

The background features a repeating pattern of stylized components. Each component consists of a central orange circular element with a green ring around its base, connected to a green circular element. The components are arranged in a grid-like pattern, with some components having additional orange elements extending from their sides. A diagonal line runs from the bottom left to the top right, creating a triangular shape at the bottom of the page.

PWB Design Guide

MULTEK
40 Parker
Irvine, Ca. 92618
(949) 609-7100



Forward

The intention of this design guide is to provide a graphic reference to designers of multi-layer printed wiring boards, PWB's. References to data transfer, material information, and numeric values are all subject to change without notice. For any design that requires something other than standard processing parameters I recommend you contact a Multek Applications Engineer for an assessment of current capabilities and materials as they relate to your proposed design.

I welcome your comments and recommendations for future revisions of this document.

Glen Walther, Applications Engineering, Multek, Irvine, Ca., 3/25/2002

Acknowledgements:

Jamie Graves for the data transmission section.

Karl Hoebener for BGA routing schemes and geometry definition.

Melissa Walther for extensive graphics creations.

Date	Change Summary
3/25/02	Original publication, Owner/Author, Glen Walther, Multek, Inc., Irvine, Ca.92618
4/02/02	Revise BGA artwork p.15, Glen Walther
4/19/02	Revise I/L graphics pgs 18 ,19 & 26. Glen Walther
6/13/02	Change "C" Drilled PTH to Plane, Standard from 0.012" to 0.010" pg 17. G. Walther
"	Change RCC resin thickness from 50/50 to 35/35, pg 11, G. Walther
"	Add "dm," drill margin and "T" thickness to Mechanical Blind graphic & table., G. Walther
"	Update I/L BGA Geometry Tables, pages 18, 19, & 20. G. Walther



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Data Transmission

FTP access (ftp.multek.com)

All organizations conducting business with Multek have 24-hour access to our FTP servers. Both anonymous and private guest accounts are supported. Our Anonymous FTP server is available to all users for uploading data. Personal accounts and project specific accounts can be arranged by following the instructions below.

This document provides step by step instructions for accessing Multek's FTP servers, including account information and additional details about our FTP services.

Anonymous FTP Access Instructions

Command Summary	
Command Description	Syntax
Invoke FTP Session	ftp ftp.multek.com
Log in as ftp or anonymous	ftp <i>or</i> anonymous
Password (Enter your Email Address)	e.g. Jdoe@company.com
Change to /pub directory (required)	cd /pub
Change to [division] (required), where [division] is either irvine or roseville	cd irvine <i>or</i> cd roseville
Create personal directory (recommended)	mkdir company_name
Change to company_name directory (if applicable)	cd company_name
Set transfer mode to binary (required)	bi
Activate file progress hash marks (optional)	hash
Begin file transmission	put filename.zip
Quit FTP session	bye

Our FTP Watchdog handles all incoming data. Upon completion of data transmission, your files will be immediately moved to a secure location on our network. Statistics are then collected and forwarded to the sender, confirming byte size, transfer date/time and checksum. Our data administrators (data@multek.com) receive similar confirmation and will be your point of contact. If you have not received a confirmation within 30 minutes of the file transfer, please contact data@multek.com or ftp-admin@multek.com.



Personal and Project Specific Accounts

Under special circumstances Multek can assign individual FTP accounts. If you are interested in obtaining an account, please contact your sales representative or leave an email with ftp-admin@multek.com. Specify your desired login name and a list of email addresses who should be contacted after files have been uploaded. Also, please provide a call back number so that we may contact you to arrange an account password.

Incoming Data Requirements

Virtually every aspect of Multek's engineering and manufacturing operations are data driven. By reducing processing variation and manufacturing cycle-times, we are able to provide services and products unsurpassed in the industry. The objective is getting off on the right foot, and it all begins with the data and information provided by our customers.

The following briefly describes preferred methods of receiving data and information, data formats, compression methods and media. Use this document as a guideline for preparing data and documentation when issuing orders to Multek.

