>✔</td>
<td></td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>RF and microwave circuits</td>
<td>✔</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Multilayer PCBs up to 6 layers</td>
<td>✔</td>
<td>✔</td>
<td></td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Contour routing of circuit boards</td>
<td>✔</td>
<td>✔</td>
<td></td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Flexible and rigid-flex circuit milling</td>
<td>✔</td>
<td>✔</td>
<td></td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Front panels/sign engraving</td>
<td>✔</td>
<td>✔</td>
<td></td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Machining cut outs in front panels</td>
<td>✔</td>
<td>✔</td>
<td></td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>SMD stencil cutting</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Housing production</td>
<td>✔</td>
<td>✔</td>
<td></td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Wave solder pallets</td>
<td>✔</td>
<td>✔</td>
<td></td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Depanelization and rework</td>
<td>✔</td>
<td>✔</td>
<td></td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Test adapter drilling</td>
<td>✔</td>
<td>✔</td>
<td></td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Inspection templates</td>
<td>✔</td>
<td>✔</td>
<td></td>
<td>✔</td>
<td>✔</td>
</tr>
</tbody>
</table>
Front panels/sign engraving
LPKF ProtoMat circuit board plotters engrave front panels and signs with extraordinary precision, on plastics, Plexiglas, aluminum, brass, and more.

Machining cut outs in front panels
LPKF ProtoMat circuit board plotters with fast spindle speed motors rout aluminum front panels quickly and easily.

SMD stencil cutting
In the mass production of SMT circuit boards, the use of polyimide solder masks is critical, driving the precision of solder application and protecting the board from environmental influences.

Housing production
In addition to flat circuit boards and signs, LPKF ProtoMat circuit board plotters are useful in a prototyping lab when routing out and machining three-dimensional objects, such as housings and pockets in material.

Wave solder pallets
Wave solder pallets hold PCBs steady during wave soldering. LPKF ProtoMat circuit board plotters with stepper motor Z-axis control are ideal for routing and milling support structures in thick, temperature-resistant plastics.

Depanelization and rework
An LPKF ProtoMat can be a valuable element in a fast-paced production environment, providing independent depaneling of populated and unpopulated circuit boards. ProtoMat circuit board plotters are also excellent for certain kinds of rework and circuit tuning.

Test adapter drilling
Bed-of-nails testing platforms require custom fabricated plastic adaptors, and high speed LPKF ProtoMat circuit board plotters with stepper motors controlling the Z-axis are perfect for this application.

Inspection templates
LPKF ProtoMat circuit board plotters are well suited for the precise machining of solder frames and inspection templates — two crucial elements of quality control in the mass production of printed circuit boards.

Application Notes

LPKF recommends the S100 or H100 when the primary application is RF/microwave.

LPKF recommends the increased accuracy and ease-of-use afforded by the optional fiducial recognition camera (the camera is standard with the H100).

Note that the LPKF MultiPress S, required for pressing 4+ layer boards, has a maximum layout area of 200 x 275 mm (7.8" x 10.8").

Working with flexible substrates requires a vacuum table, an option on the S62 and the S100. A vacuum table is a standard feature of the H100.

LPKF recommends the S100 or S62 for routing aluminum front panels.

LPKF recommends the S100 and S62 for the high clearances necessary for plastic and aluminum housings.

LPKF recommends the S100 or S62 with stepper controlled Z-axis and a high clearance.

LPKF recommends the S100 and S62 for rework because of the high clearance, however the X60 will depanel unpopulated PCBs.

LPKF recommends an S100 or other high-speed ProtoMat to avoid melting template plastic.
Introduction to ProtoMat accessories, options, tools, and consumables

Contents

Options & Accessories ................... 31
   for the ProtoMat circuit board plotters

Tools ................................. 35
   Reliable tooling for the ProtoMat circuit board plotters

Consumables  ......................... 39
   for the ProtoMat circuit board plotters

Options & Accessories
Expand the functionality of an LPKF ProtoMat circuit board plotter (and other LPKF equipment) with a variety of precision accessories. Install accessories (such as acoustic cabinets, etc.) onsite and in a matter of minutes.

Most every LPKF ProtoMat circuit board plotter can be enhanced before it ever leaves the factory with the addition of a number of factory-installed options (such as non-contact air-bearing depth limiter). All options are custom-designed to perfectly complement and enhance an LPKF system.

Tools
LPKF’s commitment to the highest quality extends to every piece of tooling. Custom-designed for LPKF, these milling, drilling, and routing bits are 100% top-quality carbide, resulting in the longest possible life, precise cuts, and reduced drill flex. Tools are divided into two main groups — 36 mm (1.42”) long tools for surface work (milling bits and endmills), and 38 mm (1.5”) long bits that are intended to work through the material, such as contour routers, and drill bits.

Consumables
LPKF produces quality supplies and consumables for all ProtoMat circuit board plotters. From copper-clad material to cleaning pads and adhesives, LPKF realizes that the highest-quality end product must begin with the highest-quality initial components.
Options & Accessories
for ProtoMat circuit board plotters

Expand the capabilities of the ProtoMat and other LPKF systems with a variety of precision accessories and options. These additions, made from the highest quality materials and durably designed for the most challenging prototyping situation, are the perfect complement to any system. Accessories are easy to install at the customer level, and options (such as the non-contact working depth limiter) are options installed at the factory.

- **Increased functionality**
- **Highest quality construction**
- **Perfect integration**
Options

Fiducial recognition camera
Well-suited for multilayer up to 6 layers!
Use the LPKF fiducial recognition camera to help align a board for multilayer production more quickly and accurately than a pin-only system. The camera also provides for automatic inspection of the tool bit status and a direct measuring function. The camera includes driver software that integrates seamlessly with BoardMaster and provides automatic recognition and alignment to existing fiducials in the circuit board. The S-series camera requires USB 2.0 in the host computer, and no additional hardware. The ProtoMat X60 camera includes a special frame-grabber video card and requires an empty peripheral slot in a Windows® computer.

<table>
<thead>
<tr>
<th>Fiducial recognition camera</th>
<th>ProtoMat S-series camera</th>
<th>ProtoMat X60</th>
</tr>
</thead>
<tbody>
<tr>
<td>Part #</td>
<td>115789</td>
<td>114487</td>
</tr>
</tbody>
</table>

Vacuum tabletop
This option holds the workpiece tightly against the work surface, eliminating any substrate irregularities such as twisting or warpage. The tabletop also prevents the board from slipping after it has been flipped for multi-sided milling or drilling.

<table>
<thead>
<tr>
<th>Vacuum tabletop</th>
<th>ProtoMat S42</th>
<th>ProtoMat S62 and S100</th>
</tr>
</thead>
<tbody>
<tr>
<td>Part #</td>
<td>117048</td>
<td>115693</td>
</tr>
</tbody>
</table>

Acoustic cabinet
LPKF acoustic cabinet reduce noise and dust emissions, making ProtoMat models even more ideal for CAD offices and electronics prototyping laboratories. The shelving unit is ideal for extra tools and consumables, as well as accessories such as switches and dust extraction mechanisms.

<table>
<thead>
<tr>
<th>Acoustic cabinet for ProtoMat S42</th>
</tr>
</thead>
<tbody>
<tr>
<td>Part #</td>
</tr>
<tr>
<td>Machine</td>
</tr>
<tr>
<td>Dimensions (W/H/D)</td>
</tr>
<tr>
<td>Noise reduction</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Option</th>
<th>LPKF ProtoMat</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>S100</td>
</tr>
<tr>
<td>Fiducial recognition camera</td>
<td>+</td>
</tr>
<tr>
<td>Vacuum tabletop</td>
<td>+</td>
</tr>
<tr>
<td>Acoustic cabinet</td>
<td>●</td>
</tr>
</tbody>
</table>

● standard  + optional – not available
Accessories

**Dust extraction**
The LPKF dust extraction system, complete with a HEPA absolute filter, keeps the work area clean and free of debris of all sizes, from drill shavings to microscopic dust. The milling depth limiter, a precise tool, requires a dust-free surface against which to operate. The integrated AutoSwitch ensures that the dust extraction system is switched on and off automatically. This guarantees safety, increases the lifetime of the dust extraction system and reduces noise when the machine is not running.

<table>
<thead>
<tr>
<th>Dust extraction</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Part #</td>
<td>114647</td>
</tr>
<tr>
<td>Vacuum pressure</td>
<td>Max. 22,500 Pascal</td>
</tr>
<tr>
<td>Air flow rate</td>
<td>241 m³/hr (0.140 cfm)</td>
</tr>
<tr>
<td>Power consumption</td>
<td>800 W (230 V) or 960 W (120 V)</td>
</tr>
<tr>
<td>Dimensions (W/H/D)</td>
<td>250 x 300 x 350 mm (10” x 12” x 14”)</td>
</tr>
<tr>
<td>Acoustic pressure</td>
<td>50 dB(A)</td>
</tr>
<tr>
<td>Absolute filter</td>
<td>HEPA filter</td>
</tr>
<tr>
<td>Remote control</td>
<td>Controlled by software LPKF BoardMaster</td>
</tr>
</tbody>
</table>

**Measuring microscope**
The LPKF measuring microscope is the ideal tool for calibrating ProtoMat isolation depths, with a built-in light, 60x magnification, and a precision metric scale.

<table>
<thead>
<tr>
<th>Measuring microscope</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Part #</td>
<td>113495</td>
</tr>
</tbody>
</table>

**Precision ring setter**
Use the LPKF ringsetter for autochange ProtoMat models to allow different tool use without readjusting the milling depth. Contains adjustment unit and measuring microscope.

<table>
<thead>
<tr>
<th>Precision ring setter</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Part #</td>
<td>116698</td>
</tr>
</tbody>
</table>

**Brush head** *(only for ProtoMat S62, ProtoMat S100 and ProtoMat X60)*
The brush head, used primarily during rework procedures, helps protect placed components, while maintaining a sufficient low-pressure region for the vacuum system to remove debris from the work area.

<table>
<thead>
<tr>
<th>Brush head</th>
<th>ProtoMat S62 und S100</th>
<th>ProtoMat X60</th>
</tr>
</thead>
<tbody>
<tr>
<td>Part #</td>
<td>113421</td>
<td>113815</td>
</tr>
</tbody>
</table>
Compressors
LPKF air compressors supply a steady, reliable source of compressed air for systems requiring compressed air.

<table>
<thead>
<tr>
<th>Compressors</th>
<th>Small compressor</th>
<th>Large compressor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Part #</td>
<td>101092</td>
<td>104863</td>
</tr>
<tr>
<td>Tank size (liters)</td>
<td>6</td>
<td>50</td>
</tr>
<tr>
<td>Max. pressure</td>
<td>6 bar (116 psi)</td>
<td>10 bar (145 psi)</td>
</tr>
<tr>
<td>Output</td>
<td>33 l/min (1.1 cfm)</td>
<td>165 l/min (5.8 cfm)</td>
</tr>
<tr>
<td>External Dimensions</td>
<td>360 x 430 x 360 mm (14.2” x 16.9” x 14.2”)</td>
<td>1000 x 770 x 390 mm (39.4” x 30.3” x 15.4”)</td>
</tr>
<tr>
<td>Weight</td>
<td>21 kg (46 lbs)</td>
<td>56 kg (123 lbs)</td>
</tr>
<tr>
<td>Acoustic noise level dB(A) at a distance of 4 m (157.5”)</td>
<td>52</td>
<td>68</td>
</tr>
<tr>
<td>Recommended for</td>
<td>LPKF ProtoPlace</td>
<td>LPKF ProtoMat S100 LPKF ProtoMat H100 LPKF ProtoMat X60</td>
</tr>
</tbody>
</table>

StatusLight
The LPKF StatusLight connects to an LPKF ProtoMat and indicates the status of the machine in such a way that it’s visible even across a busy factory floor or in other environments where constant close monitoring is impractical.

<table>
<thead>
<tr>
<th>Status light</th>
<th>ProtoMat S-series</th>
<th>ProtoMat H100</th>
</tr>
</thead>
<tbody>
<tr>
<td>Part #</td>
<td>120128</td>
<td>119036</td>
</tr>
</tbody>
</table>

Accessories

<table>
<thead>
<tr>
<th>Accessories</th>
<th>LPKF ProtoMat S100</th>
<th>S62</th>
<th>S42</th>
<th>H100</th>
<th>X60</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dust extraction</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>●</td>
<td>+</td>
</tr>
<tr>
<td>Measuring microscope</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Precision ring setter</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Brush head</td>
<td>+</td>
<td>+</td>
<td>−</td>
<td>−</td>
<td>−</td>
</tr>
<tr>
<td>Compressors</td>
<td>+</td>
<td>−</td>
<td>−</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>StatusLight</td>
<td>+</td>
<td>−</td>
<td>−</td>
<td>+</td>
<td>−</td>
</tr>
</tbody>
</table>

● standard  + optional  − not available
LPKF milling, drilling and routing tools

Reliable tools for LPKF ProtoMat circuit board plotters

LPKF’s commitment to the highest-quality components extends to every piece of tooling. Custom-designed for LPKF, these milling, drilling, and routing bits are 100% top-quality carbide, resulting in the longest possible life, precise cuts, and reduced drill flex. Tools are divided into two main groups – 36 mm (1.42”) long tools for surface work (milling bits and endmills), and 38 mm (1.5”) long bits that are intended to work through the material, such as contour routers, and drill bits.
### Micro Cutter/Fine-Line Milling Tool 1/8”
Conical custom-designed tool with orange distance ring.

<table>
<thead>
<tr>
<th>Part #</th>
<th>Size</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>115836</td>
<td>36 mm, 0.10–0.15 mm (4–6 mil)</td>
<td>For fine isolation tracks on 18 µm copper.</td>
</tr>
</tbody>
</table>

![Micro Cutter/Fine-Line Milling Tool 1/8”](image)

**Base material**

**Copper layer**

**Isolation**

**Aluminum engraving**

### Universal Cutter 1/8”
Conical custom-designed tool with orange distance ring.

<table>
<thead>
<tr>
<th>Part #</th>
<th>Size</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>115835</td>
<td>36 mm, 0.2–0.5 mm (8–20 mil)</td>
<td>For cutting isolation tracks in any copper board material with variable copper thickness.</td>
</tr>
</tbody>
</table>

![Universal Cutter 1/8”](image)

**Base material**

**Copper layer**

**Isolation**

### End Mill (RF) 1/8”
Cylindrical custom-designed tool with blue distance ring.

<table>
<thead>
<tr>
<th>Part #</th>
<th>Size</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>115832</td>
<td>36 mm, d=0.15 mm (6 mil)</td>
<td>For minimal substrate removal to cut isolation tracks in RF applications.</td>
</tr>
<tr>
<td>115833</td>
<td>36 mm, d=0.25 mm (10 mil)</td>
<td></td>
</tr>
<tr>
<td>115834</td>
<td>36 mm, d=0.40 mm (16 mil)</td>
<td></td>
</tr>
</tbody>
</table>

![End Mill (RF) 1/8”](image)

**Base material**

**Copper layer**

**Isolation**

### End Mill 1/8”
Cylindrical custom-designed tool with violet distance ring.

<table>
<thead>
<tr>
<th>Part #</th>
<th>Size</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>115839</td>
<td>36 mm, d=0.80 mm (31 mil)</td>
<td>For engraving aluminum front panels, for rub-out areas and wider isolation tracks.</td>
</tr>
<tr>
<td>115840</td>
<td>36 mm, d=1.00 mm (39 mil)</td>
<td></td>
</tr>
<tr>
<td>115841</td>
<td>36 mm, d=2.00 mm (79 mil)</td>
<td></td>
</tr>
<tr>
<td>115842</td>
<td>36 mm, d=3.00 mm (118 mil)</td>
<td></td>
</tr>
</tbody>
</table>

![End Mill 1/8”](image)

**Base material**

**Copper layer**

**Isolation**

**Engraving**

**Aluminum**
**End Mill long 1/8”**
Cylindrical custom-designed tool with light green distance ring.

<table>
<thead>
<tr>
<th>Part #</th>
<th>Size</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>115837</td>
<td>38 mm, d=1.00 mm (39 mil)</td>
<td>For cutting aluminum and routing soft materials for RF and microwave applications.</td>
</tr>
<tr>
<td>115838</td>
<td>38 mm, d=2.00 mm (79 mil)</td>
<td></td>
</tr>
</tbody>
</table>

**Contour router**
Cylindrical custom-designed tool with yellow distance ring.

<table>
<thead>
<tr>
<th>Part #</th>
<th>Size</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>115844</td>
<td>38 mm, d=1.00 mm (39 mil)</td>
<td>For routing inner and outer board contours and holes &gt;2.4 mm (&gt;94 mil).</td>
</tr>
<tr>
<td>115845</td>
<td>38 mm, d=2.00 mm (79 mil)</td>
<td></td>
</tr>
</tbody>
</table>

**Spiral Drill**
Cylindrical tool with green distance ring.

<table>
<thead>
<tr>
<th>Part #</th>
<th>Size</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>115846</td>
<td>38 mm, d=0.20 mm (8 mil)</td>
<td>For drilling holes &lt;2.4 mm (&lt;94 mil).</td>
</tr>
<tr>
<td>115847</td>
<td>38 mm, d=0.30 mm (12 mil)</td>
<td></td>
</tr>
<tr>
<td>115848</td>
<td>38 mm, d=0.40 mm (16 mil)</td>
<td></td>
</tr>
<tr>
<td>115849</td>
<td>38 mm, d=0.50 mm (20 mil)</td>
<td></td>
</tr>
<tr>
<td>115850</td>
<td>38 mm, d=0.60 mm (24 mil)</td>
<td></td>
</tr>
<tr>
<td>115851</td>
<td>38 mm, d=0.70 mm (28 mil)</td>
<td></td>
</tr>
<tr>
<td>115852</td>
<td>38 mm, d=0.80 mm (31 mil)</td>
<td></td>
</tr>
<tr>
<td>115853</td>
<td>38 mm, d=0.85 mm (33 mil)</td>
<td></td>
</tr>
<tr>
<td>115854</td>
<td>38 mm, d=0.90 mm (35 mil)</td>
<td></td>
</tr>
<tr>
<td>115855</td>
<td>38 mm, d=1.00 mm (39 mil)</td>
<td></td>
</tr>
<tr>
<td>115856</td>
<td>38 mm, d=1.10 mm (43 mil)</td>
<td></td>
</tr>
<tr>
<td>115857</td>
<td>38 mm, d=1.20 mm (47 mil)</td>
<td></td>
</tr>
<tr>
<td>115858</td>
<td>38 mm, d=1.30 mm (51 mil)</td>
<td></td>
</tr>
<tr>
<td>115859</td>
<td>38 mm, d=1.40 mm (55 mil)</td>
<td></td>
</tr>
<tr>
<td>115860</td>
<td>38 mm, d=1.50 mm (59 mil)</td>
<td></td>
</tr>
<tr>
<td>115861</td>
<td>38 mm, d=1.60 mm (63 mil)</td>
<td></td>
</tr>
<tr>
<td>115862</td>
<td>38 mm, d=1.70 mm (67 mil)</td>
<td></td>
</tr>
<tr>
<td>115863</td>
<td>38 mm, d=1.80 mm (71 mil)</td>
<td></td>
</tr>
<tr>
<td>115864</td>
<td>38 mm, d=1.90 mm (75 mil)</td>
<td></td>
</tr>
<tr>
<td>115865</td>
<td>38 mm, d=2.00 mm (79 mil)</td>
<td></td>
</tr>
<tr>
<td>115866</td>
<td>38 mm, d=2.10 mm (83 mil)</td>
<td></td>
</tr>
<tr>
<td>115867</td>
<td>38 mm, d=2.20 mm (87 mil)</td>
<td></td>
</tr>
<tr>
<td>115868</td>
<td>38 mm, d=2.30 mm (91 mil)</td>
<td></td>
</tr>
<tr>
<td>115869</td>
<td>38 mm, d=2.40 mm (94 mil)</td>
<td></td>
</tr>
<tr>
<td>115870</td>
<td>38 mm, d=2.95 mm (116 mil)</td>
<td></td>
</tr>
<tr>
<td>115871</td>
<td>38 mm, d=3.00 mm (118 mil)</td>
<td></td>
</tr>
</tbody>
</table>
Tool set with 1/8” shaft and distance rings
For all LPKF ProtoMat models. Includes tools with pressed-on distance rings.

<table>
<thead>
<tr>
<th>Part #</th>
<th>Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>115909</td>
<td>5x Spiral Drill 1/8”, 38 mm (1.5”), d=0.60 (24 mil)</td>
</tr>
<tr>
<td></td>
<td>5x Spiral Drill 1/8”, 38 mm (1.5”), d=0.70 (278 mil)</td>
</tr>
<tr>
<td></td>
<td>5x Spiral Drill 1/8”, 38 mm (1.5”), d=0.80 (31 mil)</td>
</tr>
<tr>
<td></td>
<td>5x Spiral Drill 1/8”, 38 mm (1.5”), d=0.90 (35 mil)</td>
</tr>
<tr>
<td></td>
<td>5x Spiral Drill 1/8”, 38 mm (1.5”), d=1.00 (39 mil)</td>
</tr>
<tr>
<td></td>
<td>2x Spiral Drill 1/8”, 38 mm (1.5”), d=1.10 (43 mil)</td>
</tr>
<tr>
<td></td>
<td>2x Spiral Drill 1/8”, 38 mm (1.5”), d=1.30 (51 mil)</td>
</tr>
<tr>
<td></td>
<td>2x Spiral Drill 1/8”, 38 mm (1.5”), d=1.50 (59 mil)</td>
</tr>
<tr>
<td></td>
<td>2x Spiral Drill 1/8”, 38 mm (1.5”), d=3.00 (118 mil)</td>
</tr>
<tr>
<td></td>
<td>1x Contour Router 1/8”, 38 mm (1.5”), d=1.00 (39 mil)</td>
</tr>
<tr>
<td></td>
<td>1x Contour Router 1/8”, 38 mm (1.5”), d=2.00 (79 mil)</td>
</tr>
<tr>
<td></td>
<td>2x End Mill 1/8”, 36 mm (1.4”), d=1.00 mm (39 mil)</td>
</tr>
<tr>
<td></td>
<td>1x End Mill 1/8”, 36 mm (1.4”), d=2.00 mm (79 mil)</td>
</tr>
<tr>
<td></td>
<td>2x End Mill (RF) 1/8”, 36 mm (1.4”), d=0.40 mm (16 mil)</td>
</tr>
<tr>
<td></td>
<td>10x Universal Cutter 1/8”, 36 mm (1.4”), 0.2–0.5 mm (8–20 mil)</td>
</tr>
</tbody>
</table>

RF and Microwave Set with distance rings

<table>
<thead>
<tr>
<th>Part #</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>116394</td>
<td>Tools with distance rings:</td>
</tr>
<tr>
<td></td>
<td>5x End Mill (RF) 1/8”, 36 mm, d=0.25 mm (10 mil)</td>
</tr>
<tr>
<td></td>
<td>3x End Mill (RF) 1/8”, 36 mm, d=0.40 mm (16 mil)</td>
</tr>
<tr>
<td></td>
<td>3x End Mill (RF) 1/8”, 36 mm, d=0.15 mm (6 mil)</td>
</tr>
<tr>
<td></td>
<td>5x End Mill 1/8”, 36 mm, d=1.00 mm (39 mil)</td>
</tr>
<tr>
<td></td>
<td>2x End Mill 1/8”, 36 mm, d=2.00 mm (79 mil)</td>
</tr>
<tr>
<td></td>
<td>2x End Mill 1/8”, 38 mm, d=2.00 mm (79 mil)</td>
</tr>
</tbody>
</table>

The tool sets may differ depending on your country of origin. Please contact your local representative for details (page 126).

LPKF recommends only tools manufactured by LPKF and assumes no liability for machine damage or work quality when non-LPKF tooling is used.
Consumables
for ProtoMat circuit board plotters

LPKF produces the highest-quality supplies and consumables for all ProtoMat circuit board plotters. From copper-clad material to cleaning pads and adhesives, LPKF realizes that the highest-quality end products must begin with the highest-quality starting components.
**Starter sets** (for first ProtoMat use)

LPKF Starter sets are comprehensive collections of work material, bits, and other accessories designed to reduce startup time by supplying all needed components.

Starter sets are recommended individually for each ProtoMat.

<table>
<thead>
<tr>
<th>Machine</th>
<th>Part #</th>
<th>Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>LPKF ProtoMat S100</td>
<td>117527</td>
<td><strong>For use without vacuum table</strong> 10x Drill underlay material 229 x 305 mm (9” x 12”), 2 mm (0.08”) (pредрilled)</td>
</tr>
<tr>
<td></td>
<td>122159</td>
<td><strong>For use with vacuum table</strong> 2x sinter backing plate white 315 x 239 x 5 mm (12.4” x 9.4” x 0.2”)</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>both sets additionally contain:</strong> 10x Base plate FR4, 229 x 305 mm (9” x 12”), 0/35 µm (предрilled)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5x Base plate FR4, 229 x 305 mm (9” x 12”), 35/35 µm (предрilled)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5x Base plate FR4, 229 x 305 mm (9” x 12”), 18/18 µm (предрilled)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5x Micro Cutter with distance ring 1/8”, 36 mm (1.4”), d=0.1-0.15 mm (4–6 mil)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3x End Mill (RF) with distance ring 1/8”, 36 mm, d = 0.15 mm (6 mil)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10x End Mill (RF) with distance ring 1/8”, 36 mm (1.4”), d=0.25 mm (10 mil)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3x End Mill (RF) with distance ring 1/8”, 36 mm (1.4”), d=0.40 mm (16 mil)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5x End Mill with distance ring 1/8”, 36 mm (1.4”), d=1.00 (39 mil)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2x End Mill with distance ring 1/8”, 36 mm (1.4”), d=2.00 (79 mil)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2x End Mill with distance ring 1/8”, 38 mm (1.5”), d=2.00 (79 mil)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1x Special tape</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3x PCB cleaner</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1x Tool Set 1/8” shaft with distance rings, (115909) details see page 38</td>
</tr>
<tr>
<td></td>
<td>115791</td>
<td><strong>For use without vacuum table</strong> 10x Drill underlay material 229 x 305 mm (9” x 12”), 2 mm (0.08”) (предрilled)</td>
</tr>
<tr>
<td></td>
<td>122157</td>
<td><strong>For use with vacuum table</strong> 2x sinter backing plate white 315 x 239 x 5 mm (12.4” x 9.4” x 0.2”)</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>both sets additionally contain:</strong> 10x Base plate FR4, 229 x 305 mm (9” x 12”), 0/35 µm (предрilled)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5x Base plate FR4, 229 x 305 mm (9” x 12”), 35/35 µm (предрilled)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5x Base plate FR4, 229 x 305 mm (9” x 12”), 18/18 µm (предрilled)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5x Fine line milling with distance ring 1/8”, 36 mm (1.4”), d=0.1-0.15 mm (4–6 mil)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5x End Mill (RF) with distance ring 1/8”, 36 mm (1.4”), d=0.25 mm (10 mil)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1x Special tape</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3x PCB cleaner</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1x Tool Set 1/8” shaft with distance rings, (115909) details see page 38</td>
</tr>
<tr>
<td>LPKF ProtoMat S42</td>
<td>117717</td>
<td><strong>For use without vacuum table</strong> 10x Drill underlay material 229 x 305 mm (9” x 12”), 2 mm (0.08”) (предрilled)</td>
</tr>
<tr>
<td></td>
<td>122158</td>
<td><strong>For use with vacuum table</strong> 2x sinter backing plate white 315 x 239 x 5 mm (12.4” x 9.4” x 0.2”)</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>both sets additionally contain:</strong> 10x Base plate FR4, 229 x 305 mm (9” x 12”), 0/35 µm (предрilled)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5x Base plate FR4, 229 x 305 mm (9” x 12”), 35/35 µm (предрilled)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1x Special tape</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3x PCB cleaner</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1x Tool Set 1/8” shaft with distance rings, (115909) details see page 38</td>
</tr>
<tr>
<td>LPKF ProtoMat H100</td>
<td>113867</td>
<td>10x Base plate FR4, A3, 35/35 µm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10x Base plate FR4, A4, 18/18 µm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10x End Mill 1/8”, 38 mm (1.5”), d=1.00 (39 mil)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10x End Mill (RF) 1/8”, 36 mm , d=0.25 mm (10 mil)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10x Micro Cutter 1/8”, 36 mm, 0.1–0.15 mm (4–6 mil)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1x Tool Set 1/8” shaft, (115909) details see page 38</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4x Honeycomb material for vacuum table</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1x PCB cleaner</td>
</tr>
</tbody>
</table>

These kits may differ depending on your country of origin. Please contact your local representative for details (page 126).
### Multilayer sets for multilayer PCB production

LPKF multilayer starter sets include all materials necessary to fabricate the highest-quality multilayer boards, using a ProtoMat circuit board plotter and a MultiPress S.

<table>
<thead>
<tr>
<th>Part #</th>
<th>Description</th>
<th>Content</th>
<th>Boards per package</th>
</tr>
</thead>
<tbody>
<tr>
<td>121103</td>
<td>4-layer Multilayerset or MultiPress S, Galvanik H- and S-series</td>
<td>Size of material: 229 x 305 mm (9” x 12”)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Base material for 10 multilayers with 4 layers consisting of:</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>20x laminate multilayer 0/5 µm (229 x 305 x 0.2 mm) with protection foil</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>40x Prepreg (200 x 275 x 0.1 mm) (7.9” x 10.8” x 0.004”)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>5x Pressing cardboard cushion (229 x 305 mm) (9” x 12”)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>10x Base plate FR4 18/18 µm (229 x 305 x 1 mm) (9” x 12” x 0.04”)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1x Pack seal rings</td>
<td></td>
</tr>
<tr>
<td>121102</td>
<td>4-layer Multilayerset for MultiPress S, ProConduct H- and S-series</td>
<td>Size of material: 229 x 305 mm (9” x 12”)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Base material for 10 multilayers with 4 layers consisting of:</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>20x laminate multilayer 0/18 µm (229 x 305 x 0.2 mm) without protection foil</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>40x Prepreg (200 x 275 x 0.1 mm) (7.9” x 10.8” x 0.004”)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>5x Pressing cardboard cushion (229 x 305 mm) (9” x 12”)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>10x Base plate FR4 18/18 µm (229 x 305 x 1 mm) (9” x 12” x 0.04”)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1x Pack seal rings</td>
<td></td>
</tr>
<tr>
<td>121093</td>
<td>6-layer Multilayerset for MultiPress S, Galvanik H- and S-series</td>
<td>Size of material: 229 x 305 mm (9” x 12”)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Base material for 10 multilayers with 6 layers consisting of:</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>20x laminate multilayer 0/5 µm (229 x 305 x 0.2 mm) with protection foil</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>60x Prepreg (200 x 275 x 0.1 mm) (7.9” x 10.8” x 0.004”)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>5x Pressing cardboard cushion (229 x 305 mm) (9” x 12”)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>20x Base plate FR4 18/18 µm (229 x 305 x 0.36 mm) (9” x 12” x 0.014”)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1x Pack seal rings</td>
<td></td>
</tr>
<tr>
<td>124481</td>
<td>8-layer Multilayerset for MultiPress S, Galvanik H- and S-series</td>
<td>Size of material: 229 x 305 mm (9” x 12”)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Base material for 10 multilayers consisting of:</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>20x laminate multilayer 0/5 µm (229 x 305 x 0.2 mm) with protection foil</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>80x Prepreg (200 x 275 x 0.1 mm) (7.9” x 10.8” x 0.004”)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>5x Pressing cardboard cushion (229 x 305 mm) (9” x 12”)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>20x Base plate FR4 18/18 µm (229 x 305 x 0.36 mm) (9” x 12” x 0.014”)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1x Pack Reinforcing rings, Ø 13 mm</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>4x Slotted headless screw with chamfered end</td>
<td></td>
</tr>
</tbody>
</table>

### Drill underlay material and parts for vacuum table

- **Drill underlay material and parts for vacuum table**

  Raises the board from the work surface to avoid damage to the table during drilling. LPKF underlay boards help prevent drilling debris from clinging to bits. The honeycomb material for vacuum table supports the workpiece perfectly. Also the sinter backing plates can be changed separately.

<table>
<thead>
<tr>
<th>Part #</th>
<th>Description</th>
<th>Boards per package</th>
</tr>
</thead>
<tbody>
<tr>
<td>116148</td>
<td>Honeycomb material for desktop vacuum table for ProConduct® and ProtoMat S-series vacuum table, 5 mm thick, Ø 3.5 mm</td>
<td>4</td>
</tr>
<tr>
<td>114297</td>
<td>Honeycomb material for vacuum table H100, 5 mm thick, Ø 2.5 mm</td>
<td>4</td>
</tr>
<tr>
<td>116099</td>
<td>Air-permeable backing material for vacuum table for ProtoMat S-series</td>
<td>4</td>
</tr>
<tr>
<td>116002</td>
<td>Air-permeable backing material for vacuum table for ProtoMat H100</td>
<td>2</td>
</tr>
<tr>
<td>106388</td>
<td>Drill underlay material, DIN A4, d=2 mm</td>
<td>10</td>
</tr>
<tr>
<td>106389</td>
<td>Drill underlay material, DIN A3, d=2 mm</td>
<td>10</td>
</tr>
<tr>
<td>115966</td>
<td>Drill underlay material (predrilled), 229 mm x 305 mm (9” x 12”), d=2 mm</td>
<td>10</td>
</tr>
</tbody>
</table>
Copper-clad FR4 board material  
(1.5 mm thickness)

<table>
<thead>
<tr>
<th>Part #</th>
<th>Description</th>
<th>Boards per package</th>
</tr>
</thead>
<tbody>
<tr>
<td>115971</td>
<td>Base plate FR4, 229 mm x 305 mm (9&quot; x 12&quot;), 5/5 µm with protective Cu-foil, predrilled with 3 mm registration holes</td>
<td>10</td>
</tr>
<tr>
<td>115968</td>
<td>Base plate FR4, 229 mm x 305 mm (9&quot; x 12&quot;), 0/18 µm, predrilled with 3 mm registration holes</td>
<td>10</td>
</tr>
<tr>
<td>115967</td>
<td>Base plate FR4, 229 mm x 305 mm (9&quot; x 12&quot;), 18/18 µm, predrilled with 3 mm registration holes</td>
<td>10</td>
</tr>
<tr>
<td>115969</td>
<td>Base plate FR4, 229 mm x 305 mm (9&quot; x 12&quot;), 0/35 µm, predrilled with 3 mm registration holes</td>
<td>10</td>
</tr>
<tr>
<td>115970</td>
<td>Base plate FR4, 229 mm x 305 mm (9&quot; x 12&quot;), 35/35 µm, predrilled with 3 mm registration holes</td>
<td>10</td>
</tr>
<tr>
<td>112059</td>
<td>Base plate FR4, A3, 5/5 µm with protective Cu-foil</td>
<td>10</td>
</tr>
<tr>
<td>106398</td>
<td>Base plate FR4, A3, 18/18 µm</td>
<td>10</td>
</tr>
<tr>
<td>106400</td>
<td>Base plate FR4, A3, 0/35 µm</td>
<td>10</td>
</tr>
<tr>
<td>106401</td>
<td>Base plate FR4, A3, 35/35 µm</td>
<td>10</td>
</tr>
</tbody>
</table>

Multilayer material

<table>
<thead>
<tr>
<th>Part #</th>
<th>Description</th>
<th>Boards per package</th>
</tr>
</thead>
<tbody>
<tr>
<td>119574</td>
<td>Base plate FR4 18/18 µm, 229 x 305 (k) x 1 mm (9&quot; x 12&quot; x 0.04&quot;)</td>
<td>1</td>
</tr>
<tr>
<td>119575</td>
<td>Base plate 104 ML, 18/18 µm, 229 x 305 (k) x 0.36 mm (9&quot; x 12&quot; x 0.01&quot;)</td>
<td>1</td>
</tr>
<tr>
<td>119571</td>
<td>Thin laminate 104 ML, 5/0 µm, 229 x 305 (k) x 0.2 mm (9&quot; x 12&quot; x 0.008&quot;) with protection Cu-foil</td>
<td>1</td>
</tr>
<tr>
<td>119572</td>
<td>Prepreg type 2125, 275 (k) x 200 x 0.1 mm (10.8&quot; x 7.9&quot; x 0.004&quot;) for multilayer</td>
<td>2</td>
</tr>
<tr>
<td>119573</td>
<td>Pressing cardboard cushion for multi-layer, 229 x 305 x 0.1 mm (9&quot; x 12&quot; x 0.004&quot;)</td>
<td>1</td>
</tr>
<tr>
<td>119577</td>
<td>Pressing metal sheet for MultiPress S, 229 x 305 x 0.4 mm (9&quot; x 12&quot; x 0.016&quot;)</td>
<td>1</td>
</tr>
</tbody>
</table>

Cleaning pad

<table>
<thead>
<tr>
<th>Part #</th>
<th>Description</th>
<th>Pads per package</th>
</tr>
</thead>
<tbody>
<tr>
<td>106403</td>
<td>Metal-free ultra-fine PCB cleaning pads remove oxidation from the copper surface of a work piece.</td>
<td>10</td>
</tr>
</tbody>
</table>

Adhesive tape

<table>
<thead>
<tr>
<th>Part #</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>106373</td>
<td>Masking tape to hold work material flat to the work surface and leave no residue or contamination behind.</td>
</tr>
</tbody>
</table>
LPKF CircuitCAM and BoardMaster
Comprehensive software package

Each LPKF circuit board plotter includes a comprehensive software package for importing data from any PCB layout CAD package and controlling the circuit board plotter. This software is designed to be simple to use, perfectly matched to the hardware, and compatible with all standard CAD programs.

LPKF CircuitCAM PCB imports design data from virtually every known design package, and allows the user to modify or change the layout on-the-fly.

LPKF BoardMaster prepares layout files to send to any LPKF circuit board plotter. Additionally, LPKF BoardMaster allows the layout to be manipulated – such as duplication, rotation, or tiling. LPKF BoardMaster also controls the LPKF circuit board plotter.

These minor variations of the software are used in specialized applications:

LPKF CircuitCAM Lite is a version of CircuitCAM PCB, optimized for the more economical LPKF ProtoMat S42.

LPKF CircuitMaster is a version of BoardMaster PCB that is optimized for full control of the LPKF ProtoLaser S.
LPKF CircuitCAM – the software interface to your CAD/EDA system

**Simple and functional**
LPKF CircuitCAM processes the same data and data files required by a commercial board fabricator. CircuitCAM automatically imports aperture tables and tool lists, followed by Gerber and NC drilling files:

- **Data import:** Imports Gerber®, GerberX, HP-GL™, Excellon®, Sieb & Meier, DXF, Barco®, DDB++®
- **Data export:** Exports Gerber®, GerberX, HP-GL™, LMD, Excellon®, DXF formats
- **Intelligent insulation:** This process guarantees removal of copper using various automatic and individually adjustable insulation options, reducing milling time and increasing tool life, with up to four different tools per insulation strategy and freely definable rub-outs – including polygons.

- **Design rule check:** Checks track/gap spaces.
- **Auto contour routing:** Automatically generates routing paths with definable breakout tabs.
- **Auto ground plane:** Automatically generates ground planes.
- **Direct drawing input:** Draws simple front panels or printed circuit boards.
- **Editing directly:** For example, modifying line-widths, changing hole diameters, shifting holes, adding copper areas, etc.
- **True type fonts:** CircuitCAM understands TTF and TTC during text functions.
- **Auto assign:** Automatically assigns production phases/tools for BoardMaster.
- **Machining order control:** Modifies cutting direction and sequence.

### Specification table

<table>
<thead>
<tr>
<th></th>
<th>LPKF CircuitCAM LITE</th>
<th>LPKF CircuitCAM PCB</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Import formats</strong></td>
<td>Gerber Standard (RS-274-D), Extended Gerber (RS-274-X),</td>
<td>Gerber Standard (RS-274-D), Extended Gerber (RS-274-X),</td>
</tr>
<tr>
<td></td>
<td>Excellon NC Drill (version 1 and 2), Sieb &amp; Meier NC Drill,</td>
<td>Excellon NC Drill, HP-GL™, Barco® DP, AutoCAD™ DXF, ODB</td>
</tr>
<tr>
<td></td>
<td>HP-GL™</td>
<td>++®</td>
</tr>
<tr>
<td><strong>Supported shapes</strong></td>
<td>Circle, square, rectangle (also rounded or angled),</td>
<td></td>
</tr>
<tr>
<td></td>
<td>octagon, oval, marker, IEC 1182 (1000–1024) including</td>
<td></td>
</tr>
<tr>
<td></td>
<td>thermal reliefs, fiducials, etc., special (arbitrary</td>
<td></td>
</tr>
<tr>
<td></td>
<td>definable)</td>
<td></td>
</tr>
<tr>
<td><strong>Export formats</strong></td>
<td>LPKF BoardMaster (LMD)</td>
<td>LPKF BoardMaster (LMD), Gerber Standard (RS-274-D),</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Excellon NC Drill, HP-GL™, DXF</td>
</tr>
<tr>
<td><strong>Editing functions</strong></td>
<td>Original modification, relocating, duplicating,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>rotating, mirroring, erasing, extending/severing lines,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>line/path extension/shortening, line path/segment parallel</td>
<td></td>
</tr>
<tr>
<td></td>
<td>shifting, line path/object polygon conversion (Fill),</td>
<td></td>
</tr>
<tr>
<td></td>
<td>curve linking/closing</td>
<td></td>
</tr>
<tr>
<td><strong>Special functions</strong></td>
<td>Contour routing path generator with breakout tabs</td>
<td>Routing path generator with breakout tabs, volume</td>
</tr>
<tr>
<td></td>
<td></td>
<td>operations, joining/separating objects, step &amp;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>repeat (multiple PCB), polygon cut-out, ground plane</td>
</tr>
<tr>
<td></td>
<td></td>
<td>generation with defined clearance, batch functions</td>
</tr>
<tr>
<td><strong>Display functions</strong></td>
<td>Zoom window (freely definable), zoom in/out, overview,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>redraw, individual layers selectable/visible, panning</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(keyboard), layer in solid/outline/center line display,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>16 pre-set colors (up to 16 million freely available),</td>
<td></td>
</tr>
<tr>
<td></td>
<td>different colors for tracks and pads of the same layer,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>different colors for insulation tools</td>
<td></td>
</tr>
<tr>
<td><strong>Marker functions</strong></td>
<td>Single element, total layer, all layers, pad groups,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>selection and limiting to specific layers possible for</td>
<td></td>
</tr>
<tr>
<td></td>
<td>lines/polygons/circles/rectangles/pads/holes (multiple</td>
<td></td>
</tr>
<tr>
<td></td>
<td>choice and restriction to specific layers possible)</td>
<td></td>
</tr>
<tr>
<td><strong>Graphic functions</strong></td>
<td>Lines (open/closed), circle, polygon, rectangle, pad,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>hole, text (TTF, TTC)</td>
<td></td>
</tr>
<tr>
<td><strong>Control functions</strong></td>
<td>Measuring</td>
<td>Measuring, design rule check</td>
</tr>
<tr>
<td><strong>Insulation methods</strong></td>
<td>Single insulation method, additional multiple insulation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>of pads, removal of residual copper spikes (spike</td>
<td></td>
</tr>
<tr>
<td></td>
<td>option), milling out of large insulation areas (rub-out),</td>
<td></td>
</tr>
<tr>
<td></td>
<td>concentric or in serpentines maintaining minimum</td>
<td></td>
</tr>
<tr>
<td></td>
<td>insulation spaces, zone insulation (only PCB version),</td>
<td></td>
</tr>
<tr>
<td></td>
<td>inverse insulation</td>
<td></td>
</tr>
<tr>
<td><strong>Insulation tools</strong></td>
<td>1–2 tools</td>
<td>1–4 tools</td>
</tr>
<tr>
<td><strong>Languages</strong></td>
<td>English, German, French, Spanish, Japanese and Chinese</td>
<td></td>
</tr>
<tr>
<td>**Hard-/software</td>
<td>Microsoft® Windows® 2000/XP, 1.2 GHz processor or</td>
<td></td>
</tr>
<tr>
<td>requirements**</td>
<td>better, min. 512 MB RAM, screen resolution min. XGA</td>
<td></td>
</tr>
<tr>
<td><strong>Supplied with</strong></td>
<td>LPKF ProtoMat S42 *</td>
<td>LPKF ProtoMat S62, S100, H100, X60 and</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ProtoLaser S</td>
</tr>
</tbody>
</table>

* Upgrade from LITE to PCB available. Specifications subject to change.
**LPKF BoardMaster – the powerful and comfortable control software**

LPKF’s BoardMaster software combines a user-friendly interface with precision process control. The software accepts milling and drilling data created by CircuitCAM, as well as HP-GL™ files from various design software packages.

**User-friendly operating interface**
BoardMaster’s WYSIWYG interface shows all milling and drilling data as well as the size of the base material. Simple mouse clicks rotate and move layouts, as well as creating step-and-repeat copies of layouts on the workpiece. BoardMaster constantly displays process status.

**Intelligent tool management**
LPKF BoardMaster controls all tool parameters, such as feed rate and tool RPM. BoardMaster monitors bit life and prompts for a tool change at appropriate times. Tool changes are kept at a minimum by BoardMaster’s optimizing monitoring process.

**Automatic data transmission**
All processing phases and associated tool data are transferred directly from CircuitCAM to BoardMaster. Production can start immediately.

---

### Specification table

<table>
<thead>
<tr>
<th>LPKF BoardMaster</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Import formats</strong></td>
<td>LPKF-Mill-Drill (*.LMD), HP-GL™</td>
</tr>
<tr>
<td><strong>Control</strong></td>
<td>All ProtoMat circuit board plotters</td>
</tr>
<tr>
<td><strong>Display functions</strong></td>
<td>WYSIWYG display of machining data, zoom in/out/working area/projects, previous view, all viewing methods available at all times, even during the machining process, graphical display of the current head position</td>
</tr>
<tr>
<td><strong>Placement functions</strong></td>
<td>Copy, move, step and repeat, handles multiple artworks and placements simultaneously</td>
</tr>
<tr>
<td><strong>Selection methods</strong></td>
<td>Total production phase, specific tools, individual drill holes/lines/segments, selection from/up to a specific hole/line segment</td>
</tr>
<tr>
<td><strong>Tool management</strong></td>
<td>RPM and head down time, travel speed, registering and saving actual tool life, initiating the tool change procedure if tool lifetime is exceeded, working mode profiles customized for ProtoMat models</td>
</tr>
<tr>
<td><strong>Tool library</strong></td>
<td>Unlimited, individual library for different material types, individual customizable parameters</td>
</tr>
<tr>
<td><strong>Programming material size</strong></td>
<td>Positioning with corner coordinates, with the mouse, coordinates input via keyboard, option of saving frequently used material sizes</td>
</tr>
<tr>
<td><strong>Languages</strong></td>
<td>English, German, Spanish, Japanese, French, Chinese</td>
</tr>
<tr>
<td><strong>Other</strong></td>
<td>Acoustic signal at end of production phase and display of production time remaining, estimated production time is displayed before start, integration of a camera option with automatic fiducial recognition, Check for broken tools</td>
</tr>
<tr>
<td><strong>Hardware and software requirements</strong></td>
<td>Microsoft® Windows® 2000/XP, 1.2 GHz processor or better, min. 256 MB RAM, screen resolution XGA, serial port or USB</td>
</tr>
</tbody>
</table>

Specifications subject to change.
LPKF ProtoLaser S
Direct laser structuring of circuit boards

<table>
<thead>
<tr>
<th>Item</th>
<th>LPKF ProtoLaser S</th>
</tr>
</thead>
<tbody>
<tr>
<td>Part #</td>
<td>124102</td>
</tr>
<tr>
<td>Order info</td>
<td>Inside front cover</td>
</tr>
</tbody>
</table>

When should a prototype PCB be produced? How fast can a small batch be produced? The answer is: right now! PCB designers take a huge stride in achieving this goal with the compact LPKF ProtoLaser S.