Table of Contents	
<u>Data and Documentation Formatting</u>	
<ul style="list-style-type: none">• Photo plotting Data• Aperture Information• N/C drill and Tool data• Fabrication Drawing(s)• Readme Document and/or Special Instructions• Net List Data	
Data Packaging	
<ul style="list-style-type: none">• Compression Methods• Data Encryption	
Data Transfer	
<ul style="list-style-type: none">• Transfer Media• Electronic transfer	



Data and Documentation Formatting

Photo plotting Data	
Data Formats	Gerber Rs274-X
	Gerber 274-D
	MDA Autoplot
	Barco DPF
	Orbotech backup
	Autocad DWG or DXF
	ODB++ (Valor Backup)
Data Type	ASCII
	EBCDIC
Units	English
	Metric

Aperture Information	
Formats	Embedded within Plot Data
	Columnated ASCII
	Legible Document
Units	English
	Metric

N/C Drill Data	
Formats	Excellon II
	Plot Data Format
Data Type	ASCII
	EBCDIC
Units	English
	Metric

N/C Drill Tool Information	
Formats	Embedded Tool Header
	ASCII Tool File
	Legible Document
Units	English
	Metric

Fabrication drawings	
Formats	HPGL, HPGL2, PLT, PCL. *.hpg, *.hp, *.plt, *.pcl
	Autocad DWG or DXF. *.dwg, *.dxf
	Postscript. *.ps, *.eps
	Raster Files. *.mil, *.tif, *.gif
	Portable Data Format. *.pdf
	Hard Copy Drawing

Readme Document and/or special Instructions	
	ASCII Text File
Formats	Embedded within Aperture Information
	Legible Document

Net List Data	
	IPC-D-356
	Mentor Neutral File Format
Formats	Cadence Allegro
	Any CAD output containing information listed in the table below
Units	English
	Metric

Net List Data Reference table	
Field Description	Required or Optional
Net / Signal name	Required
Reference Designator (Device Nomenclature)	Required
Pin Identifier (Pin Number)	Required
Test Point location (x , y)	Required
Access Side Indicator	Required if SMD both sides
Test Point Characteristics (SMD or PTH)	Required if SMD
Feature Size (Pad Size, Hole Diameter, etc.)	Optional



Data Packaging

Compression Methods	
Compression Utility	Operating System
PKWARE Win Zip, PKZip, PKArc	UNIX or DOS/MS Windows
Unix Compress	UNIX
Tar Compress .Tgz	UNIX
LHA (Shareware)	DOS
GNU's GZIP (Shareware)	UNIX or DOS
ARJ (Shareware)	DOS
UNIX Pack	UNIX

Data Encryption	
Encryption Utility	Operating System
VIA-CRYPT PGP	MS Windows
UUENCODE	Cross Platform

Data Exchange

Transfer Media
4mm DAT/DDS Tape (TAR)
1/4" data Cartridge (TAR)
3 1/2" diskette (DOS Formatted)
CD-ROM Compact Disk
100MB Iomega Zip Disk

Electronic Exchange
<ul style="list-style-type: none"> • FTP (Anonymous or Secured Account) • Email attachments to data@multek.com



APPROVED MATERIALS

Material	Grade Name	Supplier	DSC Tg (°C)	UL	Comments
FR-4	N4000-6	Nelco	180	94V-0	Cores & Prepregs
FR-4	N4000-13	Nelco	200	94V-0	Cores & Prepregs
FR-4	ED130	Isola	140	94V-0	Thick Cores Only
FR-4	FR-404	Isola	150	94V-0	Cores & Prepregs
FR-4	FR-408	Isola	180	94V-0	Cores & Prepregs
FR-4	N4000-2	Nelco	140	94V-0	Cores & Prepregs
FR-4/PPO	R5715	Matsushita	180 (TMA)	94V-0	4 Mil Cores & Up & Prepregs
FR-4/PPO	Getek ML-200	GE	180	94V-0	Cores & Prepregs
FR-4/BT	N5000	Nelco	180	94V-0	Cores & Prepregs
Polyimide	76N	Arlon	220 (TMA)	94V-0	Cores & Prepregs
Polyimide	31N	Arlon	260 (TMA)	94 V-1	Cores Only
Polyimide	N7000-2HT	Nelco	260 (TMA)	94V-0	Cores & Prepreg
Cy. Ester	N8000	Nelco	250 (TMA)	94V-0	Cores & Prepregs
Polyimide	N7000-3	Nelco	260 (TMA)	94 V-1	Cores & Prepregs

Other Special Materials Used In Specific Customer Applications

¹	R04003	Rogers	280	No	Cores Only
	RO4350	Rogers	280	94V0	Cores Only
²	RO4403	Rogers	280	94V0 ³	1080 Prepreg
PTFE	CLTE	Arlon	300 (Tmelt)	No	Cores Only
CTFE	6700	Arlon	190 (Tmelt)	No	Bonding Film
CTFE	B600	Furon	190 (Tmelt)	No	Bonding Film
FR-4/Thermount ⁴	55NT	Arlon	180	No	Prepreg
FR-4	No-Flow 47N	Arlon	130	94V-0	Prepreg