Using the new LPKF laser technique, the ProtoLaser S structures boards within minutes – and with much higher precision than conventional systems. Even large boards can now be processed with laser accuracy – with precise geometries on almost any substrate. The ProtoLaser S is very compact and laboratory approved. On its rollers it moves through each laboratory-door and needs only compressed air and a power socket for operation.

- Extremely high resolution, precise geometries, optimal repeatability
- Ideal for RF and microwave circuits
- Maximum working area 229 x 305 x 10 mm (9” x 12” x 0.4”)
- Prototyping and on-demand production of customized small batches
- All coatings and base materials

Structuring speed: 6 cm²/min
Minimum cutting channel width: 25 µm
Minimum corner radius: 12.5 µm
Minimum track/gap: 50/25 µm *
* on ceramic substrate with 5 µm metallization
Efficient for all types of PCB materials

Circuit layouts structured by laser
The LPKF ProtoLaser S selectively ablates the conductive layer, usually copper, from the substrate. This cuts the insulation channels to precisely create the planned tracks and pad surfaces.

Areas of application
The ProtoLaser S is ideal for the efficient prototyping of complex digital and analogue circuits, and HF and microwave PCBs, up to 229 x 305 mm in size. The potential to produce highly precise geometries in almost any material makes the ProtoLaser S the perfect system for the production of antennas, filters, and numerous other applications which require precise, steep edge quality.

High repetition accuracy
The repeatability of the results far exceeds the ability of mechanical or chemical methods, which are also negatively affected by wear and process fluctuations. The ProtoLaser S guarantees constant properties even where many iteration steps are required, and for complete small batches.

PCB materials
The ProtoLaser S processes a whole range of different substrates, e.g. copper-coated FR4, aluminium-coated PET films, ceramics, TMM, Duorid or PTFE. The contact-free process demonstrates its special benefits when flexible and sensitive materials are involved – which it processes reliably and without causing any damage.

Working area 229 x 305 mm (9” x 12”)

Only 20 minutes from a bare board to a structured PCB shown here with layout dimensions of 210 x 295 mm (8.3” x 11.6”). Not only fast, but with unprecedented geometrical precision.

Structuring time <20 min
The LPKF ProtoLaser S features:

- LPKF software
- Fiducial recognition and autofocused laser
- A camera recognizes the position of the board from the fiducials and aligns the laser accordingly. The Z-drive automatically guarantees optimal focusing of the laser beam.

And many more, such as:

- Vacuum table
  - The integrated vacuum table secures flexible substrates flat on the table.

- Vacuum extraction
  - The highly effective extraction and filter system creates optimal conditions within the closed laser chamber during processing.

- Pilot laser
  - The LPKF ProtoLaser S has a pilot tool. This marks the selected working area on the surface of the base material with a laser.

Experimental results using the LPKF ProtoLaser S

The Institute for High Frequency Technology and Radio Systems at Leibniz University Hannover, in co-operation with LPKF, put an LPKF ProtoLaser through a stringent testing program. Direct comparisons with etched printed circuit boards revealed that the laser-structured PCBs were far superior in important criteria such as repetition accuracy, correspondence with simulation results, and geometry precision.

The printed circuit board shown here measuring 60 x 70 mm (2.4" x 2.8") shows a planar broadband radio network element for balanced antenna structures (frequency range 1–6 GHz). Structuring took less than five minutes!

- PCB size: 60 x 70 mm (2.4" x 2.8")
- Material: FR4, 0.5 mm, 18 µm Cu
- Structuring time: <5 min

Fine structures

- Coupling slot as an integral part of feed network
- Precision attention to details

- 85 µm
- 225 µm
- 75 µm
Applications

**Ultrafine boards**
Product reliability is an utmost priority in highly integrated circuits. The LPKF ProtoLaser S far exceeds the specifications for track/gap widths of less than 125 µm/125 µm defined for ultrafine technical applications, and is therefore an ideal solution for the efficient prototyping of complex digital circuits.

**HF circuits**
The tool less laser technology is ideal for building precise HF circuit geometries and does so at high structuring speeds. The repeatability precision essential for HF applications is guaranteed during product development for any number of iteration steps, as well as for the production of small batches. All standard high frequency substrates can be processed, e.g. PTFE, TMM, ceramics as well as FR4 in lower frequency ranges.

**Ultrafine boards**
Product reliability is an utmost priority in highly integrated circuits. The LPKF ProtoLaser S far exceeds the specifications for track/gap widths of less than 125 µm/125 µm defined for ultrafine technical applications, and is therefore an ideal solution for the efficient prototyping of complex digital circuits.

**Circuits on flexible substrates**
The LPKF ProtoLaser S also works just as well on flexible substrates, producing precise, reliable results without causing any damage to the substrate. The flexible materials are held firmly in place on the vacuum table.

**Further applications**

**RFIDs on PET film substrates**
Structuring aluminium-coated substrates is usually a complicated task in RFID prototype development. Not so with the LPKF ProtoLaser S, which can simply and reliably process substrates such as coated PET films. The perfect tool for efficient on-demand prototype production or small batch production.

**HF filters on ceramic substrates**
The LPKF ProtoLaser S really shows its class when processing metal-coated ceramics. The laser beam removes metal coating on ceramic substrates precisely and quickly – up to thicknesses of 300 µm!
**Accessories, software and tools**

### Accessories

**Starter set LPKF ProtoLaser S**
Unpack and go.
Part # 124195

**Compressor**
The LPKF air compressors with freeze dryers and filter systems guarantee reliable supplies of compressed air.
Part # 122805

**Dust extraction**
The dust extraction system with the high pressure turbine and a HEPA filter keeps refuse and debris of all sizes away from the working area.
Part # 124391

**Measuring microscope**
The LPKF measuring microscope has 60 times magnification, a metric precision scale and a built-in light source for perfect processing control.
Part # 113495

**Adjustment tool set for ProtoLaser S**
A precision tool set for adjusting the work table and laser.
Part # 118005

### Software (included)

**LPKF CircuitCAM PCB/CircuitMaster software**
The CircuitCAM/CircuitMaster software package imports and processes the CAD data and controls the operation of the LPKF ProtoLaser S during structuring of the base material.

CircuitCAM imports a variety of file types including Gerber® Standard (RS-274-D), Gerber® Extended (RS-274-X), DBF (Barco), Excellon® NC Drill (versions 1 and 2), Sieb & Meier NC Drill, DXF, HP-GL™ and ODB++. CircuitMaster controls the production process in real-time, especially the ProtoLaser system, and has a library with a broad range of substrate/conductor combinations.

**LPKF ProtoLaser S**

<table>
<thead>
<tr>
<th>Part #</th>
<th>Max. working area (W/H/D)</th>
<th>Structuring speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>124102</td>
<td>229 x 305 x 10 mm (9” x 12&quot; x 0.4”)</td>
<td>( \Omega ) 6 cm²/min ( \Omega ) on laminated substrate</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Beam diameter in focus</th>
<th>Minimum track/space</th>
<th>Resolution scan field</th>
</tr>
</thead>
<tbody>
<tr>
<td>25 µm (1 Mil)</td>
<td>50 µm/25µm (2 mil/1 mil) *</td>
<td>2 µm (0.08 mil)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Repeatability</th>
<th>Laser pulse frequency</th>
<th>Machine dimensions (W/H/D)</th>
</tr>
</thead>
<tbody>
<tr>
<td>±2 µm (±0.08 mil) b</td>
<td>10–100 kHz</td>
<td>20 x 1,430 x 750mm (34.4” x 56.3” x 29.5”) c</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Machine weight</th>
<th>Operation environment specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>260 kg (573.2 lbs)</td>
<td>Electric supply</td>
</tr>
<tr>
<td></td>
<td>Compressed air supply</td>
</tr>
<tr>
<td></td>
<td>Cooling</td>
</tr>
<tr>
<td></td>
<td>Ambient temperature</td>
</tr>
<tr>
<td></td>
<td>Exhaust</td>
</tr>
<tr>
<td></td>
<td>Electric supply</td>
</tr>
<tr>
<td></td>
<td>Volume flow</td>
</tr>
<tr>
<td></td>
<td>Filter</td>
</tr>
<tr>
<td></td>
<td>Machine dimensions (W/H/D)</td>
</tr>
<tr>
<td></td>
<td>Weight</td>
</tr>
</tbody>
</table>

**Specifications subject to change.**

---

*Note that the size of tracks and gaps depend on material and laser parameters.

*This value reflects direct repeated movements of the laser beam.

*Height with open working door 1,730 mm (68.1”).

Specifications subject to change.

---

This machine is designated as a Class I laser product during normal operations. It becomes a Class IV laser product in maintenance mode.

www.lpkf.com  See page 126 to locate an LPKF distributor near you.
How good are laser-structured PCBs? The quality can be proven by testing in our own laboratories and test series run by external organisations.

**Insulation resistance – satisfies IPC standard TM 650**

Insulation resistance can be used to measure whether structuring has been successful. The measurements were carried out by a certified organization to examine the ProtoLaser S results as per IPC standard TM-650, Test 2.5.27.

Although the high voltages of 500 V specified in the IPC standard are only of limited value for standard electronic applications, the structured sample achieved resistances in the $10^9$ Ohm range for the tracks and gaps. Much lower insulation separations are possible when tested under lower voltage conditions. Even narrow insulation channel widths of 50 µm on laminated materials and 25 µm on ceramic materials produced high-Ohm insulation resistances in in-house tests.

**Adhesion resistance**

Laminated materials tend to delaminate when exposed to heat. How do the copper areas behave after laser structuring? The IPC-standard gives an approach: it defines the measuring method to check the adhesion strength. FR4 material meets the usual value of 8 N/cm. The measurements referring to the IPC standard attest the laser structuring process not to affect the adhesion between substrate and conductive coating, also for other materials.

**Geometrical accuracy**

The Institute for High Frequency Technology at Leibniz University Hannover, tested printed circuit boards structured with laser beams. It certified the high geometrical accuracy of this technology throughout, and found that it produced better repeatability than other methods. These findings are backed up by measurements with REM and 3D stereomicroscopes.
Introduction to Through-Hole Plating

Assuring professional quality through-hole conductivity is critical in the production of state-of-the-art PCB prototypes and breadboards. LPKF offers several solutions to complement its already impressive line of equipment for producing in-house prototypes. Each solution offers in-house conductivity, reducing prototyping turnaround time and drastically reducing time-to-market in prototyping and development cycles.

The LPKF ProConduct® system is a simple-to-use through-hole conductivity solution perfect for small fabrication runs. The ProConduct® system avoids the use of chemical baths by using a manually applied conductive polymer that works quickly and efficiently to plate through-holes in boards of any size or shape.

LPKF’s MiniContac RS and Contac RS systems are professional stand-alone chemical through-hole plating solutions, ideal for prototyping situations with multilayer boards or PCBs with high hole count. The chemistry is self-contained and virtually maintenance-free. Reverse pulse plating assures a regular and efficient plating, even in the smallest diameter through-holes.

For prototyping and ease-of-use, the LPKF EasyContac is hard to beat. A manual rivet through-hole conductivity system, the EasyContac lives up to its name – requiring no chemicals or disposal considerations at all and it’s easy to master.

Contents

LPKF ProConduct® .................................. 53
In-house PCB through-hole conductivity without chemicals
LPKF Contac RS and MiniContac RS ........ 57
Professional stand-alone electroplating tank
LPKF EasyContac .................................. 61
Manual through-hole conductivity for two-layer PCBs
Comparison of through-hole conductivity solutions ..................... 63
LPKF introduces the ProConduct® through-hole conductivity system, new technology for producing conductive through-holes without chemical electroplating tanks or potentially hazardous chemical processing.

The LPKF ProConduct® through-hole conductivity system is an ideal solution for many in-house rapid PCB prototyping environments. ProConduct® is perfect for low volume production, laboratories or shops where chemical electroplating is impractical, or any circumstance requiring an economical through-hole conductivity solution. Thanks to a parallel process even boards with high hole count are possible.

- **No plating tank or chemicals required**
- **Reliable and thermally stable plating results**
- **Compact, fast and easy to use**
- **Key plating component for PTFE and other difficult substrates (RF)**
Easy to handle

LPKF ProConduct® uses a specially-developed conductive polymer to quickly and easily plate vias in just a few minutes. This four-step easy-to-learn process lends itself well to parallel processing and results in smoothly plated through-holes in a fraction of the time and cost of chemical electroplating:

1. Mill the board with a LPKF circuit board plotter.

2. Apply a special adhesive film to the surface of a milled PCB and drill the through-holes.

Perfect results

The LPKF ProConduct® system plates vias as small as 0.4 mm (15 mil) up to an aspect ratio of 1:4. Smaller holes are possible under special conditions. The basic process requires only a few minutes for double-sided and even multilayer boards. The electrical resistance of LPKF ProConduct® results is extremely low – approximately 19.2 mΩ, depending on the material thickness (see specifications table).

Key to in-house work

When combined with a LPKF ProtoMat circuit board plotter, the LPKF ProConduct® system becomes a key component to an in-house rapid PCB prototyping solution, featuring security, flexibility, and speed.
Apply the conductive polymer to the PCB to fill the through-holes, then use the vacuum table to remove the excess conductor.

Remove the film, cure the treated PCB in an oven for about thirty minutes.

The resistance of a finished via depends on the diameter, but lies in the range of 10–25 mΩ. After temperature cycling (-40 °F to 250 °F), the resistance value after 250 cycles only increases marginally (max. 28 mΩ, as shown in table, blue bar). The test board used is FR4 double-sided with 35 µm (1 oz/ft²) copper.

Comparing RF-measurements of filters up to 4 GHz have not shown any difference in RF-characteristics between the ProConduct-paste and standard electroplated vias!

Dr. Geck, chief engineer at the Institute of Radiofrequency and Microwave Engineering, University of Hanover, Germany

---

**Fast temperature change cycles**

-40 °C/125 °C (-40 °F/250 °F) @ 1.6 mm (64 mil) FR4 PCB

<table>
<thead>
<tr>
<th>Hole diameter (mm)</th>
<th>Initial value</th>
<th>100 cycles</th>
<th>250 cycles</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.4</td>
<td>35</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>0.5</td>
<td>25</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>0.6</td>
<td>15</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>0.7</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>0.8</td>
<td>0.4</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>0.9</td>
<td>0.2</td>
<td>0.3</td>
<td>0.3</td>
</tr>
<tr>
<td>1.0</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
</tr>
</tbody>
</table>
LPKF ProConduct®

LPKF ProConduct® set
Each LPKF ProConduct® set includes:

<table>
<thead>
<tr>
<th>Amount</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>Protective film foil</td>
</tr>
<tr>
<td>10</td>
<td>Filter fleece</td>
</tr>
<tr>
<td>20</td>
<td>2.9 g pack of polymer conductor</td>
</tr>
<tr>
<td>1</td>
<td>Screen printing roller</td>
</tr>
<tr>
<td>1</td>
<td>Brush</td>
</tr>
<tr>
<td>1</td>
<td>Pinch roll</td>
</tr>
<tr>
<td>1</td>
<td>PCB cleaner</td>
</tr>
<tr>
<td>1</td>
<td>ProConduct® cleaner</td>
</tr>
<tr>
<td>1</td>
<td>Work gloves (50 pairs)</td>
</tr>
<tr>
<td>1</td>
<td>Lined work gloves</td>
</tr>
<tr>
<td>5</td>
<td>Base material FR4 18/18 µm</td>
</tr>
<tr>
<td>5</td>
<td>Base material FR4 35/35 µm</td>
</tr>
<tr>
<td>1</td>
<td>Honeycomb material</td>
</tr>
</tbody>
</table>

Content subject to change.

Accessories

Hot air oven
Hot air oven cures ProConduct® polymer.

Part # 115877

Desktop vacuum table
Vacuum table specially designed for the ProConduct® system to draw off excess polymer before curing.

Part # 115878

Vacuum pump
Vacuum pump provides steady vacuum for vacuum table.

Part # 114647

Specification table

<table>
<thead>
<tr>
<th>LPKF ProConduct</th>
<th>115790</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max. base material</td>
<td>229 x 305 mm (9” x 12”)*</td>
</tr>
<tr>
<td>Min. hole diameter</td>
<td>0.4 mm (15 mil) up to aspect ratio of 1:4 *</td>
</tr>
<tr>
<td>Number of through-plated holes per circuit board</td>
<td>No limit</td>
</tr>
<tr>
<td>Number of layers</td>
<td>4</td>
</tr>
<tr>
<td>Solderability</td>
<td>Reflow soldering &lt;220 °C (428 °F), manual soldering *</td>
</tr>
<tr>
<td>Base material types</td>
<td>FR4, FR3, RF and micromave materials (incl. PTFE based materials)</td>
</tr>
<tr>
<td>Process duration</td>
<td>approx. 35 min</td>
</tr>
<tr>
<td>Resistance</td>
<td>Average 19.2 mΩ with SD of 7.7 mΩ</td>
</tr>
</tbody>
</table>

* Small holes on request
* Ask for recommended types of solder

Specifications subject to change.
LPKF Contac RS and MiniContac RS
Professional stand-alone electroplating tanks

<table>
<thead>
<tr>
<th>Item</th>
<th>LPKF Contac RS</th>
<th>MiniContac RS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Part #</td>
<td>120742</td>
<td>119987</td>
</tr>
<tr>
<td>Order Info</td>
<td>Inside front cover</td>
<td></td>
</tr>
</tbody>
</table>

The LPKF Contac RS and MiniContac RS are through-hole plating systems specially developed for the professional production of prototype and small batch production printed circuit boards, featuring Reverse Pulse Plating and unmatched ease-of-use. The systems are ideal for any rapid PCB prototyping situation, especially small runs and tight work locations. They employ reliable formaldehyde-free Black-Hole-Technology for direct metallization.

The Contac RS offers the largest board size capacity of any LPKF plating solution, plating boards as large as 460 x 330 mm (18.0” x 13.0”), as well as a heated tank for chemical tin plating (tin plating is excellent for optimal soldering of through-hole plated circuit boards and oxidation protection). A sink bath is connected via an external water supply for the cleaning step.

The LPKF MiniContac RS handles circuit boards as large as 230 x 330 mm (9.0” x 13.0”). The system is completely closed and needs no external connection.

- **Compact, fast and easy to use**
- **No analysis or special chemical knowledge needed**
- **Features Reverse Pulse Plating for uniform copper deposition**
- **Chemical tinning with LPKF Contac RS**
- **Plates very small diameter through-holes <0.2 mm (8 mil)**
- **Perfect for multilayer printed circuit boards**

www.lpkf.com    See page 126 to locate an LPKF distributor near you.
Increased production reliability with LPKF Contac RS and MiniContac RS

**Advantage of Reverse Pulse Plating**
Both systems feature Reverse Pulse Plating and reliable Black-Hole-Technology for direct metallization. This is especially useful for through-holes with a high aspect ratio or small hole diameter.

**Typical electroplating**
Typical electroplating uses a single direction current flow to perform the copper deposition.

**Reverse Pulse Plating**
The Reverse Pulse Plating interrupts the electroplating process with brief current reversals. This prevents dimensional copper build-up at the hole entrances.

- **Please find more information on reverse pulse plating process on page 109.**

**Easy to use**
These microprocessor-controlled electroplating tanks feature a hands-on interface with a simple-to-use, menu-driven, four-line display.

**Easy process and simple chemistry**
The through-hole plating process starts with a pre-treatment of the printed circuit board. The PCB is cleaned, degreased, pre-treated, and activated with the Blackhole® carbon ink. A galvanic bath adds the copper coating, then after another rinse and cleaning step, the boards are ready for soldering.

The LPKF MiniContac RS uses only four easy-to-change baths to complete the plating process. The LPKF Contac RS offers two additional baths: a rinsing bath and a bath for tin plating. No chemical knowledge or background is required to operate either system.

**Chemical tinning**
The LPKF Contac RS provides a chemical bath for tin plating. The chemical tinning protects the through-plated printed circuit board against oxidation and is the optimal preparation for the soldering process.
Choose the right tank for your application

<table>
<thead>
<tr>
<th>Substrate size</th>
<th>LPKF MiniContac RS</th>
<th>LPKF Contac RS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>230 mm (9&quot;)</td>
<td>460 mm (18&quot;)</td>
</tr>
<tr>
<td></td>
<td>330 mm (13&quot;)</td>
<td>330 mm (13&quot;)</td>
</tr>
<tr>
<td></td>
<td>525 mm (20.7&quot;)</td>
<td>540 mm (19.5&quot;)</td>
</tr>
<tr>
<td></td>
<td>750 mm (29.5&quot;)</td>
<td>900 mm (35.4&quot;)</td>
</tr>
</tbody>
</table>

Plating and tinning

- Copper
- Copper and Tin

Dimensions

- Compact!
- Larger substrate!

Applications

The LPKF Contac RS and MiniContac RS are ideal for the following applications:

**Versatile plating technology**
Plating most common circuit board materials, including FR4 (G10), FR5 and microwave substrates such as RO3000®, RO4000® and TMM®.

**High-quality multilayer plating**
Ideal for the manufacturing of multilayer printed circuit boards.
**Consumables**

<table>
<thead>
<tr>
<th>Product</th>
<th>Part #</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plating chemicals – MiniContac RS</td>
<td>119986</td>
<td>First filling of plating chemicals for MiniContac RS, including 6 l Cleaner 110, 5 l Cleaner 210, 4 l Activator 310, 16 l Copper Plater 400, and 0.25 l Shine 400.</td>
</tr>
<tr>
<td>Plating chemicals – Contac RS</td>
<td>120743</td>
<td>One year supply of plating chemicals for Contac RS systems, including 30 l Cleaner 110, 30 l Cleaner 210, 10 l Activator 310, 35 l Copper Plater 400, 0.5 l Shine 400.</td>
</tr>
<tr>
<td>Cleaner 110</td>
<td>107914</td>
<td>1 l [1 quart] of Cleaner solution</td>
</tr>
<tr>
<td>Cleaner 210</td>
<td>107915</td>
<td>1 l [1 quart] of Cleaner solution</td>
</tr>
<tr>
<td>Activator 310</td>
<td>107916</td>
<td>1 l [1 quart] of Activator solution</td>
</tr>
<tr>
<td>Copper Plater 400</td>
<td>102439</td>
<td>1 l [1 quart] of Copper plater solution</td>
</tr>
<tr>
<td>Shine 400</td>
<td>107917</td>
<td>1 l [1 quart] of Shine solution</td>
</tr>
<tr>
<td>Tin-based bright dip – Contac RS</td>
<td>109131</td>
<td>1 l sufficient for 40 PCB’s of size 100 x 160 mm. Contains one pack of 1170 g tin powder sufficient for a filling capacity of 13 l.</td>
</tr>
</tbody>
</table>

**Specifications**

<table>
<thead>
<tr>
<th>Part #</th>
<th>LPKF Contac RS</th>
<th>LPKF MiniContac RS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Activator</td>
<td>Carbon</td>
<td>Carbon</td>
</tr>
<tr>
<td>Max. base material size</td>
<td>460 x 330 mm (18.0” x 13.0”)</td>
<td>230 x 330 mm (9.0” x 13.0”)</td>
</tr>
<tr>
<td>Max. board size</td>
<td>430 x 290 mm (16.9” x 11.4”)</td>
<td>200 x 290 mm (7.9” x 14.4”)</td>
</tr>
<tr>
<td>Hole diameter</td>
<td>&gt;0.2 mm (8 mil)</td>
<td>&gt;0.2 mm (8 mil)</td>
</tr>
<tr>
<td>Number of plated holes</td>
<td>Unlimited</td>
<td>Unlimited</td>
</tr>
<tr>
<td>Max. number of layers</td>
<td>8 (depends on material and layout)</td>
<td>8 (depends on material and layout)</td>
</tr>
<tr>
<td>Max. resistance</td>
<td>&lt;10 mΩ</td>
<td>&lt;10 mΩ</td>
</tr>
<tr>
<td>Environmental compatibility</td>
<td>Good</td>
<td>Good</td>
</tr>
<tr>
<td>Processing reliability</td>
<td>Very good</td>
<td>Very good</td>
</tr>
<tr>
<td>Process duration</td>
<td>Approx. 90–120 min</td>
<td>Approx. 90 min</td>
</tr>
<tr>
<td>Base material types</td>
<td>FR4, RO3000®, RO4000®, TMM® *</td>
<td>FR4, RO3000®, RO4000®, TMM® *</td>
</tr>
<tr>
<td>Power supply</td>
<td>115/230 V, 50–60Hz, max. 1.5 kW</td>
<td>115/230 V, 50–60Hz, 0.6 kW</td>
</tr>
<tr>
<td>Ambient temperature</td>
<td>18–25 °C (64.4–77 °F)</td>
<td>18–25 °C (64.4–77 °F)</td>
</tr>
<tr>
<td>Dimensions (W/H/D)</td>
<td>900 x 540 x 800 mm (35.4” x 19.5” x 31.5”)</td>
<td>750 x 525 x 500 mm (29.5” x 20.7” x 19.7”)</td>
</tr>
<tr>
<td>Chemical tinning</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Reverse pulse plating</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Weight</td>
<td>94 kg (207 lbs) unfilled; 160 kg (352 lbs) filled</td>
<td>42 kg (92 lbs) unfilled; 71 kg (156 lbs) filled</td>
</tr>
</tbody>
</table>

* Further materials upon request.

Specifications subject to change.
**LPKF EasyContac**

**Manual through-hole conductivity for two-layer PCBs**

EasyContac, a manual system for providing through-hole conductivity for double-sided boards, is ideal for situations where a fast, chemical-free, economical solution is required.

The LPKF EasyContac plates PCB through-holes using simple tools that are easy to operate. With very little effort, small projects can be economically processed, without the use of speciality tools or tanks or chemicals. In particular, the LPKF EasyContac is perfect for projects where 2-sided soldering is impractical. All necessary tooling is included with each set.

- **Economical and fast for small projects**
- **Requires no special tooling**
- **Easy to learn**

---

**Item** | **LPKF EasyContac**
---|---
**Part #** | 110914
**Order info** | Inside front cover

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Learn more about LPKF EasyContac or find a distributor near you at [www.lpkf.com](http://www.lpkf.com).
**Ideal for small projects**
The LPKF EasyContac system was specifically developed for prototype circuit boards and PCB repairs with up to fifty through-holes per circuit board.

**Portable toolset**
All the necessary parts are conveniently packed in a portable toolcase, perfect for field engineers. Each set includes:

<table>
<thead>
<tr>
<th>Amount</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Automatic punch tool with stamp tip A for 0.6 (24 mil) and 0.8 mm (32 mil) (inner diameter) rivets</td>
</tr>
<tr>
<td>1</td>
<td>Tool tip B for 1.0 (40 mil) and 1.2 mm (48 mil) (inner diameter) rivets</td>
</tr>
<tr>
<td>1</td>
<td>Pair of tweezers</td>
</tr>
<tr>
<td>1</td>
<td>Anvil plate</td>
</tr>
</tbody>
</table>

**Copper alloy rivets**

<table>
<thead>
<tr>
<th>Amount</th>
<th>Diameter (mil)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,000</td>
<td>0.8 (32)</td>
</tr>
<tr>
<td>1,000</td>
<td>1.0 (40)</td>
</tr>
<tr>
<td>1,000</td>
<td>1.2 (48)</td>
</tr>
<tr>
<td>1,000</td>
<td>1.4 (56)</td>
</tr>
</tbody>
</table>

The internal diameter is 0.2 mm (8 mil) or 0.4 mm (16 mil) smaller than the desired external diameter.

Content subject to change.

**Easy to learn**
Rivets are simply placed in the through-holes, supported by a backing plate, and riveted with a stamping tool. A touch of solder completes the connection.

**Specification table**

<table>
<thead>
<tr>
<th>LPKF EasyContac</th>
<th>110914</th>
</tr>
</thead>
<tbody>
<tr>
<td>Part #</td>
<td>110914</td>
</tr>
<tr>
<td>Max. base material size</td>
<td>No limit</td>
</tr>
<tr>
<td>Number of layers</td>
<td>2</td>
</tr>
<tr>
<td>Maximum resistance</td>
<td>10 mΩ</td>
</tr>
<tr>
<td>Environmental compatibility</td>
<td>Excellent</td>
</tr>
<tr>
<td>Through-plated holes/min</td>
<td>2 or 3</td>
</tr>
<tr>
<td>Process reliability</td>
<td>Good</td>
</tr>
<tr>
<td>Base material types</td>
<td>FR4, 1.5 mm (59 mil) thickness</td>
</tr>
</tbody>
</table>

Specifications subject to change.
Comparison of through-hole conductivity solutions

LPKF offers three different through-hole conductivity solutions for the rapid PCB environment. Each enjoys a unique set of features and is uniquely applicable to a set of applications.

The application best determines the method of creating through-hole conductivity. Characteristics such as the size of the workpiece and the size of the production run are key, as well as special factors, such as certain substrates, circuit types, and other conditions.

<table>
<thead>
<tr>
<th>Solutions</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>LPKF ProConduct®</td>
<td>A versatile manual conductivity solution that works without chemical baths. The LPKF ProConduct® uses a specially developed conductive polymer to quickly and easily plate vias in just a few minutes.</td>
</tr>
<tr>
<td>LPKF Contac RS/MiniContac RS</td>
<td>Professional stand-alone chemical electroplating solutions, with reverse pulse plating. The Contac RS and MiniContac RS systems are self-contained and require no additional chemical maintenance.</td>
</tr>
<tr>
<td>LPKF EasyContac</td>
<td>An easy-to-use low quantity manual through-hole conductivity solution. Simplicity, portability, and its compact nature make the EasyContac system an ideal entry-level through-hole conductivity system.</td>
</tr>
</tbody>
</table>

**Small production run, low hole count**
Although the Contac RS/MiniContac RS and ProConduct® systems will perform well for small production runs and low hole count boards (less than fifty holes), the EasyContac system is designed specifically for such applications.

**Small production run, high hole count**
For small production runs, the ProConduct® system, Contac RS and MiniContac RS plate any number of holes quickly and easily.

**Medium production run**
For medium production runs, the Contac RS and MiniContac RS electrochemical plating solutions are the ideal solution. These tanks quickly process circuit boards of a variety of shapes and sizes, consistently producing copper-plated through-holes.

**Difficult surfaces**
Substrates that possess particular challenges, such as pure PTFE.

**RF/microwave circuitry**
The strict geometric requirements of RF/microwave circuitry are best served by the LPKF ProConduct®.

**Tin plating**
For applications requiring tin-plated surfaces, LPKF’s Contac RS electrochemical through-hole plating system includes the option of a heated tank for tin plating.

**Chemical concerns**
For environments and laboratories where chemicals are a concern, the LPKF EasyContac and ProConduct® both provide excellent through-hole conductivity, without a single chemical bath.

**High-power circuitry**
High-power circuitry requires larger holes and heavier plating and for these applications, LPKF recommends using the Contac RS electroplating product.

**Reverse pulse plating**
The LPKF Contac RS and MiniContac RS use reverse pulse plating to achieve substantially cleaner results in through-hole plating. Reverse pulse plating provides a more uniform coating of copper and prevents the build-up and clogging of copper at the mouths of the through-hole.

* only Contac RS
In any rapid PCB prototyping situation, keeping the process as simple and as quick as possible is paramount to a successful operation. The sooner a prototype is completed, the sooner the design can be tested under production conditions and the smaller that design loop, the shorter the time-to-market.

Today’s complex prototyping requires higher circuit density than ever before, and that includes multilayer boards. A multilayer board allows for a much more compact layout because circuits can be routed on hidden layers within the substrate itself.

A typical multilayer circuit board consists of various layers of the following three items:
- A base material (or substrate), such as FR4 or alumina, which supports the circuit.
- Copper (or other conductor) layers, where the circuits are structured.
- Prepreg, an insulative layer sandwiched between layers of copper.

These layers must be bonded properly to assure that no air or other impurities can contaminate or otherwise damage the interior of the circuit.

The final key to a successful multilayer board is a consistent, high-quality method of creating through-hole continuity that is complementary to the multilayer process.
The LPKF MultiPress S is a bench-top multilayer press, ideal for creating multilayer circuit boards in a laboratory or prototyping environment. The MultiPress S is useful when speed, security, or convenience are key factors in the creation of custom or prototype printed circuit boards and is an indispensable tool in any rapid PCB prototyping situation. With a shorter pressing time of approximately 90 minutes, the system offers faster turnaround times than ever before: develop production-quality multilayer prototype boards in less than a day!

- **Multilayer PCB prototypes and production boards in-house**
- **Very fast process**
- **Easy-to-use LCD interface**
- **Uses preprogrammed or user-programmed profiles**
- **Bonds rigid and flexible substrates**
- **Perfect for RF-materials**

<table>
<thead>
<tr>
<th>Item</th>
<th>LPKF MultiPress S with automatic hydraulics</th>
<th>LPKF MultiPress S with hand pump</th>
</tr>
</thead>
<tbody>
<tr>
<td>Part #</td>
<td>120736</td>
<td>120734</td>
</tr>
<tr>
<td>Order Info</td>
<td>Inside front cover</td>
<td></td>
</tr>
</tbody>
</table>
**Bringing Multilayer Prototyping In-House**

The LPKF MultiPress S bonds multilayer circuits of all common rigid and flexible substrates. It delivers equal pressure to the full press plate area. With precise control of all important process parameters such as temperature, pressure and cycle times, the LPKF MultiPress S produces regular and durable lamination. Specific process profiles with temperature peaks up to 250 °C (482 °F) can bond even RF-materials together. A powerful heating unit and efficient heat transmission for short cool-down phases reduce process times to a minimum.

**Small Footprint**

The MultiPress S enjoys a remarkably small footprint. It measures only 600 x 530 mm (23.6" x 20.9"), making it ideal for small spaces in R&D and prototyping laboratories. LPKF also provides an optional table specially designed for the MultiPress S, or it can be placed on any surface certified to support at least 170 kg (375 lbs).

**Accessories and upgrades**

**Mobile table**

LPKF provides an optional table specially designed for the MultiPress S.

Part #: 107050

**Programmable Profiles**

Nine different heating/pressing/cooling profiles can be programmed into the MultiPress S's microprocessor-controlled system, allowing for total customization of the process from start to finish.

**Operation**

The MultiPress S is delivered with an automatic hydraulic press mechanism, which provides constant and reliable pressure control. The LPKF MultiPress S can also be equipped with a hand pump instead of an automatic press, to accommodate lower budgets.

**Specification table**

<table>
<thead>
<tr>
<th>Part #</th>
<th>LPKF MultiPress S with automatic hydraulics</th>
<th>LPKF MultiPress S with hand pump</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Part #</td>
<td>Max. layout area</td>
</tr>
<tr>
<td>120736</td>
<td>120734</td>
<td>200 x 275 mm (7.8&quot; x 10.8&quot;)</td>
</tr>
</tbody>
</table>

Part #: 120736

|          | 120734                                    | Max. layout area                 | Max. press area                  | Max. pressure | Max. temperature | Max. number of layers | Pressing time | Weight | Power supply | Microprocessor controlled | Dimensions pressure unit (W/H/D) | Weight pressure unit | Base materials |
| 120734   | 120734                                    | 200 x 275 mm (7.8" x 10.8")     | 229 x 305 mm (9.0" x 12.0")     | 286 N/cm² within the press area | 250 °C (480 °F) | 8 (depends on material and layout) | Approx. 90 min a | 170 kg (375 lbs) b | 230V, 50/60 Hz, 2.3 kW | 9 pressure/temperature/time profiles | 600 x 620 x 530 mm (23.6" x 24.4" x 20.9") | 5 kg (11 lbs) | FR4, others upon request |

Specifications subject to change.

*a* depending upon Prepeg  

*b* plus weight of hand pump or automatic hydraulic press mechanism
Applications

Besides standard FR4 multilayer boards, the LPKF MultiPress S is ideal for the following applications:

Rigid-flex
Rigid-flexible printed circuit boards combine flexible and rigid printed circuit boards. They can be processed in principle similar to multilayers. For the professional bonding of rigid-flexible printed circuit boards only an increase of press temperature and pressure is necessary; compared to the bonding of rigid multilayers. In addition in the rigid part different prepregs are partly used.

RF multilayer
RF multilayer boards are created on special base materials and prepregs. RF bonding films and RF prepregs are bonded similar to FR4 multilayer boards, but use a higher temperature and pressure.

Special notes for multilayer board production

The LPKF MultiPress S is an ideal solution for the rapid development of boards as complex as eight layers. Using the various time, temperature, and pressure profiles permits a great deal of flexibility when assembling and bonding the layers for a multilayer prototype. Building from the center, the MultiPress S bonds all layers of the prototype simultaneously, creating a prototype the quality of which is indistinguishable from any production board – in a fraction of the time an exterior board house would require.
Introduction to SMT prototyping

Contents

LPKF ProMask and ProLegend ............. 69
In-house production of solder-resist masks
LPKF ZelPrint LT300 and
ZelPrint LT300 RP ..................... 73
SMT solder paste printer
LPKF ProtoPlace .......................... 77
Pick & Place assembly system
LPKF ProtoFlow and ProtoFlow N2 ........ 81
Lead-free reflow oven ideal for in-house rapid
PCB prototyping
Review of rapid prototyping for
SMT circuitry ........................... 85

Although accuracy and precision is vital, the real key to a well-functioning SMT prototyping solution is a tightly integrated suite of tools.

1. The circuit board must be milled, routed and through-plated, using a tool such as the ProtoMat S100 and Contac RS. This creates the printed circuit board on the substrate.

2. An insulative mask must be applied to the board, to avoid shorts and corrosion during the remaining steps and after production.

3. Solder paste must be applied where components will be placed. Application of solder paste is a precision operation.

4. The printed circuit board must be populated. All components must be placed precisely and because SMD components are so small, this must usually be performed using a semi-automated placement system such as the LPKF ProtoPlace.

5. The final step in any SMT prototyping process is the reflow soldering process, where the populated printed circuit board is heated in a carefully regulated temperature profile sequence that melts the solder paste.

LPKF provides exactly these tools, perfect for SMT prototyping situations of any size and shape.
LPKF ProMask and ProLegend

In-house screenprinting and solder-resist masks

An easy-to-use cost-effective solution for producing professionally masked PCBs in an in-house prototyping environment. LPKF ProMask gives already milled prototype circuit boards the professional finish they deserve. The quick and simple process enables the soldering of SMD or conventional components with no fear of short circuits.

- Compact, quick and easy to use
- Professional finish and perfect soldering
- Four simple steps to a professional result

<table>
<thead>
<tr>
<th>Item</th>
<th>LPKF ProMask®</th>
<th>ProLegend</th>
</tr>
</thead>
<tbody>
<tr>
<td>Part #</td>
<td>117072</td>
<td>117584</td>
</tr>
<tr>
<td>Order info</td>
<td>Inside front cover</td>
<td></td>
</tr>
</tbody>
</table>
Professional solder-resist masks for in-house prototyping

The LPKF ProMask is an easy-to-apply green solder-resist mask. This professional finish, ideal for all rapid PCB projects, is especially critical for SMT projects, where lines are very close and circuit isolation/insulation is a key component of the prototyping process. The ProMask system requires very little training and no prior experience to master.

Perfect results for in-house prototyping

The LPKF ProMask finishes prototype PCBs professionally and helps protect traces and prevent short circuits from soldering conventional through-hole or SMT components.

Easy to use

The LPKF ProMask includes all the necessary instructions, tools, and supplies. All consumables are premeasured and individually sealed.

Environmentally friendly

All remnants from the ProMask process are rendered environmentally harmless with an included Ph conditioning powder. Disposal is safe and simple.

Security and rapid turnaround time

In-house PCB prototyping moves circuits from design to prototype to market faster by eliminating production delays and high costs associated with outside vendors. Additionally, all designs remain securely within the organization.

LPKF ProMask Set

All the necessary parts are conveniently packed in a portable toolcase, perfect for field engineers. Each set includes:

<table>
<thead>
<tr>
<th>Amount</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>Solder resist</td>
</tr>
<tr>
<td>1</td>
<td>Developer dish</td>
</tr>
<tr>
<td>1</td>
<td>5 cm roller with pan</td>
</tr>
<tr>
<td>20</td>
<td>Laser printed foil DIN A4</td>
</tr>
<tr>
<td>10</td>
<td>LPKF developer</td>
</tr>
<tr>
<td>10</td>
<td>LPKF conditioner</td>
</tr>
<tr>
<td>1</td>
<td>Cleaner</td>
</tr>
<tr>
<td>1</td>
<td>PCB cleaner</td>
</tr>
<tr>
<td>10</td>
<td>Foam roller</td>
</tr>
<tr>
<td></td>
<td>Various accessories</td>
</tr>
</tbody>
</table>

Content subject to change.

Produce professional legend printing with LPKF ProLegend!

Produce professionally finished boards with LPKF’s ProLegend, a simple-to-use method of adding screenprinting, logos, and circuit legends to any prototype PCB.
Apply the solder-resist mask in four simple steps

1 Producing the artwork
   The artwork template is easily produced by printing it from LPKF CircuitCAM (version 5.0 or above) on a standard laser printer (for best results 600 or 1,200 dpi).

2 Applying the solder-resist lacquer
   The lacquer is simply mixed using the single portion packets of lacquer and hardener. It is then applied to the finished prototype PCB using a disposable roller. After application the PCB is pre-dried for 10 minutes in the hot air oven.

3 Exposing PCB with the artwork
   The PCB is placed in the image exposure unit and the artwork is placed over it using registration marks. The exposure unit is switched on for 30 seconds after which the board is removed and the artwork film pulled off.

4 Developing and hardening the solder-resist mask
   A bath of developer is prepared from the developer powder and hot water. The PCB is immersed in the bath and the non-exposed resist is removed by gently brushing. The lacquer residue is rinsed off under flowing water, then the resist is hardened for 30 minutes in the hot air oven after which the board can be cleaned with LPKF cleaner and rinsed with water.

ProLegend’s process is almost identical.
Please contact a sales representative for more information.
Accessories and consumables

### Accessories

**UV-Exposer**
Transfer the artwork pattern to the PCB surface in approximately thirty seconds.

230/240 V: Part # 117050
110/120 V: Part # 117192

**Hot air oven**
Pre-dry the PCB and harden the resist in thirty minutes using the hot air oven. The oven offers an integrated time switch clock and a precise temperature regulator.

Part # 115877

### Consumables

**LPKF ProMask Consumables Set**
Includes ProMask lacquer gel, developing foils, and developer.

Part # 117108

### Specification table

<table>
<thead>
<tr>
<th></th>
<th>LPKF ProMask</th>
<th>LPKF ProLegend</th>
</tr>
</thead>
<tbody>
<tr>
<td>Part #</td>
<td>117072</td>
<td>117584</td>
</tr>
<tr>
<td>Maximum base material dimensions</td>
<td>229 x 305 mm (9” x 12”)</td>
<td></td>
</tr>
<tr>
<td>Maximum working area of image exposor</td>
<td>240 x 340 mm (9.5” x 13”)</td>
<td></td>
</tr>
<tr>
<td>Processing time</td>
<td>Approx. 60 min</td>
<td></td>
</tr>
<tr>
<td>Pad separation</td>
<td>≥0.5 mm (20 mil) fine pitch</td>
<td></td>
</tr>
<tr>
<td>Adhesion strength</td>
<td>Class H and T, testing method: IPC-SM-840 C, Subsection 3.5.2.1</td>
<td></td>
</tr>
<tr>
<td>Solder bath resistance</td>
<td>20 sec at 265 °C (509 °F), testing method: IPC-SM-840 C, Subsection 3.7.2</td>
<td>20 sec at 288 °C (550 °F), testing method: MIL-P 55 110 D</td>
</tr>
<tr>
<td></td>
<td>10 sec at 288 °C (550 °F), testing method: MIL-P 55 110 D</td>
<td>20 sec at 288 °C (550 °F), testing method: UL 94 (lead-free)</td>
</tr>
<tr>
<td>Surface resistance</td>
<td>2x 10 exp14 Ω, testing method: VDE 0303, Section 30, DIN IEC 93</td>
<td>Class H and T, testing method: IPC-SM-840 C, Subsection 3.9.1</td>
</tr>
<tr>
<td>Moisture resistance and isolation resistance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Solvent/Cleaning agent stability</td>
<td>IPC-SM-840 C (10% caustic cleaner, isopropyl alcohol, monoethanolamine)</td>
<td></td>
</tr>
<tr>
<td>Minimum capital height</td>
<td>2.0 mm (with 1,200 dpi laser printer)</td>
<td></td>
</tr>
<tr>
<td>Minimum capital strength</td>
<td>0.1 mm (with 1,200 dpi laser printer)</td>
<td></td>
</tr>
<tr>
<td>Hardware requirements</td>
<td>Min. 600 dpi laser printer</td>
<td></td>
</tr>
<tr>
<td>Software requirements</td>
<td>CircuitCAM 5.1 or higher</td>
<td></td>
</tr>
</tbody>
</table>

Specifications subject to change.
LPKF ZelPrint LT300 and ZelPrint LT300 RP
SMT solder paste printer

On-contact fine-pitch printing
Parallel stencil separation
Printing populated double-sided boards
Compatible with various stencil frames
Test print screen included
Screen printing
Optional vacuum table for printing on flex and rigid PCBs

The LPKF ZelPrint LT300 is a precision manual stencil printer. This tabletop model can be used for prototypes and for small batches of fine pitch SMT boards. On-contact fine-pitch printing, precise vertical separation between stencil and PCB, and slow snap-off provides superb printing results. This unique solution allows printing of 0.3 mm (12 mil) pitch (ultra-fine-pitch area).

The LPKF ZelPrint LT300 boasts high positioning accuracy, simple operation and the ability to use milled polymer stencils (limited to 0.65 mm [25 mil] pitch), reducing costs and increasing efficiency in the production of circuit board prototypes.

This printer is shipped with a ZelFlex stretching frame for stencils, but is also compatible with various other frames.

The LPKF ZelPrint LT300 RP is equipped with a ZelFlex stretching frame and adapter, used for directly clamping polymer stencils of DIN A4 size, made with a LPKF ProtoMat.

<table>
<thead>
<tr>
<th>Item</th>
<th>LPKF ZelPrint LT300</th>
<th>LPKF ZelPrint LT300 RP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Part #</td>
<td>107356</td>
<td>122241</td>
</tr>
<tr>
<td>Order info</td>
<td>Inside front cover</td>
<td>Inside front cover</td>
</tr>
</tbody>
</table>
**Fine pitch printing**
Precise three-dimensional (X, Y, rotation and clearance) adjustment, including rotation of the PCB and the stencil with micrometer screws, is vital for superior printing results. Excellent positioning accuracy, and a specially developed lever for quick parallel separation of the PCB and stencil, makes ultra-fine-pitch printing possible. Micrometer screws easily and precisely adjust the PCB-screen gap.