UL approved Laminate / Prepreg mixed packages

Material	Grade Name	Supplier	DSC Tg (°C)	UL.	Comments
FR-4	FR-404/N4205	Allied Signal/Nelco	Same as Prepreg used	94V0	Core & Prepreg
FR-4	N4105/FR-404	Allied Signal/Nelco	Same as Prepreg used	94V0	Core & Prepreg
FR4/PPO	Getek ML-200 / 47 N	GE / Arlon	Same as Prepreg used	94V0	Core & Prepreg

Multek is constantly evaluating new dielectrics and resin systems. If you do not find the material your job requires on this list, please contact a Multek Applications Engineer for additional information on new materials.

¹ Rogers 4003 & 4350 are ceramic filled hydrocarbon materials.

² Rogers 4403 is a glass reinforced thermoset plastic.

³ Only valid for “cap lam” construction. Not approved for “foil lam” construction.

⁴ Thermount is a registered trademark of Dupont



Copper Foils

Weights Available

¼ ounce (with peelable carrier)

½ ounce (Preferred for most constructions)

1 ounce

Resin Coated Copper, RCC

(Units = microns)

<u>Copper Thickness</u>	<u>C Stage Resin</u>	<u>B Stage Resin</u>
9	35	35
12	35	35
18	35	35

Distributed Capacitance Cores

Multek is a licensed user of ZBC-2000 buried capacitance layers from several different mass laminators. Each Power / Ground pair (core) yields approximately 450 pF/in² distributed capacitance. The artwork for distributed capacitance layers follows the same geometric guidelines used for creating power and ground planes.

Ohmega Ply®⁵

Planar resistor foils are available in 25, 50, and 100 ohms/ values. See page 32 for design guidelines for planar resistors.

New Materials

If the material your job requires is not on the above listing, please contact the Multek Technology Center for the latest materials currently under testing and development. UL 94V-0 certifications are currently underway on several new high speed materials.

⁵ Ohmega Ply is a registered trademark of Ohmega Technologies, Inc.



Engineering Services

Multek offers engineering services from early design phases through product end of life.. Multek's goal is to be involved with our customer's designers in early product development so that we may help minimize the number of product iterations and thus minimize time to market for new products. These services include "on demand" Field Applications Engineers, In-House Applications Engineers, Planning Engineers, and Product Engineers.

Field Applications Engineers and In-House Applications Engineers assist customers with interpretation of capabilities and how processes and methods may be adapted to meet the needs of specific products. This includes the selection of the most cost effective materials consistent with the demands of the design in development. These Multek engineers also provide stack up models from proof of concept through detailed final lay up instructions complete with required dielectric thickness and line widths for specified impedance values.

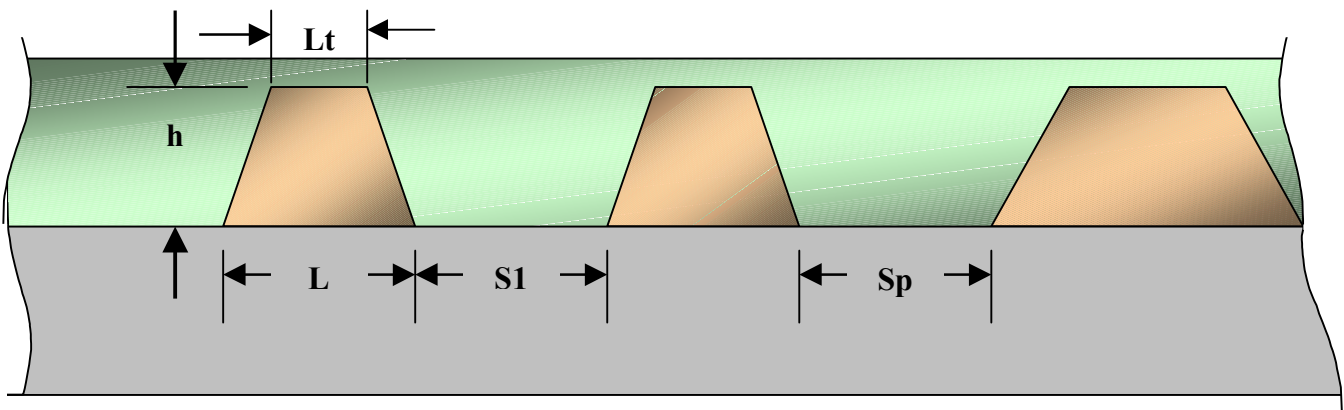
Multek's Data Administrators conduct design rule checks (DRC's) on all incoming Gerber data files as an early check for compatibility with standard manufacturing capabilities. When netlists are provided by our customers, Multek's CAM Engineers compare the netlist with the Gerber extracted netlist to insure the PWB we build is the PWB you want. In addition, CAM and Planning Engineering is on duty 24 hours/day, Monday through Friday, to assist with "time critical" data issues.