**Advanced features**
The LPKF ZelPrint LT300 features freely adjustable, high-clearance PCB nesting pins that allow boards populated on one side to be printed on the other. Frames, such as the LPKF ZelFlex, easily mount on adjustable supports and clamp with height and length adjustable fixing clamps. The LPKF ZelPrint LT300 includes a test print screen for fast set-up of new print jobs.

**Polymer stencil for rapid PCB prototyping**
The ability to use milled polymer stencils (limited to 0.625 mm/25 mil pitch) reduces costs and increases efficiency in the production of circuit board prototypes.
Vacuum table
Vacuum table for printing on flex and rigid PCBs as well as for fast clamping of rigid PCBs is available as an option. Flex and rigid boards can be easily moved to the LPKF ProtoPlace together with a vacuum table as 100% compatibility is ensured. The table can be easily and freely moved from one device to another without disconnection or interruption of vacuum.

Special perforated ceramic printing plate is also available as an option for vacuum table to move assembled flex boards an into reflow oven.

Further information upon request!

Accessories

ZelFlex Frames for LPKF ZelPrint LT300

Mechanical stretching frame
Insert plastic or metal stencils into double-sided LPKF ZelFlex ZR frames. The fast exchange and patented stretching system optimizes tensioning and easy handling.

Pneumatic stretching frame
Professional quick-release stencil frame with pneumatic 4-side action: Ideal for high-volume environments. Frame maintains tension even after air is disconnected.

Further stretching frames upon request!

ZelFlex Frames for LPKF ZelPrint LT300 RP

Mechanical stretching frame
LPKF ZelFlex ZR 266 x 380 is specially designed for DIN A4 polymer stencils.

Options
Squeegees
LPKF offers different types of squeegees for the application of solder paste.

Test print screen
Test print screen is a unique solution for fast set up of a new print job.
Part # 115632

Specification table

<table>
<thead>
<tr>
<th>Specification</th>
<th>LPKF ZelPrint LT300</th>
<th>LPKF ZelPrint LT300 RP</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Part #</strong></td>
<td>107356</td>
<td>122241</td>
</tr>
<tr>
<td><strong>Frame dimensions</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Width up to 430 mm (16.92&quot;)</td>
<td>Width up to 430 mm (16.92&quot;)</td>
<td></td>
</tr>
<tr>
<td>Length adjustable from 420 to 520 mm (16.54&quot; to 20.47&quot;)</td>
<td>Length adjustable from 420 to 520 mm (16.54&quot; to 20.47&quot;)</td>
<td></td>
</tr>
<tr>
<td>Height adjustable from 20 to 40 mm (0.78&quot; to 1.57&quot;)</td>
<td>Height adjustable from 20 to 40 mm (0.78&quot; to 1.57&quot;)</td>
<td></td>
</tr>
<tr>
<td><strong>Max. printing area</strong></td>
<td>300 x 300 mm (11.8&quot; x 11.8&quot;)</td>
<td>300 x 300 mm (11.8&quot; x 11.8&quot;)</td>
</tr>
<tr>
<td><strong>Print stroke</strong></td>
<td>Manual</td>
<td>Manual</td>
</tr>
<tr>
<td>X and Y ±10 mm (0.4&quot;/400 mil), ø±5&quot;</td>
<td>X and Y ±10 mm (0.4&quot;/400 mil), ø±5&quot;</td>
<td></td>
</tr>
<tr>
<td>Max. PCB thickness</td>
<td>5 mm (0.2&quot;), optionally more</td>
<td>5 mm (0.2&quot;), optionally more</td>
</tr>
<tr>
<td>Frame type</td>
<td>ZR 362 x 480</td>
<td>ZR 266 x 380 with adapter</td>
</tr>
<tr>
<td>Squeegee type</td>
<td>Hand squeegee, rubber, 260 mm (10.2&quot;)</td>
<td>Hand squeegee, metal, 150 mm (5.9&quot;)</td>
</tr>
<tr>
<td>Accuracy (machine)</td>
<td>±0.025mm (±1 mil)</td>
<td>±0.025mm (±1 mil)</td>
</tr>
<tr>
<td>Double-side printing</td>
<td>Max. height of components 15 mm (0.59&quot;)</td>
<td>Max. height of components 15 mm (0.59&quot;)</td>
</tr>
<tr>
<td>Dimensions (W/H/D)</td>
<td>850 x 180 x 530 mm (33.4&quot; x 7.1&quot; x 20.9&quot;)</td>
<td>850 x 180 x 530 mm (33.4&quot; x 7.1&quot; x 20.9&quot;)</td>
</tr>
<tr>
<td>Weight</td>
<td>30 kg (66 lbs)</td>
<td>30 kg (66 lbs)</td>
</tr>
<tr>
<td>Ambient operating conditions</td>
<td>Temperature: 15–35 °C (59–95 °F)</td>
<td>Temperature: 15–35 °C (59–95 °F)</td>
</tr>
<tr>
<td></td>
<td>Humidity: 30–80%</td>
<td>Humidity: 30–80%</td>
</tr>
</tbody>
</table>

Specifications subject to change.
LPKF ProtoPlace
Pick & Place assembly system

The LPKF ProtoPlace is an ergonomically designed, semi-automatic pick & place system for the professional assembly of SMT printed circuit board prototypes and small batch projects. The ProtoPlace allows fast assembling of SMT boards, with the user controlling each step of the assembly process to get through a keyboard and LC-display. Most functions are easily executed from an interface panel with four directional arrows.

An optional camera system coupled with the monitor ensures easy and accurate component positioning control, so the ProtoPlace can precisely assemble circuits.

Manually guided movements of the ProtoPlace manipulator can be locked in X, Y and Z-directions, and fine adjustments can be performed using micrometer screws. A pneumatic device supports the positioning of the components, eliminating errors and guaranteeing accuracy.

Three different feeder types supply the components. An integrated dispenser for adhesives and solder paste is standard equipment.

- Precise fine-pitch component assembly
- Pneumatic component placement
- Integrated multifunctional adhesives and solder paste dispenser
- Optional camera system aids component positioning
- Optional motorized turntable
- Different feeders are available as an option
- Multiple feeder positions
- Optional vacuum table for flex boards
- Microprocessor-controlled electronics
The LPKF ProtoPlace features:

**Micro-table**

The micro-table clamps printed circuit boards as large as 297 x 420 mm (11.8” x 16.5”). A fine-adjustment capability and X- and Y-axis lockdowns make the ProtoPlace ideal for the placement of complex components.

**Manipulator**

The manipulator pick & place the components, and applies paste, glues and washers. The manipulator easily reaches every feeder (stick and tape feeders, turntable, or palette) by using a vacuum picking needle. An additional manual control rotates components where needed and automatically places components.

**Keyboard**

The integrated multifunctional keyboard allows the direct selection of functions and setting precise individual parameters.

**LC-display**

All functions and parameters can be easily selected and displayed on the four-lined LC-display, while directing the operator to the next step.

**Dispensing with Micro Camera**

For a precise dispensing of conductive adhesive or solder paste, advanced features of the LPKF ProtoPlace can be used, such as: blocking of manipulator head, precise micrometer movements in X/Y direction and triggering dispenser using footswitch. The micro camera option, used together with the dispenser, is very helpful for complex tasks.

**And much more, such as:**

**Multifunctional dispenser**

This external unit dispenses soldering paste, glues, and washers from its mount directly on the manipulator. It also enables dispensing of low viscosity media.

**Air controls**

The air regulator regulates pressure during dispensing, vacuum during placement, and vacuum during dispensing.

**Foot switch**

The integrated foot switch provides additional hands-free mode control to the user.
### LPKF Place-E for educational purposes

The LPKF Place-E is specially designed to meet educational needs for an affordable in-class assembly process. The LPKF Place-E is an intuitive ergonomic pick & place system, where components can be picked up from 15 antistatic bins using a vacuum pipette. A movable hand rest provides a stable support for the operator’s hand while placing components. For delicate components a single LPKF-ProtoPlace for the whole group can be useful.

### Process organisation for 20 participants

<table>
<thead>
<tr>
<th>Solder paste printing</th>
<th>Assembling</th>
<th>Reflow soldering</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 min. for 1 PCB</td>
<td>20–30 min. for 1 PCB</td>
<td>5 min. for 1 PCB</td>
</tr>
<tr>
<td>60 min. for 20 PCBs</td>
<td>appx. 60 min. for 20 PCBs</td>
<td>25 min. for 20 PCBs</td>
</tr>
</tbody>
</table>

In a running process each student operates self-contained at the Printer. Time for all settings and printing one board takes about 3 min.

Two students work one after another on one LPKF Place-E.

In one LPKF ProtoFlow four PCBs, PCB size less than 150 x 100 mm (6” x 4”), will be soldered at the same time. This process takes about 5 min.

### Accessories for LPKF ProtoPlace

#### Micro camera
The micro camera mounts directly on the manipulator and feeds a video signal of the process to the optional monitor. This increases control and accuracy when placing fine-pitch components.

Part # 115040

#### Color LCD monitor
The optional LCD monitor, in tandem with the optional micro camera, allows the user to track and control small parts placement very precisely.

Part # 119777

#### Motorized turntable
The optional motorized turntable stores individual components in bins, and permits a significantly accelerated picking process. The bins can be labelled with type, value and sign.

- 45 component bins: Part # 114460
- 75 component bins: Part # 114461
- 90 component bins: Part # 114462
### Accessories

#### Vacuum table
Vacuum table for placement of components on flex or rigid PCBs. Details see page 75.

**Part # 119684**

#### Compressor
Features extra quiet operation (52 dB), a 6 l (1.5 gal) container, produces 6 bar and an output of 33 l/min (1.1 ft³/min).

**Part # 101092**

#### Air supply unit
Air pressure regulator with water separator and 5um filter; mounted on stand for clamping on the table.

**Part # 124919**

#### Feeder carrier
Place up to twelve different component feeders into the optional feeder carrier. The feeder carrier is necessary if tape feeder or stick feeders are required.

**Part # 115590**

#### Tape feeders
The LPKF ProtoPlace uses tape feeders serving 8 mm, 12 mm, and 16 mm components.

- Tape feeder 8 mm: **Part # 116004**
- Tape feeder 12 mm: **Part # 116008**
- Tape feeder 16 mm: **Part # 116009**

#### Stick feeders
The LPKF ProtoPlace supports stick feeders serving different components.

- S08–S028: **Part # 101356**
- S08L–S028L: **Part # 101356**
- PLCC28–PLCC44: **Part # 101357**
- PLCC52–PLCC84: **Part # 103897**

### Specification table

<table>
<thead>
<tr>
<th>LPKF ProtoPlace</th>
<th>114459</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Part #</strong></td>
<td></td>
</tr>
<tr>
<td>Maximum PCB size</td>
<td>297 x 420 mm (11.8” x 16.5”)</td>
</tr>
<tr>
<td>Minimum size of components</td>
<td>0201 chip components</td>
</tr>
<tr>
<td>Pulse/pause duration</td>
<td>0.1–9 sec/0.1–2 sec</td>
</tr>
<tr>
<td>Number of dosing points</td>
<td>Up to 300 per minute</td>
</tr>
<tr>
<td>Dosing quantity</td>
<td>Min. 0.2 µliters</td>
</tr>
<tr>
<td>Turntable position</td>
<td>Back and/or left</td>
</tr>
<tr>
<td>Feeders position</td>
<td>Left</td>
</tr>
<tr>
<td>Operating air pressure</td>
<td>0.1–4 bar (1.4–58 psi)</td>
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<tr>
<td>Vacuum</td>
<td>Max. 0.8 bar (11.4 psi)</td>
</tr>
<tr>
<td>Weight</td>
<td>25–35 kg (55–77 lbs) depending on accessories</td>
</tr>
<tr>
<td>Dimensions (W/H/D)</td>
<td>1.000 x 500 x 900 mm (40” x 20” x 35”)</td>
</tr>
<tr>
<td>Dimensions (W/H/D) (w/ all feeders and turntable)</td>
<td>760 x 250 x 760 mm (30” x 10” x 30”)</td>
</tr>
<tr>
<td>Ambient operating conditions</td>
<td>Temperature: 15–35 °C (59–95 °F)</td>
</tr>
<tr>
<td></td>
<td>Humidity: 30–80%</td>
</tr>
<tr>
<td>Compressed air supply</td>
<td>6 bar (87 psi), min. 10 l/min (0.35 cfm), oil free, water free</td>
</tr>
<tr>
<td>Power supply</td>
<td>115/230 V, 50–60 Hz, 10 W</td>
</tr>
</tbody>
</table>

Specifications subject to change.
The ProtoFlow is LPKF’s premiere convection oven, ideal for lead-free reflow soldering. A host of features and accessories make it one of the most useful components in any rapid PCB prototyping environment.

The LPKF ProtoFlow is a key component in lead-free rapid SMT prototyping and small batch production. Compact and versatile, it offers precisely controlled temperature/time profiles and a large working area with motorized drawer for automatic cool-down. The special MultiZone function enables the reflow time to be divided into three separate phases with temperature ramp definitions for each phase. Four internal sensors, together with 3 separately controlled heaters, allow an even and precisely controlled heat distribution over the PCB’s entire surface. The LPKF ProtoFlow is an excellent device for SMT reflow soldering, hardening of conductive through-hole plating polymer, and other thermal processes.

The LPKF ProtoFlow N2 is equipped with a digital flow meter for inert gas. The nitrogen atmosphere substantially prevents oxidation during the reflow process, assuring optimal results of soldered joints.

- Lead-free reflow process
- User-friendly LC-display with keyboard ensures easy operation
- Preprogrammed with industry standard profiles
- Integrated USB port for easy programming of reflow profiles and process recording and analysis
- Motorized drawer for automatic cool-down after reflow phase
- Inert gas option of LPKF ProtoFlow N2 prevents oxidation
- Profile recorder option

<table>
<thead>
<tr>
<th>Item</th>
<th>LPKF ProtoFlow</th>
<th>LPKF ProtoFlow N2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Part #</td>
<td>117609</td>
<td>117817</td>
</tr>
<tr>
<td>Order info</td>
<td>Inside front cover</td>
<td>Inside front cover</td>
</tr>
</tbody>
</table>
Guaranteed sophisticated PCB prototyping in the lab

**User friendly menu navigation**
The LC-display together with the keyboard allows for extremely easy programming. All profile parameters such as temperature, process duration, and reflow ramp-up can be individually programmed and stored as a custom profile.

**Motorized drawer**
The LPKF ProtoFlow is equipped with a motorized drawer which opens automatically to begin the cool-down phase after the reflow process has been completed. Therefore, the operator does not need to be present during the reflow process to open the drawer.

**Illuminated process chamber**
Observe the process through the ProtoFlow’s window. Integrated interior lighting reveals the status of the soldering process and allows for on-the-fly job modification where needed to optimize the reflow process.

**PC support**
Every LPKF ProtoFlow is equipped with intuitive PC software, which enables real-time temperature recording, profile programming, and profile database via the USB communication port. Profile chart and temperature values are created in a spreadsheet.
Applications

The LPKF ProtoFlow is ideal for SMT reflow soldering, curing of adhesives and conductive polymers, and other thermal procedures.

Options

Inert gas option
An external connection with digital flow meter for inert gas is available for the LPKF ProtoFlow N2. The nitrogen atmosphere significantly reduces the oxidation during the soldering process, and ensures better solder joint results.

Art.-Nr. 117817

Profile recorder
The LPKF ProtoFlow can be fitted with a Profile recorder module for measuring real-time temperatures of particular areas or components on the PCB by using four thermocouple probes. This is a useful aid for reflow profiling, monitoring actual temperature of sensitive components, or for testing SMT components during the reflow cycle. Temperature profiles from up to four user-positioned sensors can be displayed in a temperature/time chart during the process, and can be stored for reference or further analysis. PC with USB port and a spreadsheet are necessary for the recording option.

Art.-Nr. 117850
## Specification table

<table>
<thead>
<tr>
<th></th>
<th>LPKF ProtoFlow</th>
<th>LPKF ProtoFlow N2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Part #</strong></td>
<td>117609</td>
<td>117817</td>
</tr>
<tr>
<td><strong>Max. PCB size</strong></td>
<td>230 x 305 mm (9&quot; x 12&quot;)</td>
<td>230 x 305 mm (9&quot; x 12&quot;)</td>
</tr>
<tr>
<td><strong>Preheating temperature/time</strong></td>
<td>220 °C (428 °F), 999 sec</td>
<td>220 °C (428 °F), 999 sec</td>
</tr>
<tr>
<td><strong>Max. reflow temperature/time</strong></td>
<td>320 °C (608 °F), 600 sec</td>
<td>320 °C (608 °F), 600 sec</td>
</tr>
<tr>
<td><strong>Long thermal treatment temperature/time</strong></td>
<td>220 °C (428 °F), 64 h</td>
<td>220 °C (428 °F), 64 h</td>
</tr>
<tr>
<td><strong>Temperature stabilization time</strong></td>
<td>&lt;5 min</td>
<td>&lt;5 min</td>
</tr>
<tr>
<td><strong>PCB cooling</strong></td>
<td>Double, speed-adjustable bottom-mounted fan</td>
<td>Double, speed-adjustable bottom-mounted fan</td>
</tr>
<tr>
<td><strong>Power connection</strong></td>
<td>230 V, 50–60 Hz, single phase</td>
<td>230 V, 50–60 Hz, single phase</td>
</tr>
<tr>
<td><strong>Max. power consumption</strong></td>
<td>3.2 kW</td>
<td>3.2 kW</td>
</tr>
<tr>
<td><strong>Dimensions (W/H/D)</strong></td>
<td>647 x 315 x 450 mm (25.5&quot; x 12.4&quot; x 17.7&quot;)</td>
<td>647 x 315 x 450 mm (25.5&quot; x 12.4&quot; x 17.7&quot;)</td>
</tr>
<tr>
<td><strong>Weight</strong></td>
<td>22 kg (48.5 lbs)</td>
<td>22 kg (48.5 lbs)</td>
</tr>
<tr>
<td><strong>Ambient operating conditions</strong></td>
<td>Temperature: 15–35 °C (59–95 °F)</td>
<td>Temperature: 15–35 °C (59–95 °F)</td>
</tr>
<tr>
<td></td>
<td>Humidity: 30–80%</td>
<td>Humidity: 30–80%</td>
</tr>
<tr>
<td><strong>Operating N2 pressure</strong></td>
<td>–</td>
<td>7 bar (101.5 psi)</td>
</tr>
<tr>
<td><strong>N2 flow range</strong></td>
<td>–</td>
<td>200–500 l/h (0.12–0.29 cfm)</td>
</tr>
</tbody>
</table>

Specifications subject to change.
Review of rapid prototyping for SMT circuitry

LPKF Laser & Electronics provides this complete suite of tools for the creation of in-house PCB prototyping of SMT components.

The LPKF ProtoMat S100, an excellent high-speed circuit board plotter can produce PCB prototypes in a matter of minutes.

The LPKF ProMask provides the ability to cover PCB traces with a solder resistant green mask, protecting traces during the remaining process and beyond into production.

The LPKF ProConduct® through-hole conductivity system is ideal for many in-house rapid PCB prototyping environments, for low volume production, labs or shops where chemical electroplating is impractical.

The LPKF ZeiPrint LT300 RP, a manual fine-pitch stencil printer, applies solder paste in exact amounts and locations on a prototype PCB.

The LPKF ProtoPlace desktop pick & place machine uses a precision manipulator to set SMT components onto a PCB prototype, from small chips to large QFPs.

The LPKF MultiPress S is a bench-top hydraulic press, ideal for creating multilayer circuit boards in a laboratory or prototyping environment.

The LPKF ProtoFlow is a lead-free reflow oven. Featuring a large working area and precisely controlled temperature, it is perfect for the final step of producing a SMT rapid prototype.

Create SMT prototypes in the laboratory in a fraction of the time of using an external vendor. Complete multiple product life cycles in a single day, reducing dramatically the critical time-to-market, using LPKF’s integrated suite of rapid PCB tools.
Working in development presents several problems when prototyping circuits.

In our situation developing a prototype circuit card is usually an on demand situation (spur of the moment) that at times we would have to complete by utilizing wire wrap, or bread boarding from a schematic.

Most of the time being a long and drawn out project with sometimes mixed results, and depending on the size of the circuit, a pain to rework.

In this situation utilizing our ProtoMat H100 system we can produce a more reliable circuit card that is easily reproducible in a matter of hours instead of days with minimal user input once the process is started, and easily support our on demand style work atmosphere.

Thanks,
Michael

Michael S. Baranowski
Technical Specialist
General Dynamics Land Systems
USA

The LPKF ProtoMat is small and easy to use. It is very useful to make all kinds of small-series PCBs. And it corresponds fast to design changes!

DENSO CORPORATION, Development Division
Mr. Tomokazu Watanabe
Japan

We are a small research and development lab, so the purchase of our S62 demanded a large commitment from our operational budget. However the results have been all I could have asked for; we have total control of project scheduling. Depending on the scale our engineer can design, test and re-implement a board in 2–3 days, where before he would be at the mercy of the priorities of an outsource. Having an in-house PC Board plotter has allowed us to focus on design problems rather than the ‘hurry up and wait’ problems of scheduling issues.

Greg Ford
Gregory Industrial Computer Ltd.
Canada
Customer statements

Higher educational research often demands repeated creation of new and improved prototypes. The Institute of Biomedical Engineering at the University of New Brunswick, Fredericton, N.B., Canada, has a long history in the research and clinical aspects of advanced myoelectric controls systems for artificial limbs, and it’s recognized worldwide for this work.

“The design and fabrication of prototypes is a key element of much of this research, and it is here that we utilize the ProtoMat S62”, says chief technologist John Hayden. He looked to the S62 because of the increasing demands placed on board production by surface-mount components. He also indicated that some designs were using the minimum isolation width to keep board size to a minimum.

Research that uses RF layout for wireless bio sensors will be one of the projects tackled in the near future.

John Hayden
Institute of Biomedical Engineering
University of New Brunswick
Canada

You can’t beat the performance of an LPKF system for RF & Microwave prototyping. We do up to three iterations of design within a day.

Leonard Weber
Agilent
Santa Rosa, CA
USA

Being a small company, sales is always pressuring us to get out new products. With the ProtoMat M60, we are literally able to prototype our design the very next day. This better enables us to meet our deadlines, keep the sales’ folk happy and most importantly satisfy our customers. It is a great machine and so is the customers service!

Shane De Lima, R&D Engineer
The Bodine Company
Collierville
USA
Find an LPKF solution for all your technical needs!

LPKF offers more than only rapid PCB prototyping in-house systems. We are proud to offer the following laser-based machines for the production of stencils, for the production of printed circuit boards, 3D-MID solutions and laser plastic welding.

Stencil production with LPKF Stencil Lasers and LPKF Quality Inspection Systems

LPKF is a worldwide leader in Stencil Lasers, offering leading technology for the production of SMT solder paste stencils. LPKF Stencil Lasers are accurate and reliable.

LPKF offers a variety of machines to suit any stencil laser application.

LPKF StencilLaser G6080

LPKF StencilCheck

Use LPKF’s new StencilCheck software in conjunction with any third-party scanner to inspect stencil wear and ensure that all apertures are clean.

Applications

EL stencil  Waferbump  Metal stencil  Precision cut metal components
The LPKF MicroLine series laser systems cut flexible or rigid circuit boards easily, as well as cover layers.

LPKF MicroLine 3D laser systems for the laser direct structuring (LPKF LDS®) of three-dimensional printed circuit boards

Electronic products constantly become more compact, lightweight and encompass a higher functionality at the same time. LPKF MicroLine 3D laser systems are particularly developed for the manufacturing of three-dimensional Molded Interconnect Devices (MID). These permit the combination of mechanical and electrical functions at confined space. Previous procedures for the production of MIDs are bound too expensive, product specific tools for structuring striplines on the respective component. The increasing miniaturization of the structures on MID components additionally increases the effort on time and costs for appropriate tools. The MicroLine 3D laser systems produce the finest conductive structures with the LPKF LDS® procedure directly out of the computer onto the component. Thus LPKF offers a flexible and economic alternative.

LPKF MicroLine UV laser systems for laser cutting of flex circuits and cover layers

The electronics market is characterized by faster product cycles and smaller tolerances. LPKF MicroLine UV laser systems offer exactly the flexibility, reliability and the outstanding precision discerning customers require. The outline cuts flexible and rigid-flexible circuit boards without any burr formation as well as producing PAD openings in foils takes place with highest precision and flexibility. Changeover times for alternate products are reduced and rework costs eliminated. Thus you improve the quality of your products and minimize costs.

Applications
Other technical solutions

**LPKF MicroLine UV laser system for laser depaneling of rigid circuit boards.**

Electronic devices are constantly getting smaller and more sensitive. For depanelization it is essential to reduce influencing forces to a minimum. At the same time the requirements increase for precision and speed. With modern laser technology the LPKF MicroLine UV 3000i handles these technological hurdles for depanelization of assembled panels. Any forms can be cut fast and economically without mechanical stress. Electronic devices can be placed very near to the PCBs edge, so the electronic developer’s benefits from the greatest possible design freedom.

![LPKF MicroLine UV 3000i](image)

**Applications**

![Depanelization of assembled PCBs](image)

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**LPKF laser plastic welding**

Laser plastics welding offers many technological as well as economic advantages over conventional welding procedures. The Plastics Welding Division of LPKF Laser & Electronics AG concentrates on this innovative technology and offers simple economic solutions for any set of requirements.

![LPKF laser plastic welding](image)

**For more information please contact:**

LPKF Laser & Electronics AG  
Business Unit Laser Plastic Welding  
Gundstraße 15  
D-91056 Erlangen  
Germany

Phone +49-(0)9131-61657-10  
Fax +49-(0)9131-61657-77  
E-mail info@laserquipment.de  
Web www.laserquipment.de
**LPKF’s comprehensive job shop serves the needs of the laser micromachining industry**

Comprehensive service in Laser-micro-machining LaserMicronics GmbH, Germany, offers a comprehensive job shop, focusing on micromachining and material processing by industrial lasers. LaserMicronics enjoys full access to LPKF’s laser systems as well as other top-of-the-line prototyping systems, and is also capable of both small batch and high volume production (in close cooperation with LPKF System customers).

LaserMicronics is an innovative pioneer in process development providing a powerful knowledge base for nearly all high-end applications. LaserMicronics strictly exercises the demands of the DIN EN ISO 9001:2000 at both production facilities in Garbsen and Erlangen, Germany.

For more information please contact:

LaserMicronics GmbH
Osteriede 7
D-30827 Garbsen
Germany

Phone +49-(0)5131-9 08 11-0
Fax +49-(0)5131-9 08 11-29
E-mail info@lasermicronics.de
Web www.lasermicronics.com

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**Innovative motion control, precision drive technology, portal and measuring systems**

LPKF Motion & Control GmbH, a subsidiary of LPKF Laser & Electronics, develops and manufactures innovative drive and motion control technology, providing products such as precision drives, granite based air-guided systems with linear or spindle drives, highly mobile single and multi-dimensional linear induction motors, position measuring systems and interpolators, 3D measuring systems and modern control systems and servo controls.

For more information please contact:

LPKF Motion & Control GmbH
Mittelbergstraße 17
D-98527 Suhl
Germany

Phone +49-(0)3681-8924-0
Fax +49-(0)3681-8924-44
E-mail info@lpkf-mc.de
Web www.lpkf-mc.de
Introduction

This technical guide provides a brief overview of the innovative prototyping solutions made by LPKF: Producing reliable prototypes quickly without the use of hazardous chemicals, eliminating the need to send any confidential data outside of your organization.

**LPKF Circuit Board Plotters**

The LPKF ProtoMat® series features unmatched precision, flexibility and ease-of-use. These machines structure the PCBs and are therefore the core element of in-house PCB prototyping. LPKF circuit board plotters considerably shorten the production times of prototype PCBs thus decreasing the development time needed for new products. The high-speed spindle motors operate at 42,000–100,000 rpm. The system resolution as fine as 0.25 µm (0.01 mil), and extremely high repeatability, guarantee the production of ultrafine structures, even for HF and microwave applications. With a range of sizes and features, LPKF has the ideal system for each application.

**Laser structuring of PCBs**

For the highest precision on the market, nothing surpasses PCB structuring using the LPKF ProtoLaser S. The tool less and non-touch structuring method is already preconfigured for many substrates and PCB materials. This system is unmatched world-wide thanks to its outstanding ability to machine high frequency boards and ceramic materials.

**Multilayer boards and through-hole plating**

LPKF PCB prototyping systems make production of high quality multilayer boards fast and simple. The LPKF MultiPress S lamination press bonds each layer in multilayer boards. Multilayer boards are safely through-plated using the chemical-free LPKF ProConduct® method, or the LPKF Contac RS and LPKF MiniContac RS electroplating systems.

**Software**

The LPKF CircuitCAM software and the LPKF BoardMaster® machine control software are included with each LPKF circuit board plotter as well as the LPKF ProtoLaser S. CircuitCAM imports CAD data from Gerber®, GerberX, HP-GLTM, Excellon®, Sieb & Meier, Barco® and ODB++® formats. LPKF BoardMaster® imports the production data (LMD files) from CircuitCAM or HP-GLTM data and controls the structuring process. The graphic data is prepared comfortably using the WYSIWYG software.

**SMT prototyping**

LPKF solutions cover every aspect of the in-house production process for SMT prototypes. LPKF ProMask® and LPKF ProLegend are ideal for applying solder resists or artwork printing. Solder paste or adhesive is applied with outstanding accuracy using the LPKF ZelPrint LT300. The precision placement of SMD components using the LPKF ProtoPlace, and reflow soldering with the LPKF ProtoFlow, are two simple and inexpensive solutions developed by LPKF for each step in the SMT prototyping process.

**Reliable in-house production**

Just a few hours are required from draft design to a finished prototype – without sending sensitive draft data out of your organization. LPKF technologies are also ideal for the in-house production of small batches on-demand – because all process steps are carried out without any special tools or stencils.
Basic knowledge printed circuit boards

**Base materials**
The base material is the most important component in all high quality printed circuit boards. It consists of any one of a range of substrates coated on the top with a conducting material – and in the case of double-sided layouts, also on the bottom. The most popular substrate for PCBs is FR4, a fibreglass reinforced epoxy resin. FR4 substrates come in varying thicknesses ranging between 0.25 mm (10 mil) to 3.125 mm (125 mil) – most applications use 0.74 mm (29 mil) or 1.5 mm (59 mil) base materials.

Popular substrates for high frequency and microwave applications are RO4000®, a fibreglass reinforced epoxy resin incorporating ceramic particles; TMM® substrates consisting of epoxy resin with ceramic particles; and PTFE substrates with special electrical and mechanical properties. In the case of rigi-flex substrates, flexible polyimide substrates create a link between rigid FR4 boards.

FR4 is by far the most frequently used conductor. The amount of copper laminate is usually measured in micrometres (µm – measured directly) or in ounces (oz – measured as ounces per square foot). Most commonly used copper layers are 35 µm (1 oz). In some applications, the copper is coated with an additional metal such as nickel, tin or gold (surface finish).

**Multilayer boards**
Multilayer boards are PCBs with a theoretically unlimited number of conducting layers separated by insulating layers. Multilayers are usually made up on the inside of double-sided boards, while the outer layers consist of single-sided boards. Prepregs are laminates with no conducting layer which are also used as insulators. Heat and pressure is used to bond each layer to form a multilayer board.
Double-sided boards with LPKF ProtoLaser S and LPKF ProtoMats

Double-sided PCBs are coated with conducting material on both outer sides and have structured base materials. LPKF circuit board plotters can be used to drill holes in the boards and are therefore an ideal addition to the LPKF ProtoLaser S laser structuring system. The basic steps involved in processing a two-sided PCB are described as follows.

1. Data input
The software supplied with the LPKF ProtoLaser S and the LPKF ProtoMats processes all standard layout data formats. They position the layouts on the blanks and control the structuring.

2. Create fiducials
The fiducials are drilled with the LPKF circuit board plotter. The LPKF ProtoMats can be upgraded with an optical fiducial identification system for more precise positioning of the boards. The LPKF ProtoLaser S has these already included.

3. Structure the boards
Once the fiducials have been made, the LPKF ProtoLaser S/ProtoMat® structures the tracks – first on the front, and after rotation of the PCB, also on the back. The fiducials are used for precise positioning.

4. Drilling the holes for through-hole plating
The vias for through-hole plating are drilled by the LPKF circuit board plotter.

5. Through-hole plating
The LPKF ProConduct® is used after the vias have been drilled to reliably create the through-hole plating without using any messy chemicals. The PCB is now ready for further processing or incorporation in a multilayer board.
Basic data to the selection of the correct machine and procedure

LPKF supplies everything required for the production of fully assembled PCBs. Easy to operate machines and user-friendly methods are available for every processing step, from board structuring to reflow soldering. Many processing steps are precisely covered by one machine or one method. In some cases, LPKF has a range of solutions. This description helps you make the best choice – or simply call our professional service team.

Selecting the optimal system for printed circuit board structuring from a wide range of systems is more complicated than just matching the technical specifications to the planned applications, e.g. choosing the optimum through-hole plating system. Some criteria to help fine-tune the selection are described in the following, and can at least help to create a shortlist of the potentially suitable machines/systems. When making the final choice of an LPKF circuit board plotter or a through-hole plating system, you can rely on the LPKF sales and marketing team whose expertise and many years of experience are underpinned by countless applications.

Mechanical systems for printed circuit board structuring

The LPKF circuit board plotter series consists of machines which mainly differ in the size of the working areas, different spindle motor rpms, and different accessories. The choice of a specific LPKF circuit board plotter also depends on the degree of automation.

Selecting a specific product line is possible on the basis of the maximum expected hole size:
- S-series up to 229 x 305 mm (9” x 12”)
- H-series up to 380 x 265 mm (15” x 14.4”)
- X-series up to 650 x 530 mm (25.6” x 20.8”)

The spindle motor rpm determines the possible fineness of the structures, and the smallest possible drill holes. The spindle motors in LPKF circuit board plotters S62, S100, H100 and X60 have maximum rpms between 60,000 to 100,000 and can therefore easily create structures with fineness up to 100 µm, and drill holes smaller than 0.4 mm. The spindle motor in the LPKF ProtoMat® S42 has a maximum rpm of 42,000 and can therefore create structures as fine as 200 µm and drill holes larger than 0.4 mm. For high frequency applications with softer materials (Rogers or Taconic), the ideal machines are the S100 or H100 LPKF circuit board plotters with maximum spindle motor rpms of 100,000.

The difference in the features is only a factor in the H-series and S-series machines. The S62, S100 and H100 are equipped as standard with an automatic tool change and an acoustic cabinet. The S62 and S100 also have options of being equipped with a vacuum table and a fiducial recognition camera – which are supplied as standard with a fully equipped H100. The H100 is the only machine with automatic depth control sensing which automatically senses the surface of the base material and takes this into consideration in machining.

All machines are suitable for engraving aluminium, and with the exception of the S42, also for cutting aluminium (cut-outs etc.), plastic and polymers.

The gold standard: laser structuring

The ProtoLaser S can also be used for printed circuit board structuring. With a working area of 229 x 305 mm (9” x 12”) it structures almost all material combinations in a contactless, high-precision process. Its systemic advantages mean that it can structure finer layouts than the ProtoMats: dimensions of 50/25 µm (tracks/gaps) are possible on ceramic materials.
The correct through-hole plating system

LPKF offers three different through-hole plating systems:
- through-hole connections by using the small copper rivets of the LPKF EasyContac
- the chemistry-free through-hole plating of the LPKF ProConduct®
- the professional galvanic systems of the LPKF MiniContac RS and Contac RS

On one hand, the through-hole plating system may be selected dependent of the application. On the other hand, there may be a conscious decision for choosing a chemistry-free procedure.

LPKF EasyContac is a manual through-hole plating system for double-sided printed circuit boards on standard FR4 material with a thickness of 1.5 mm (59 mil). The diameter of the rivets is between 0.8 and 1.4 mm. The system is ideal for PCB prototypes or the repair of printed circuit boards with up to 50 through-holes.

LPKF ProConduct® is a new system for easily producing conductive through-holes without chemical processing. The LPKF ProConduct® procedure is perfect for low volume production of boards with through-hole connections; when chemical electroplating is impractical. LPKF ProConduct® is suitable for multilayers of up to four layers with the smallest hole diameter of 0.4 mm with an aspect ratio of 1:4. The maximum board size is only limited by the hot-air convection oven. The resistance of a finished via with a hole diameter of 0.4 mm is approximately 25 mΩ. Since LPKF ProConduct® does not add copper to the structured circuit surfaces, the calculation of RF-applications based upon copper weight remains simple.

The galvanic through-hole plating systems LPKF MiniContac RS and Contac RS are perfectly suitable for the professional manufacturing of PCB prototypes and low volume production. The quality of through-hole electroplating is the same as through-hole plating from printed circuit board manufacturers. The systems are able to plate multilayers up to 8 layers with the smallest hole diameter of 0.2 mm with an aspect ratio of 1:10. The LPKF MiniContac RS handles PCBs with a maximum size of 230 x 330 mm (9” x 13”), while the LPKF Contac RS handles PCBs with a maximum size of 460 x 330 mm (18” x 13”). The Reverse Pulse Plating assures consistent, even coverage of conductor on the plated surfaces, while maintaining uniformity with even the smallest diameters.
PCB structuring with LPKF ProtoLaser S

High energy densities in extremely small spaces, adjustable focus and complete control of the laser spot are the features which have established lasers as precision tools in electronics production. Lasers are ideal for the direct structuring of copper-coated or copper/nickel/gold-coated boards. One of the challenges here is that the usual compound materials have different ablation thresholds. For instance, the copper in a Cu-board has to be ablated at much higher energy levels (>4,000 mJ/cm²) than the underlying substrate consisting of organic material (approx. 20–300 mJ/cm²) can bear. This can cause serious problems with the adhesive layer and the substrate.

Selective delamination
This problem has been solved with a patented technique. A laser beam with a very precisely controlled energy level first creates the artwork on the surface of the board. It then uses a lower amount of energy to precisely remove the conducting layer – usually copper – without damaging the substrate of the board.

This patented method enables lasers to directly structure PCBs made of laminated material. With the delamination process, ablation speeds of up to 6 cm²/min are possible. Because the substrate is minimally affected, the measured isolation resistances comply with IPC standard TM 650.

Vaporization
Another method is used to structure pure ceramic materials. Because the base material is unaffected by high temperatures, the conducting metal layers are vaporized with high energy laser beams. The gaps created in this way correspond to the diameter of the laser beam (25 µm). The LPKF ProtoLaser S can also be used to cut this type of material.

LPKF ProtoLaser S for prototypes and production on demand
High precision and edge accuracy make this laser technique particularly suitable for structuring high frequency artwork, where geometries must be exactly maintained to accurately match the mathematical model.

The ProtoLaser S is able to handle both types of ablation. Therefore, the laser operates largely independently of the type of substrate. For example, in addition to the popular FR4 material, PTFE-based, ceramic-filled and ceramic substrates can also be structured or cut for high frequency applications.

This technical guide does not substitute the specific manual on each product.
Differences in the production of multilayer

The production of printed circuit boards with machines and procedures from LPKF is fast and simple – the manufacturing steps are essentially identical to board-house production, however, the sequence and number of individual manufacturing steps differs in some cases. Depending on the through-hole plating process the sequence of the manufacturing steps change; the production of multilayers requires additional manufacturing steps. In the following the differences are explained in detail. The appropriate flow diagrams are printed on the folding map at the rear cover page of this catalog.

For a detailed workflow please refer to the folding page added to the back cover.

Differences in through-hole plating

Whether galvanically with the through-hole plating systems LPKF MiniContac RS and Contac RS, or chemistry-free with LPKF ProConduct®, the sequence of the manufacturing steps for the production of multilayers is different, however, the individual steps themselves are quite similar. With galvanic through-hole plating a certain sequence is necessary, while a slightly different order of operations is used for the LPKF ProConduct®.

The external layers of a printed circuit board are always milled after electroplating occurs. This is justified by the fact that the entire copper surfaces of the external layers are used as cathodes in order to achieve the current flow necessary for the through-hole plating process. If the PCB were to be placed in an electroplating bath after the circuit has been structured, the electroplating tank would re-deposit copper that was just removed, causing shorts. The LPKF MiniContac RS and Contac RS are able to electroplate multilayers up to eight layers.

Using the chemistry-free ProConduct® system, the external layers of a printed circuit board are milled before plating the holes. There is no technically compelling reason to mill the external layers before conducting in opposition to the electroplating procedure; this is rather justified by a more favorable production flow. The LPKF ProConduct® system plates through-holes of multilayers up to four layers.
**Differences in the number of layers**

The production of a double-sided printed circuit board is quite simple. Only the two (top/bottom) copper layers of the base material are milled. Depending on the through-hole plating process, the printed circuit board may be plated before or after structuring.

The production of a multilayer board is more elaborate, since it consists of several layers which must be bonded to a printed circuit board. The external layers of a multilayer PCB consist of single sided base material. The inner layers are usually composed of standard double-sided board material. Sometimes however, the use of single sided base material is also necessary in the inner layers in order to fulfill the required electrical characteristics of a specific design. The thickness, and number of Prepreg sheets inserted between the conductive layers determine the electrical characteristics of a multilayer PCB. Compared to a double-sided printed circuit board, besides the additional milling work, the manufacturing step of lamination is necessary to create a multilayer.

For the structuring of a 4-layer board, the inner layers, 2 and 3, are milled first. When using the chemistry-free through-hole conductivity, the external layers are milled afterwards. Then, the structured inner layers and the two structured external layers, with inserted prepregs in between, are bonded to make multiple layers. When using electroplating, the external layers of the finish-bonded multilayer are milled after the plating process.

For the structuring of a 6 to 8-layer multilayer the inner layers, 2 and 3, as well as the inner layers, 4 and 5, are milled first. Afterwards, the two structured inner layers and the two external layers, with Prepreg inserted between, are bonded together. Since a 6-layer multilayer can only be electroplated, the printed circuit board is plated before the final milling of the external layers.
Data preparation with LPKF software

LPKF CircuitCAM

CircuitCAM is LPKF’s universal CAM software. LPKF CircuitCAM creates the production data necessary for the printed circuit board production with an LPKF circuit board plotter in only six simple steps from the layout data provided from any CAD program. Besides these front-to-end basic functions, CircuitCAM also offers comprehensive possibilities for the direct change of the board layout. For detailed descriptions please refer to the LPKF CircuitCAM manual.

1. Standard Windows Toolbar
   This toolbar contains all the most familiar Windows tools, including file commands, printer commands, etc.

2. Front to End Tools
   Functions generating the milling and drilling actions, such as data import, contour routing, inserting break-out tabs, exporting LMD files, etc.

3. View Tools
   Functions involving zooming views in and out of a circuit file, allowing for precision placement and control, and for setting the layer properties.

4. Matching lists
   Show dockable lists for the tool, layer and job configurations.

5. Selection Tools
   Tools for marking and manipulating graphical objects.

6. Grid and Unit Tools
   Functions controlling layer manipulation, including modifying points-of-origin, units, and grid values.
Six easy steps for data preparation.

1. Data import
CircuitCAM imports CAD data from the following formats Gerber®, GerberX, HP-GL™, Excellon®, Sieb & Meier, Barco® and ODB++®. The software recognizes the type of file and automatically assigns an aperture table. When importing a single layer, the user assigns the respective layer number. The assignment of layer can be automated by an import assignment.

2. Contour routing
LPKF Software determines the routing paths for inner and outer routs of the printed circuit. Each routing path is assigned a milling tool from the tool list to determine the cutting track width. The width for the breakout tabs, which are needed in the following step, are also defined. By pressing the start button the outer contours are calculated and indicated in the real tool width on the screen.

3. Breakout tabs
The breakout tabs, defined by width in the previous step, are inserted automatically at each point in the contour outline selected by the user. The breakout tabs are the connections from the individual PCB to the surrounding full panel. They allow easy depaneling of the individual printed circuit board.

4. Rubout areas
Rubout areas are defined by simply selecting the desired rubout areas with your mouse. In these Rubout areas, the copper between pads and traces are completely removed. In other areas, only Pads and strip lines are isolated by a milling trace, which means that some copper remains on the PCB's surface. If the rubout areas are not selected to cover the entire printed circuit board, both milling times and tool wear will be saved.

5. Insulation
The user selects a standard tool from the tool list and up to three additional tools of different diameter for the milling paths. Furthermore, the user specifies the standard milling path width for strip lines and pads. After clicking on the start button all milling paths and rubout areas are displayed.

6. Export Data
The production data prepared in steps 1 to 5 are used to create an LMD file which is used by LPKF BoardMaster to drive the machine. At this point data preparation is now complete.
LPKF BoardMaster

BoardMaster is the intelligent control software for all LPKF circuit board plotters. The software processes both the production data of CircuitCAM and HP-GL™ files as well as many other versions. There are four steps to start the milling process and production set-up.

1 Function bar
The function bar shows the parameters for the current tool, the spindle speed, and the form feed. All are saved in the library for reference.

2 Tool changing position
Shows the tool changing station as well as the specific tool required for the automatic tool change; denoted by ring color.

3 Live window
Show the current view of the camera.
Four easy steps how to start the milling process and therefore the production.

1. Specify base material
The base material is placed in the working area of the circuit board plotter. The user moves the milling head towards two opposite corners of the base material and trains these points. As a result, the size and the position of the base material are specified automatically and displayed on the computer screen.

2. Data import
The production data provided by LPKF CircuitCAM or HP-GL™ data are imported. BoardMaster places the data in the center of the base material. The tool lists are taken over automatically. The data of several printed circuit boards can then be imported in succession.

3. Positioning
The printed circuit board data is moved and rotated on the base material either graphically by mouse or positioned by feeding specific coordinates into the software. It is very simple to create a step-and-repeat array, as only the number of individual PCBs and the desired distance between each PCB is needed.

4. Manufacturing
BoardMaster processes the control data and optimizes the milling process in regards to the runtime, number of tool changes and drill wear. All tool parameters such as feed rate and spindle speeds are saved in the library, so that intervention by the operator is not necessary. LPKF circuit board plotters with a fully loaded automatic tool bar can easily be started by pressing the start/stop button. LPKF circuit board plotters without automatic tool change will prompt the operator to insert the requested tool.
Milling

Milling is the actual heart of the rapid PCB prototyping process. The milling process transfers the printed circuit board layout of the outer and inner layers to the base material. The conductive coating is removed from the insulating layer. The drill shavings are extracted directly at the milling head by a vacuum system.

The easy to use LPKF circuit board plotters enable straightforward production of complex printed circuit boards without specialized user knowledge. The automation level of the milling process depends on the particular LPKF circuit board plotter model used. Options such as the vacuum table or the fiducial recognition camera additionally facilitate easy operation and reduce operator interaction to a minimum.

The milling spindle motor dictates the maximum speed required for creating the most accurate structures and smallest hole diameters possible. Therefore, the higher the spindle speed the smaller the tools that can be used. Softer base materials, for example HF-applications require a higher spindle speed as well.

Some milling tools for the structuring of printed circuit boards are provided with a conical tip. By adjusting the milling depth into the base material at the beginning of every milling process, not only the milling width, but also the minimum insulation distances are determined. During the milling process, the milling head creates downward pressure on the base material. The length of the milling tool exposed beyond the milling head dictates the depth of cut, and is adjusted with a knurled thumb screw on the milling spindle; denoted as the working depth limiter. The distance ring of a milling tool can accurately be placed using the precision ring setter. Therefore the adjustment of the working depth after each tool change is no longer necessary.

All circuit traces and pads are first isolated with the standard Universal Cutter or End Mill of your choice. This guarantees both clean and accurate, exactly equal edge geometries, which positively influence the electrical characteristics of a printed circuit board. Only in areas with small insulation spaces is a smaller milling bit used. The largest possible milling tools are used to produce large rubout areas in order to save time and cost; due to the wear on smaller tools.
The life cycle of the different tools is saved by LPKF BoardMaster in the form of maximum linear distance or the maximum holes drilled. The milling distance or the number of holes drilled by the current tool is always displayed. A warning refers to an upcoming tool change. After replacing a used tool, the counter is automatically reset to 0.

The LPKF ProtoMat H100 is equipped with an automatic depth control sensor. The air-cushioned milling head lowers the milling tool over a sensor switch which automatically sets the predefined depth that was programmed for that specific tool. Manual adjusting is thereby avoided.

The automatic tool change is a mounted magazine which holds different drilling and milling tools. It exchanges tools during the milling process which allows for unattended operation. In contrast to the manual tool change systems, the operator saves not only time, but is also relieved from having to monitor or “baby sit” the machine, waiting for the system to prompt the user for the next tool change.

The acoustic cabinet reduces the noise of the system, allowing the machine to be used in any laboratory setting. The plotter operates safely in any work environment; therefore each circuit board plotter with automatic tool change is equipped with an acoustic cabinet.

For further details please refer to the manual of the respective LPKF circuit board plotter.
Bonding multilayer

For the production of multilayers, the external layers of a printed circuit board must be bonded with the inner layers by using heat and pressure. The external layers, TopLayer and BottomLayer, are usually base materials with one conductive layer. Depending on the through-hole plating process used, the external layers are structured before or after the bonding – galvanic plating before, chemistry-free plating with LPKF ProConduct® after. The inner layers of a multilayer are mostly base materials with two conductive layers and are always structured before the bonding lamination.

The inner and external layers of a multilayer are cured by laminates without a conductive layer; called Prepreg. At the same time, the Prepreg acts as an insulator between the conductive layers. When bonding with the base material, the resin of the Prepreg becomes fluid from the high temperature press, and therefore provides an optimal connection. It is important that no bubbles between the material occur. For the best results it is necessary to adjust the correct pressure, as well as the appropriate temperature profile, depending on the specific material requirements and by the number of layers. The press temperature of a standard multilayer PCB is approximately 180 °C (356 °F).

To ensure proper flow of the melted resin, the sheets of Prepreg are cut 15 mm (0.6") smaller than the size of the base material. This border or margin has to be taken into account while the printed circuit board is being structured (i.e. to keep free of traces and pads). Four registration pins provide the accurate adjustment of the base materials, and keep the individual layers in position during the press process. The slotted registration holes (3 x 5 mm, 0.1" x 0.2") for mounting the base material to the pressing plates, are to be drilled at pre-defined positions.

LPKF MultiPress S bonds multilayer circuits of up to eight layers of all common rigid, rigid-flexible or flexible substrates. It delivers equal pressure on the full press plate area (229 x 305 mm, 9" x 12"), and therefore provides homogeneous material composition. The LPKF MultiPress S can save up to nine different time/temperature/pressure profiles, which can be programmed by the push-button LC-display. Standard profiles for LPKF materials are already pre-programmed in the factory. Special process profiles also ensure the bonding of sensitive HF-materials, which require a press temperature of approximately 230 °C (446 °F). The LPKF MultiPress S guarantees optimal results with rapid heat-up times at temperatures up to 250 °C (482 °F), as well as short cooling phases by an efficient heat transmission.
The components of a multilayer are stacked one above the other according to the respective layer structure in a special press form. Press molds and press cushions guarantee the optimal pressure distribution in the press form. The LPKF MultiPress S, with automatic hydraulics, automatically controls the different heating and press phases of a process profile. The pressure of the LPKF MultiPress S, with hand pump, must be manually developed before each press phase, and be controlled and adjusted during the entire bonding process. LC-display messages and audio signals, prompt the user for any required action, and also provide information about the phase changes during the lamination process.

For further details please refer to the manual of the LPKF MultiPress S.
Marking and drilling

Structuring a printed circuit board is not only isolation of the traces and pads by milling the conductive layer, but also drilling through-holes. The drill holes are needed for through-hole plating and serve as registration points or for the mounting of the printed circuit board.

All holes on a printed circuit board can be made with an LPKF circuit board plotter. Drilling tools with a diameter from 0.2 to 2.4 mm are available. Holes with a diameter larger than 2.4 mm are routed rather than drilled. LPKF CircuitCAM software automatically converts these large drill holes to routed holes. The drilling parameters such as spindle speed and head-down time, for ProtoMat systems equipped with a motorized Z-drive, are automatically saved by the BoardMaster control software.

Very small drill bits, or drill bits that have begun to dull, may experience something known as "drill wander" in which the drill bit can be slightly deflected, causing the exit hole on the bottom side to not be completely centered to the pad. The 90° tip of the universal cutter (1/8"), which is normally used for 200 µm isolation tracks, is the optimal tool for creating pilot holes which mark an easy entry point for the drill bit, minimizing any wander. The CAM software CircuitCAM automatically produces the appropriate production data and transfers the data to the marking drill phase of the control software LPKF BoardMaster (the operator has to adjust the appropriate penetration depth into the printed circuit board at the working depth limiter).

Cut out the printed circuit board

All LPKF circuit board plotters are suitable for the contour routing of PCBs by using the appropriate milling tools. A printed circuit board can be routed through the entire material thickness. Various styles of cut-outs or outlines can be manufactured, from circles to rectangles to complex forms. Hole diameters larger than 2.4 mm are always routed rather than drilled. LPKF circuit board plotters are also suitable for depanelization: cut step-and-repeat arrays, or individual boards with different sizes and variations.

The choice of the appropriate milling tool depends on the desired milling width. Surface milling tools with a larger diameter are more stable and can therefore be driven at a higher feed rate. On the other hand, cut-through routing tools depend on the material to be worked on; FR4 material is cut through using a contour router. For soft RF base materials or aluminium, a double-edged end mill is the right choice.

For further details please refer to the manual of the respective LPKF circuit board plotter.
Through-hole conductivity without chemicals

LPKF offers two alternative procedures for the through-hole plating of PCB’s without chemicals. The LPKF EasyContac manual through-hole plating system works with copper-alloy rivets which are manually placed in the through-holes and riveted. This procedure is ideal for double layer PCBs with up to 50 through-holes.

The LPKF ProConduct® through-hole conductivity system is ideal for PCB prototypes or low volume production. This chemistry-free procedure is extremely economical for a high number of through-holes, and can be used perfectly in environments with chemical restrictions. LPKF ProConduct® is suitable for multilayers up to four layers.

With use of the LPKF ProConduct® printed circuit boards are plated in eight simple steps.

1. **Protective film**
   After milling and cleaning the PCB, a clear adhesive Protection Film is applied to both sides of the PCB.

2. **Drilling**
   Drill the through-holes through the Protection Film and PCB using a ProtoMat circuit board plotter.

3. **Prepare vacuum table**
   With a thin layer of fleece backing material protecting the vacuum table, place the PCB on the table, covering any open vacuum table surrounding the PCB with paper or plastic in order to focus the airflow through the PCB.

4. **Coat page 1**
   Knead the portioned conductive polymer packet to soften it and spread it across the entire board surface using a squeegee, making sure to fill every hole.

5. **Apply suction**
   Switch on the vacuum table. Continue moving the polymer over the surface with the squeegee until all of the excess paste has been drawn through the drill holes.

6. **Verify and repeat for side 2**
   Verify visually that the polymer has properly coated every hole, and repeat steps 4 and 5 on the other side of the PCB.

7. **Curing**
   Carefully remove the protective film from both sides of the PCB and cure the board for 30 minutes in a 160 °C (320 °F) hot air oven.

8. **Final prep**
   After the cooldown period, wash the board with the ProConduct® citrus cleaner to get rid of any oxidation residue. Then finally rinse the PCB with warm water.

For further details please refer to the respective manual of LPKF EasyContac or LPKF ProConduct®.
Galvanic through-hole plating

The LPKF Contac RS and MiniContac RS are electroplating systems for the professional through-hole plating of PCB prototypes and short-run production. The chemical processes are identical to professional PCB electroplating systems in everything but scale. The electroplating systems are specifically designed for ease-of-use. No particular chemistry background is necessary to operate or maintain the Contac RS or MiniContac RS systems.

There are two basic differences between the two electroplating systems; Maximum plating area: the LPKF Contac RS can process base materials up to 460 x 330 mm (18" x 13"), while the LPKF MiniContac RS can use a base material size of up to 230 x 330 mm (9" x 13"). Secondly, there is a difference in the number of baths; the MiniContac RS is equipped with 4 chemical baths: two cleaning baths, an activator bath and a galvanic bath. While the Contac RS contains an additional bath for chemical tinning, as well as a rinsing bath with an external water connection to support the cleaning process.

LPKF has automated the plating process as much as possible, using a step-by-step menu-driven system to walk a user through every step of the process.

1. Washing and degreasing
The printed circuit board is washed and degreased in a cycle of two baths to make absolutely sure that all contaminants are cleared away, and that the electroplating process will function as cleanly as possible.

2. Activator application
A carbon activator is applied to the printed circuit board, adhering to all surfaces designated for plating.

3. Electroplating
The LPKF electroplating sequence includes full digital control over the process. User interaction is kept at an absolute minimum – the PCB is simply submerged in the first bath, and the computer controls the rest of the process, notifying the user when to move the PCB to the next bath.

4. Final Cleaning
The last step of the process is a final cleaning of the PCB. After the printed circuit board is dry from the final rinse, it is ready for production. The total process requires 90 to 120 minutes.
**Reverse Pulse Plating**
The Reverse Pulse Plating ensures consistent, even coverage of copper to the plated surface. This is especially useful for through-holes with small diameters or high aspect ratios. Excessive copper deposits at the hole openings are thereby prevented.

For further details please refer to the respective manuals on the LPKF Contac RS or LPKF MiniContac RS.
Solder-resist masks, legend printing

The LPKF ProMask® is an easy-to-apply green solder-resist mask. This professional finish is ideal for all rapid PCB prototypes, especially for SMT projects where lines are very close, and circuit isolation/insulation is a key component.

The LPKF ProMask® solder-resist mask is applied in four simple steps.

1. Producing the artwork
   The artwork mask is easily produced by printing it from the LPKF CircuitCAM software with a standard laser printer (resolution of at least 600 dpi is required and previous calibration using CircuitCAM is necessary).

2. Applying the solder-resist lacquer
   The lacquer is simply mixed using the single portion packets of lacquer and hardener. It is then applied to the finished prototype PCB using a disposable roller. After application the PCB is pre-dried for 10 minutes at 80 °C (176 °F) in a hot air oven.

3. Exposing PCB with the artwork
   The PCB is placed in the UV exposure unit, and the artwork is placed over it by aligning to registration marks. The UV exposure unit is switched on for 30 seconds after which the board is removed and the artwork film is peeled off.

4. Developing and hardening the solder-resist mask
   A shallow rinsing bath is prepared with developer powder and warm water, and therein the unexposed resist is removed with gentle brushing. The lacquer residue is rinsed off under flowing water, and then the resist is hardened for 30 minutes in the hot air oven. The board can then be cleaned with LPKF cleaner to get rid of any oxidation residues, and is finally rinsed with water.

For further details please refer to the manual on the LPKF ProMask®.

The legend printing with LPKF ProLegend is based on exactly the same procedures. Since the areas that are left clear on the printed developing mask will be cured by the UV exposure unit, the artwork or text must be printed as a negative image. Simply the text or legend artwork is left clear, while the surrounding area is printed black.
Solder paste printing

Contact printing of solder paste to all pads assembled with SMT components requires the highest precision. The LPKF ZelPrint LT300 is a manual solder paste printer for SMT prototypes and small batch PCB’s. This unique solution allows printing of 0.3 mm (12 mil) pitch (ultra-fine-pitch area). The thickness of the stencils, between 100 µm and 250 µm, determines the amount of solder paste applied.

Stencil frames are easily mounted to height adjustable supports, and are secured to the LT300 with robust rubberized clamps to ensure the stencil and frame stay firmly positioned during the printing process. The high-clearance, free-floating magnetic nesting pins allow boards which are already populated on one side to be printed on the other. The printed circuit board is precisely aligned with micrometer screws in X/Y directions and rotation.

A specially designed elevating/release lever provides the speed-controlled parallel separation of the printed circuit board from the stencil. The magnetic PCB mounting pins are located on a sliding carriage in order to facilitate the quick and easy exchange when applying paste to multiple boards.

The LPKF ZelPrint LT300 is suitable for the use of polymer stencils – limited to 0.625 mm (25 mil) pitch with a thickness of 125 µm. Polymer stencils can be manufactured with an LPKF circuit board plotter, which saves time and costs in relation to steel templates.

For further details please refer to the manual on the LPKF ZelPrint LT300.

Solder paste can be applied to the printed circuit board in only six simple steps.

1. **Fixing the printed circuit board**
   Position the magnetic PCB nesting pins on the carriage, and mount the PCB. Attach the test print foil prior to mounting the stencil frame.

2. **Clamping the stencil**
   Slide the carriage into the print position and roughly align the stencil frame over the PCB and test foil, before securing it with the rubberized clamps.

3. **Test print screen**
   Using the elevating/release lever, press the PCB and test print foil into the framed stencil. Then evenly apply the solder paste to the stencil using a squeegee, i.e. print the Pad footprints on to the test foil.

4. **Precise adjustment**
   Separate the PCB and test foil from the framed stencil using the elevating/release lever, and slide the carriage out from under the stencil. Using the micrometer adjustment screws, align the PCB under the transparent test foil to accurately match the orientation of the printed solder paste pattern. Once the test print pattern and PCB pads have been aligned, you may remove and clean the test print foil.

5. **Apply solder paste**
   Slide the carriage back into the print position and press the PCB up into the stencil using the elevator/release lever. Once the PCB has been pressed firmly into the stencil, use the squeegee provided to evenly apply the solder paste over the stencil and on to the printed circuit board.

6. **Separate the PCB**
   Separate the printed circuit board from the stencil using the elevator/release lever. The solder paste applied must remain on the printed circuit board and not stick to the stencil. Finally, drive the carriage into the load position.
Assembling printed circuit boards by hand has become increasingly difficult with today’s miniaturized components. Fully automatic assembly means expensive machines, as well as additional programming. The LPKF ProtoPlace is an ergonomically designed semi-automatic, pick & place system for the professional assembly of SMT printed circuit board prototypes and small batch production runs. A four-line LC-display guides the user through all steps of set-up and operating phases. Most functions are easily executed from an interface panel with four ergonomically designed directional arrows.

Three different kinds of feeders supply the components: tape feeders, stick feeders or a motorized turntable. An integrated dispenser for adhesives and solder paste is included as a standard component.

The workflow for assembling simple SMT components such as resistors, capacitors, etc. differs just a little bit from the workflow for assembling complex components such as QFP’s and PLCC’s.

### Simple SMT components are assembled in three simple steps.

1. **Pick up component**
   Pick up the desired SMT component from the appropriate Feeder by using the vacuum needle of the manipulator head.

2. **Adjust component**
   Bring the SMT component into the correct position using the X/Y axis platform, as well as the manipulator knob to turn the vacuum needle for proper orientation. Check the correct position with the optional camera and LCD color monitor.

3. **Place component**
   Place the SMT component on the printed circuit board by manually lowering the manipulator head.

### Complex SMT components are assembled in four steps.

1. **Pick up component**
   Pick up the SMT component to be assembled with the vacuum needle of the manipulator from the appropriate feeder.

2. **Roughly adjust component**
   Bring the SMT component close to the correct position using the X/Y axis shift as well as the manipulator to turn and sink the vacuum needle. Subsequently, the X, Y and Z-axis are locked in place.

3. **Exactly adjust component**
   Adjust the printed circuit board beneath the SMT component accurately using the micrometer screws. Control the accurate component positioning with the optional camera and an LCD color monitor. The camera is installed on a turnable holder to control the component positioning from different aspects.

4. **Place component**
   A pneumatic device supports the positioning of the component when operating the appropriate direction key. The adhesion of the solder paste ensures that the component does not slip.

For further details please refer to the manual on the LPKF ProtoPlace.
Lead-free and lead containing reflow soldering

Reflow soldering is the last production step of the rapid PCB prototyping process. The LPKF ProtoFlow is a reflow oven which is suitable for both standard and lead-free solder pastes; RoHS compliant reflow soldering. Printed circuit boards up to 229 x 305 mm (9” x 12”) in size and a maximum temperature of 320 °C (608 °F) can be processed. Four internal temperature sensors together with three separately controlled heaters provide an even and accurate temperature distribution over the entire printed circuit board surface. The inert gas option of the ProtoFlow N2 enables setting and digital monitoring of the nitrogen flow. The nitrogen atmosphere significantly decreases the oxidation during the soldering process and ensures better solder joints.

Preprogrammed standard reflow profiles are installed at the factory. Further temperature/time profiles can simply be programmed and saved under an individual name using the direction keys and the four-line LC-display. With the special multi-zone function it is possible to define up to five separate phases; with a programmable temperature ramp for up to three of them. The entire soldering process is automatic and does not require user interruption. The motorized drawer opens automatically for the cool-down phase of the reflow process. The integrated lighting allows the user to supervise the soldering process through a front window panel.

The LPKF ProtoFlow can be connected to a PC using a USB interface. The intuitive PC software records the process temperature in real time and allows for profile parameters to be saved. The LPKF ProtoFlow can be fitted with four optional temperature sensors, which can be mounted anywhere on the PCB or components, allowing for a complete real time data logging of temperature profiles with instant feedback to the user. This data can be stored on a PC and analyzed at any time.

For further details please refer to the manual on the LPKF ProtoFlow.
Applications

Flexible/rigid-flexible printed circuit boards
Flexible and rigid-flexible printed circuit boards usually cause difficulties in handling. To fix the boards on a work surface can cause some problems. To make the handling easier almost all LPKF systems can be equipped with a vacuum table. Reason to equip the circuit board plotter with a vacuum table is not only a safer positioning of the material, it is also to make the handling of the machine faster and more simple.

Since the base material of flexible printed circuit boards is always softer, HF tools are primarily used for the milling process. Another advantage of the HF tools is that they do not penetrate deeply into the material. Structuring a flexible printed circuit board is based on the same milling process of rigid base materials.

With rigid-flexible printed circuit boards, flexible PCB's are connected together with rigid PCB's. The production of rigid-flexible printed circuit boards is similar to the production of multilayer boards. The rigid PCB's are structured in a panel, the area where the flexible portion is to be inserted remains unstructured in the panel, and is covered with a protective foil. The flexible PCB is then pressed upon the already structured rigid areas. Finally, the unstructured area beneath the flexible printed circuit board is milled away. For manufacturing rigid-flexible boards, standard LPKF systems can be used according to the multilayers production process.

Engraving plastics and aluminum (2½ D)
With LPKF circuit board plotters, plastics and soft metals in 2½ dimensions can also be drilled and milled. With the ProtoMat S42 plastic and aluminium materials can be engraved on the surface. Other LPKF circuit board plotters with Z axis control can create very smooth 2½ D surfaces because of a spindle speed of at least 60,000 rpm.

LPKF circuit board plotters can engrave, drill mounting holes, mill front panels, or create several other types of structures and lines. Depending on the thickness of the board material, it may take several passes to mill down to the desired depth. As a rule of thumb, the maximum milling depth of any end mill tool corresponds to approximately half of that particular tool's diameter. The tool library of the LPKF BoardMaster software supports the processing of aluminum and other soft metals. The optimal feed rate and spindle speed for a long life-cycle of any LPKF tool, as well as outstanding milling results, are already included in the standard tool profiles stored in BoardMaster.
RF and microwave applications
The production of printed circuit boards for RF and microwave applications require additional considerations when compared to standard digital or analog PCBs. Materials with special electrical characteristics that have highly sensitive surfaces must be handled accordingly, and secondly, very accurate geometry is almost always required to achieve the desired frequency results.

LPKF systems and tools meet all of these requirements. The LPKF ProtoMat S100 and H100 are equipped with a high-speed spindle motor of 100,000 RPMs. Both systems have an accurately adjustable milling depth that when combined with the appropriate RF tool to ensure clean vertical geometry, work very well with soft RF base material. The non-contact working depth limiter, where the milling head slides on an air cushion over the base material with no physical contact, guarantees scratch-free processing of the printed circuit board. The laser system LPKF ProtoLaser S is unbeatable in speed and precision when working with RF and microwave applications. Fine structures and large rubout surfaces are manufactured in just a few minutes with use of the ProtoLaser S.

Apart from the purely technical requirements, data security can be a large factor. By manufacturing the PCB prototypes in-house no one outside sees the data, which avoids both errors and the unwanted drain of information.

Laser structuring
The laser system LPKF ProtoLaser S is a step up from LPKF circuit board plotters regarding precision and speed. The system was originally conceived for RF and microwave applications. When comparing laser-structured PCB’s with PCB’s manufactured by conventional techniques in regards to precision, repeatability and the coincidence to simulation results – laser structured PCB’s win. Handling of the ProtoLaser S is extremely simple.

The X/Y table with vacuum function ensures simple set-up of the ProtoLaser S system. The fiducial recognition camera and auto focus function automatically prepare the material for laser processing. With the software packages LPKF CircuitCAM and CircuitMaster, all operating parameters of the ProtoLaser can be directly controlled.

Various predefined profiles for the processing of most different applications allow for all possibilities of the printed circuit board structuring without wasting time for setup or programming. The profiles can also be adapted and stored individually. Applications such as ultra-fine pitch PCB’s, flexible printed circuit boards, RF-circuits, RFID’s on PET foil or RF-filters on ceramic substrates can be easily produced in short succession; one behind the other.
Mill stencils
Milling polymer stencils with LPKF circuit board plotters is a genuine alternative to steel stencils in the rapid PCB prototyping process, especially regarding cost effectiveness. The solder paste stencils can be milled in-house in less than 10 minutes on average. The production of the milling data over inverse isolation from CircuitCAM is extremely simple. The pads are encircled for isolation then milled out.

With the milling of polymer stencils, the advantages of speed and security can be improved upon when applying solder pastes. In combination with the SMT solder paste printer, ZelPrint LT300, and an LPKF circuit board plotter, screen printing is an economical solution for the rapid PCB prototyping, especially when compared to the work required when using a dispenser or soldering by hand.

Depanelization
Depanelization is the cutting of break-out tabs which still fasten individual printed circuit boards to a panel array. This manufacturing step is connected only indirectly with the actual production process of a printed circuit board and the later function. Therefore, the time required by milling systems for the depaneling process may be granted reluctantly, or may result in bottlenecks in the production cycle. LPKF circuit board plotters are a genuine alternative. Inserting and aligning a panel is a simple and fast task using the combination of a vacuum table and fiducial recognition camera. The tabs are separated cleanly and exactly, resulting in a printed circuit board with an accurate outline.
## Cross Reference List

<table>
<thead>
<tr>
<th>Datenaufbereitung mit</th>
<th>Product part</th>
<th>Tech Guide</th>
</tr>
</thead>
<tbody>
<tr>
<td>LPKF-Software</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LPKF CircuitCAM</td>
<td>43</td>
<td>100</td>
</tr>
<tr>
<td>LPKF BoardMaster</td>
<td>43</td>
<td>102</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Milling</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>LPKF ProtoMat S100</td>
<td>7</td>
<td>104</td>
</tr>
<tr>
<td>LPKF ProtoMat S62</td>
<td>11</td>
<td>104</td>
</tr>
<tr>
<td>LPKF ProtoMat S42</td>
<td>15</td>
<td>104</td>
</tr>
<tr>
<td>LPKF ProtoMat H100</td>
<td>19</td>
<td>104</td>
</tr>
<tr>
<td>LPKF ProtoMat X60</td>
<td>23</td>
<td>104</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Laser structuring</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>LPKF ProtoLaser</td>
<td>46</td>
<td>97</td>
</tr>
</tbody>
</table>

| Bonding multilayer    |              |           |
| LPKF MultiPress S     | 65           | 106       |

<table>
<thead>
<tr>
<th>Marking and drilling</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>LPKF ProtoMat S100</td>
<td>7</td>
<td>108</td>
</tr>
<tr>
<td>LPKF ProtoMat S62</td>
<td>11</td>
<td>108</td>
</tr>
<tr>
<td>LPKF ProtoMat S42</td>
<td>15</td>
<td>108</td>
</tr>
<tr>
<td>LPKF ProtoMat H100</td>
<td>19</td>
<td>108</td>
</tr>
<tr>
<td>LPKF ProtoMat X60</td>
<td>23</td>
<td>108</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Galvanic through-hole plating</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>LPKF Contac RS</td>
<td>57</td>
<td>110</td>
</tr>
<tr>
<td>LPKF MiniContac RS</td>
<td>57</td>
<td>110</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Through-hole conductivity</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>without chemicals</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LPKF EasyContac</td>
<td>61</td>
<td>109</td>
</tr>
<tr>
<td>LPKF ProConduct®</td>
<td>53</td>
<td>109</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cut out the printed circuit board</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>LPKF ProtoMat S100</td>
<td>7</td>
<td>108</td>
</tr>
<tr>
<td>LPKF ProtoMat S62</td>
<td>11</td>
<td>108</td>
</tr>
<tr>
<td>LPKF ProtoMat S42</td>
<td>15</td>
<td>108</td>
</tr>
<tr>
<td>LPKF ProtoMat H100</td>
<td>19</td>
<td>106</td>
</tr>
<tr>
<td>LPKF ProtoMat X60</td>
<td>23</td>
<td>108</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Solder resist masks, legend printing</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>LPKF ProMask</td>
<td>69</td>
<td>112</td>
</tr>
<tr>
<td>LPKF ProLegend</td>
<td>69</td>
<td>112</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Solder paste printing</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>LPKF ZelPrint LT300</td>
<td>73</td>
<td>113</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Assembling</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>LPKF ProtoPlace</td>
<td>77</td>
<td>114</td>
</tr>
</tbody>
</table>

| Plumbiferous and lead-free reflow soldering |              |           |
| LPKF ProtoFlow and ProtoFlow N2 | 81 | 115 |

<table>
<thead>
<tr>
<th>Applications</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Flexible and rigid-flexible PCBs</td>
<td>116</td>
<td></td>
</tr>
<tr>
<td>Engraving plastics and aluminum (2½ D)</td>
<td>116</td>
<td></td>
</tr>
<tr>
<td>RF and microwave applications</td>
<td>117</td>
<td></td>
</tr>
<tr>
<td>Laserstructuring</td>
<td>117</td>
<td></td>
</tr>
<tr>
<td>Mill stencils</td>
<td>118</td>
<td></td>
</tr>
<tr>
<td>Depanelization</td>
<td>118</td>
<td></td>
</tr>
</tbody>
</table>
Glossary

A

Activating
A treatment that renders nonconductive material receptive to electroless deposition. Non-preferred synonyms: Seeding, Catalyzing, and Sensitizing.

Annular Ring
The conductive foil and plating surrounding a hole.

Aperture
A description of the shape and size of the tool used to create a pad or track. The term comes from the days of vector photoplotters, where film was exposed by shining light through apertures (shaped holes) arrayed around the edge of a disk (or “aperture wheel”). Each aperture corresponded to a different D code in the Gerber data. Today, photoplotters use lasers to expose the film but the term “aperture” persists.

Aperture List
A list of the shapes and sizes for describing the pads and tracks used to create a layer of a circuit board.

Artwork
A phototool used to create the different layers during printed circuit board manufacture.

Artwork Master
An accurately scaled (usually 1:1) pattern which is used to produce the production master.

Aspect Ratio
The ratio of the circuit board thickness to the smallest hole diameter.

B

B-Stage Material
Sheet material impregnated with a resin cured to an intermediate stage (B-stage resin). Prepreg is the preferred term.

Backplanes and Panels
Interconnection panels into or onto which printed circuits, other panels, or integrated circuit packages can be plugged or mounted.

Bare Board
A finished PCB that has had no components added.

Barrel
The cylinder formed by plating through a drilled hole.

Base Laminate or Base Material
The substrate material upon which the conductive pattern may be formed. The base material may be rigid or flexible.

“Bed-of-Nails”
A method of testing printed circuit boards that employs a test fixture mounting an array of contact pins configured so as to engage plated-through holes on the board.

Blind-Via
A via hole that does not pass completely through the printed circuit board. A blind via starts from one side or another.

Bond Strength
The force per unit area required to separate two adjacent layers of a board by a force perpendicular to the board surface.

Bridging
A buildup of solder between tracks or pads causing a short circuit.

Buried-Via
A mechanically or laser drilled hole which interconnects internal layers only. It is not electrically connected to any external layer.

C

C-Stage
The condition of a resin polymer when it is in the solid state, with high molecular weight, being insoluble and infusible.

Center-To-Center Spacing
The nominal distance between the centers of adjacent features or traces on any layer of a printed circuit board.

Chamfer
A corner which has been rounded or angled to eliminate an otherwise sharp edge.

Circuit
The interconnection of a number of devices in one or more closed paths to perform a desired electrical or electronic function.

Circuit Layer
A layer of a printed board containing conductors, including ground and voltage planes.

Clad or Cladding
A relatively thin layer or sheet of metal foil which is bonded to a laminate core to form the base material for printed circuits.

Clearance Hole
A hole in the conductive pattern larger than, but concentric with, a hole in the printed board base material.

Coefficient of Expansion, Thermal
The fractional change in dimension of a material for a unit change in temperature.

Component Hole
A hole used for the attachment and electrical connection of component terminations, including pins and wires, to the printed circuit board.

Component Side
That side of the printed circuit board on which most of the components will be mounted.

Conductive Pattern
The configuration or design of the conductive material on the base laminate. Includes conductors, lands, and through connections.
### Glossary

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conductor Base Width</td>
<td>The conductor width at the plane of the surface of the base material. See also: Conductor Width</td>
</tr>
<tr>
<td>Conductor-To-Hole Spacing</td>
<td>The distance between the edge of a conductor and the edge of a supported or unsupported hole.</td>
</tr>
<tr>
<td>Conductor Spacing</td>
<td>The distance between tracks on a printed circuit board.</td>
</tr>
<tr>
<td>Conductor Width</td>
<td>The observable width of the pertinent conductor at any point chosen at random on the printed circuit board.</td>
</tr>
<tr>
<td>Controlled Impedance</td>
<td>The process that gives a circuit the correct impedance value. The design engineer will specify the track impedance required. From this, a suitable manufacturing build will be chosen to the suit track widths and layer spacings on the design to meet the required impedance.</td>
</tr>
<tr>
<td>Copper Foil</td>
<td>A cathode-quality electrolytic copper used as a conductor for printed circuits. It is made in a number of weights (thicknesses); the traditional weights are 1 and 2 ounces per square foot (0.0014 and 0.0028 inch thick).</td>
</tr>
<tr>
<td>Current-Carrying Capacity</td>
<td>The maximum current which can be carried continuously, under specified conditions, by a conductor without causing degradation of electrical or mechanical properties of the printed circuit board.</td>
</tr>
<tr>
<td>Datum Reference</td>
<td>A defined point, line, or plane used to locate the pattern or layer for manufacturing, inspection, or for both purposes.</td>
</tr>
<tr>
<td>Deburring</td>
<td>Process of removing a burr after board drilling. Deburring operations fall into two categories: producing a clean, sharp edge when removing heavy burr; and radiusing the edge of the holes to prevent build-up in plating.</td>
</tr>
<tr>
<td>Design Rules Check</td>
<td>A computer aided program used to check the manufacturability of the circuit board. The checks include track to track gaps, track to pad gaps, annular ring sizes, track to board edge gaps, acid trap detection, unterminated track checks.</td>
</tr>
<tr>
<td>DFM</td>
<td>Design For Manufacture.</td>
</tr>
<tr>
<td>Dielectric</td>
<td>An insulating medium which occupies the region between two conductors.</td>
</tr>
<tr>
<td>Dielectric Constant</td>
<td>That property of a dielectric that determines the electrostatic energy per unit volume for unit potential grade.</td>
</tr>
<tr>
<td>Digitizing</td>
<td>Any method of reducing feature locations on a flat plane to digital representation in X-Y coordinates.</td>
</tr>
<tr>
<td>Dimensional Stability</td>
<td>A measure of dimensional change caused by factors such as temperature, humidity, chemical treatment, age, or stress; usually expressed as units/unit.</td>
</tr>
<tr>
<td>Double-Sided Board</td>
<td>A printed board with a conductive pattern on both sides, but no inner layers.</td>
</tr>
<tr>
<td>Drill Table</td>
<td>A description of the drill sizes used to create the circuit board. The drill equivalent of an aperture list.</td>
</tr>
<tr>
<td>Edge Connector</td>
<td>The portion of the PCB used to provide external electrical connection, normally gold plated.</td>
</tr>
<tr>
<td>Electroplating</td>
<td>The electrodeposition of a metal coating on a conductive object. The object to be plated is placed in an electrolyte and connected to one terminal of a d-c voltage source. The metal to be deposited is similarly immersed and connected to the other terminal. Ions of the metal provide transfer to metal as they make up the current flow between the electrodes.</td>
</tr>
<tr>
<td>Etching</td>
<td>The process of removing unwanted metallic substance (bonded to a base) via chemical, or chemical and electrolytic means.</td>
</tr>
<tr>
<td>Fiducial</td>
<td>A feature of the printed circuit board used to provide a common measurement point for all steps in the assembly process.</td>
</tr>
<tr>
<td>Flash</td>
<td>A pad. Another term dating from the days of vector photoplotters – tracks were drawn, pads were “flashed”. See also pad. “Flash” is also a term used to describe excess material squeezed out between mold pieces during a casting.</td>
</tr>
<tr>
<td>Flux</td>
<td>A substance used to promote or facilitate fusion, such as a material used to remove oxides from surfaces to be joined by soldering or welding.</td>
</tr>
<tr>
<td>Foil</td>
<td>A thin sheet of metal, usually copper or aluminum, used as the conductor for printed circuits. The thinner the foil, the lower the required etch time. Thinner foils also permit finer definition and spacing. See Copper Foil.</td>
</tr>
<tr>
<td>FR-4</td>
<td>The standard glass epoxy substrate.</td>
</tr>
<tr>
<td>Fused Coating</td>
<td>A metallic coating (usually tin or solder alloy) which has been melted and solidified forming a metallurgical bond to the base material.</td>
</tr>
<tr>
<td>Gerber Data</td>
<td>A type of data that consists of graphics commands, usually describing how to draw a picture of a circuit. Intended for directing a photoplotter, it is the most common format for data transfer from PCB CAD systems to the manufacturing process. Gerber data is officially designated as RS-274-D (without embedded aperture codes) and RS-274-X (with embedded aperture codes).</td>
</tr>
<tr>
<td>Ground Plane</td>
<td>A conductor layer, or portion of a conductor layer, used as a common reference point for circuit returns, shielding, or heat sinking.</td>
</tr>
<tr>
<td>HP-GL™</td>
<td>Hewlett Packard Graphics Language.</td>
</tr>
<tr>
<td>Internal Layer or Inner Layer</td>
<td>A conductive pattern which is contained entirely within a multilayer printed board.</td>
</tr>
<tr>
<td>Laminates</td>
<td>A product made by bonding together two or more layers of material.</td>
</tr>
</tbody>
</table>
Lamination
The process of preparing a laminate; or a multilayer PWB.

Land
A portion of a conductive pattern usually, but not exclusively, used for the connection and/or attachment of components. Also called Pad, Boss, Terminal area, Blivet, Tab, Spot, or Donut.

Layer-To-Layer Spacing
The thickness of dielectric material between adjacent layers of conductive circuitry in a multilayer printed circuit board.

Legend
A format of lettering or symbols on the printed board; e.g., part number, component locations, and patterns.

M

Mask
A material applied to enable selective etching, plating, or the application of solder to a printed circuit board.

Microsectioning
The preparation of a specimen for the microscopic examination of the material to be examined, usually by cutting out across-section, followed by encapsulation, polishing, etching, staining, etc.

Mil
1/1,000 of one inch, or 0.001”.

Minimum Annular Ring
The minimum metal width, at the narrowest point, between the circumference of the hole and the outer circumference of the land. This measurement is made to the drilled hole on internal layers of multilayer printed circuit boards and to the edge of the plating on outside layers of multilayer boards and double-sided boards.

Minimum Electrical Spacing
The minimum allowable distance between adjacent conductors that is sufficient to prevent dielectric breakdown, corona or both, between the conductors at any given voltage and altitude.

Misregistration
The lack of conformity between two or more patterns or features.

Mixed Technology
Describes the assembly process used when pin through-hole, surface mount, and other mounting technologies on the same printed circuit board.

Multilayer Printed Circuit Boards
Printed circuit boards consisting of three or more conducting circuit planes separated by insulating material and bonded together with internal and external connections to each level of the circuitry as required.

N

Nick
A cut or notch in a track or pad.

O

Open
A loss of electrical continuity caused by a break in a track.

P

Pad
The portion of the conductive pattern on printed circuits designated for the mounting or attachment of components. Also called Land.

Panel
The base material containing one or more circuit patterns that passes successively through the production sequence and from which printed circuit boards are extracted. See Backplanes and Panels.

Panel Plating
The plating of the entire surface of a panel (including holes).

Pattern Plating
Selective plating of a conductive pattern (including holes).

PCB
Printed Circuit Board

Photo Plot
A high accuracy laser plotting system. It is used to produce actual size master patterns for printed circuit artwork directly on dimensionally-stable, high contrast silver halide photographic film.

Photoplotter
A device for generating photographic images by directing a controlled-light beam that directly exposes a light-sensitive material.

Photosensitive Resists
A material applied to enable selective etching, plating, or the application of solder to a printed circuit board.

Printed Wiring Technologies
Describes the assembly process used when pin through-hole, surface mount, and other mounting technologies on the same printed circuit board.

Prepreg
Sheet material consisting of the base material impregnated with a synthetic resin, such as epoxy or polyimide, partially cured to the B-stage.

PWT
Printed Wiring Technologies

R

Reflowing
The melting of an electro-deposit followed by solidification. The surface has the appearance and physical characteristics of being hot-dipped.

Registration
The degree of conformity of the position of a pattern, or a portion thereof, with its intended position or with that of any other conductor layer of a board.

Resist
Coating material used to mask or to protect selected areas of a pattern from the action of an etchant, solder, or plating. Also see: Dry-Film Resists, Plating Resists and Solder Resists.

Router
A machine that cuts away portions of the laminate to leave the desired shape and size of a printed circuit board.
Glossary

S

Schematic Diagram
A drawing which shows, by means of graphic symbols, the electrical connections, components and functions of an electronic circuit.

Scoring (V-Scoring)
The panels are precision cut through both sides of the panel to a preset depth. The panels remain rigid for assembly but are ready for breaking into individual circuits.

Screen Printing
A process for transferring an image to a surface by forcing suitable media through a stencil screen with a squeegee. Also called Silk Screening.

Single Sided Board
A printed circuit board that contains tracks and pads on one side of the board and no plating in the through holes.

SMT
Surface Mount Technology

Solder Leveling
The process of dipping printed circuit boards into molten solder and leveling the surface with hot air.

Solder Mask or Resist
Coatings which mask and insulate portions of a circuit pattern where solder is not desired.

Solder Side
On printed circuit boards with components on only one side, the side of the PCB that is opposite to the component side.

Surface Mount Technology (SMT)
The components are mounted on the surface of a circuit board rather than inserting components into plated through holes.

T

Tester
A device that checks a PCB for the connectivity of its circuits from the design netlist.

Thin Foil
A metal sheet less than 0.0007 inches (1/2 oz) thick or less.

Tooling Holes
The general term for non-plated holes placed on a printed circuit board or a panel used for registration and tooling purposes during the manufacturing process, testing and assembly.

Track
An electrical connection between two or more points on a PCB.

U

UL (Underwriters Laboratory)
A U.S. safety standard certification organization.

UV (Ultraviolet)
Curing Polymerizing, hardening, or cross linking a low molecular weight resinous material in a wet coating or ink, using ultraviolet light as an energy source. Ultrasonic Cleaning Equipment Equipment used for ultrasonic immersion cleaning employing a transducer which converts electrical energy into mechanical energy; an ultrasonic generator, and a tank to contain the cleaning liquid. Both automated and conveyorized ultrasonic cleaning systems exist.

V

Via or Via Hole
A plated-through hole used as a through or inner-layer connection, but in which there is no intention to insert a component lead. These holes are generally the smallest as no components are inserted in them.

W

WYSIWYG
What You See Is What You Get. This term describes a computer interface that reflects an actual physical object, as opposed to a more symbolic representation. For example, early word processing programs produced a final printed output that was very different than what appeared on the editing screen, but later programs appeared on the editing screen exactly as they were expected to print.
# Index

4-layer printed circuit boards .......... 41, 99  
6-layer printed circuit boards .......... 21, 28, 41, 99  

**Accessories** ........................................ 31, 75, 79  
Acoustic cabinet ...................................... 8, 27, 32  
Adhesive tape ............................................. 42  
Applications ............................................... 6, 116  
Assembly ................................................... 77  
Automatic tool change ............................... 5, 8, 12, 20, 96, 105  
 Autoswitch ................................................... 33  

**Base material** ....................................... 36, 42, 93, 120  
BGA (Ball Grid Array) ............................... 28–29  

**Bits** ..................................................... see Tools  

**BoardMaster** .......................................... 43, 45, 102  

**Brush head** ............................................. 33  

**CAD** ..................................................... 43  
CAM Software ............................................. 43, 100  
Ceramic ...................................................... 21, 49  

**Chemical tinning** ................................... 58  
Chemical-free ............................................. 51, 61  
Chemicals ................................................... 53  

**Circuit board plotters** .......................... see ProtoMat  

**CircuitCAM Lite** ...................................... 43  

**CircuitCAM PCB** ...................................... 43  

**CircuitMaster** ......................................... 43  

**Cleaning pad** ........................................... 30, 42  

**Compressor** ........................................... 34, 50  

**Conductive polymer** ............................... 54  
Consumables ............................................... 39  

**Contac RS** .............................................. 57, 110  

**Contour routing** ..................................... 28, 101  

**Copper-clad material** ......................... 39  

**Cut outs** ............................................... 28, 29, 108  

**Cutting** .................................................. 29  

**Data import/export** ................................. 44, 100  
Depaneling ................................................. 21, 25, 90  

**Depth limiter** ......................................... 27, 104  

**Depth sensor** .......................................... 19  
Distributors .............................................. 126  
Double sided circuit boards ................. 28  
Drill underlay material ......................... 40, 41  

Drilling ..................................................... 6, 28, 35, 108  

**Dust extraction** ....................................... 33  

**DXF** ...................................................... 44  

**EasyContac** ........................................... 61  
Electroplating ............................................ 57, 110, 121  

**Endmill** ............................................... 35  

**Engraving** .............................................. 27, 29, 36, 116  

**Fiducial recognition camera** ................ 27, 32  

**Fine pitch printing** ................................. 74  

**Flexible circuit boards** ......................... 89  

**Flexible substrates** ............................... 49, 65, 93  

**Foil** ....................................................... 121  

**Front panels** ......................................... 27, 29  

**Front-to-back alignment** ..................... 10, 14, 18, 22, 26  

**Gerber** .................................................. 44, 92, 121  

**Head lighting** ......................................... 8, 12, 16, 20  

**Hot air oven** .......................................... 56, 72, 109, 112  

**Hotline** ............................................... Cover, 109  

**Housing** ................................................. 9, 13, 29  

**Image exposure unit** ............................... 71  
Inert gas option ......................................... 83  

**In-house prototyping** ......................... 1  

**Inspection templates** ......................... 6, 28  

**Laser printer for ProMask** .................... 72  

**Laser structuring** .................................... 46, 117  

**Lead-free reflow process** ..................... 81  

**Measuring microscope** ......................... 33  

**Metal engraving** .................................... 91, 103  

**Micro camera** ........................................ 79  

**Microwave circuits** ............................... 21, 28  

**Microwave substrates** ........................... 19, 59  

**Milling** .................................................. 28, 35, 104  

**MiniContac RS** ...................................... 57, 110  

**Mobile table** .......................................... 66  

**Monitor** ............................................... 77, 79  

**Motorized turntable** ............................. 77, 79  

**Multilayer** ............................................. 64, 106  

**MultiPress S** .......................................... 65  

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Process steps
The color-coded steps are only necessary for the production of multilayer boards.

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Data preparation

<table>
<thead>
<tr>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data preparation</td>
</tr>
<tr>
<td>100</td>
</tr>
</tbody>
</table>

Milling inner layers (2+3 and 4+5) 106
Bonding multilayer 108
Marking and drilling 108
Galvanic through-hole plating 110
Milling external layers (bonded multilayer) 112
Cutting out the printed circuit board 112
Solder resist masks, legend printing 113
Solder paste printing 114
Assembling 114
Reflow soldering 115

Through-hole plating without chemicals

<table>
<thead>
<tr>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data preparation</td>
</tr>
<tr>
<td>100</td>
</tr>
</tbody>
</table>

Milling external layers (each layer done before bonding) 99 & 104
Milling inner layers (2+3) 99 & 104
Bonding multilayer 106
Marking and drilling 108
Through-hole conductivity without chemicals 109
Cutting out the printed circuit board 108
Solder resist masks, legend printing 112
Solder paste printing 113
Assembling 114
Reflow soldering 115
Printed circuit board manufacturing – clear and brief

In the workflow overview you will see the simple steps to develop a finished printed circuit board using LPKF technology; process steps for galvanic or chemistry-free through-hole plating are shown. On the declared pages you will find detailed information about the appropriate steps of the production process.

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<table>
<thead>
<tr>
<th>Data preparation</th>
<th>Page</th>
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<tbody>
<tr>
<td>Milling inner layers (2+3 and 4+5)</td>
<td>99 &amp; 104</td>
</tr>
<tr>
<td>Bonding multilayer</td>
<td>106</td>
</tr>
<tr>
<td>Marking and drilling</td>
<td>108</td>
</tr>
<tr>
<td>Galvanic through-hole plating</td>
<td>110</td>
</tr>
<tr>
<td>Milling external layers (bonded multilayer)</td>
<td>9</td>
</tr>
<tr>
<td>Cutting out the printed circuit board</td>
<td>108</td>
</tr>
<tr>
<td>Solder resist masks, legend printing</td>
<td>112</td>
</tr>
<tr>
<td>Solder paste printing</td>
<td>113</td>
</tr>
<tr>
<td>Assembling</td>
<td>114</td>
</tr>
<tr>
<td>Reflow soldering</td>
<td>115</td>
</tr>
</tbody>
</table>

Through-hole plating without chemicals

<table>
<thead>
<tr>
<th>Data preparation</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milling external layers (each layer done before bonding)</td>
<td>99 &amp; 104</td>
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<td>108</td>
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