If your design requirements exceed Multek's stated capabilities or if multiple design parameters are at process limits, design for manufacturability (DFM) evaluation services are also available.

PWB Design Geometry
(all dimensions in inches unless otherwise noted)

Outer Layers

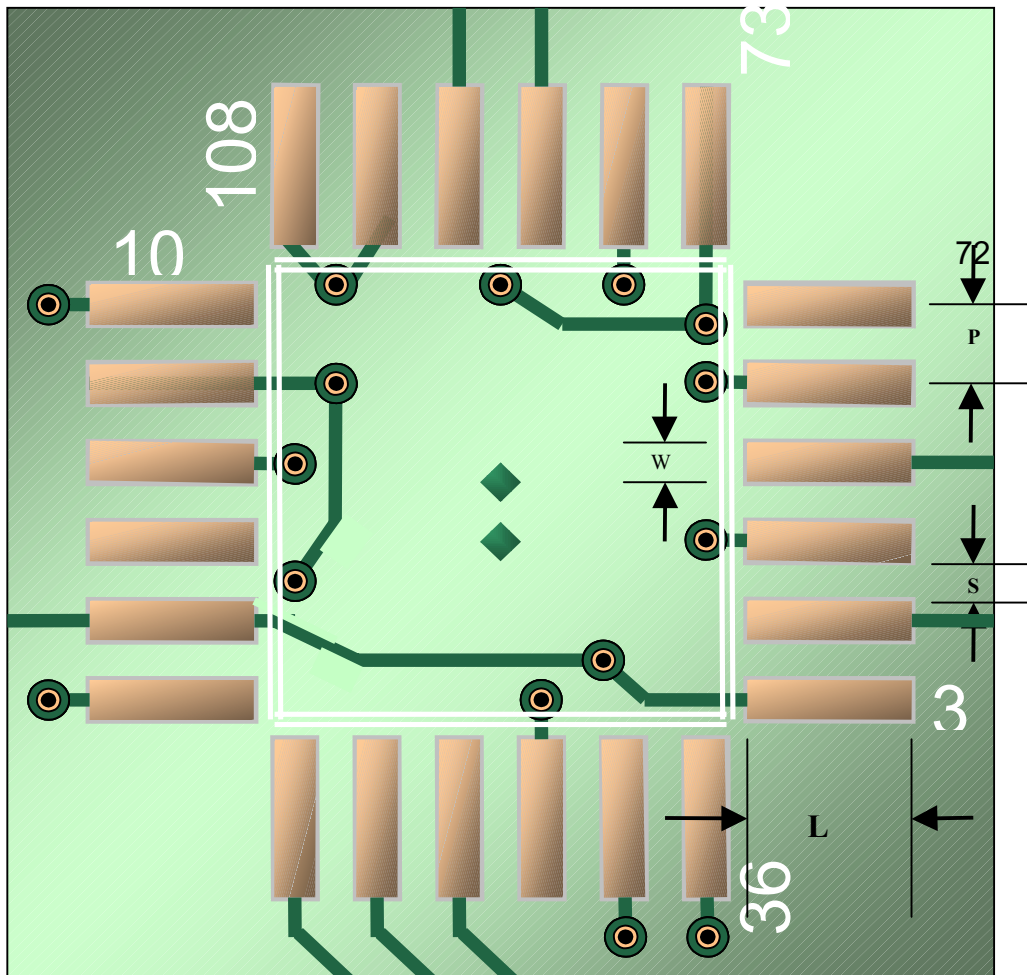
Line Width and Spacing



	Parameter	Standard	Advanced
L	Min. Line Width	.005	.003
S1	Min. Space (line to line)	.005	.00375
Sp	Min. Space (line to pad)	.005	.004
Lt	Top of Line	L - .0005	L - .0005
h	Height of Line *	.0018 ~ .0022	.0018 ~ .0022

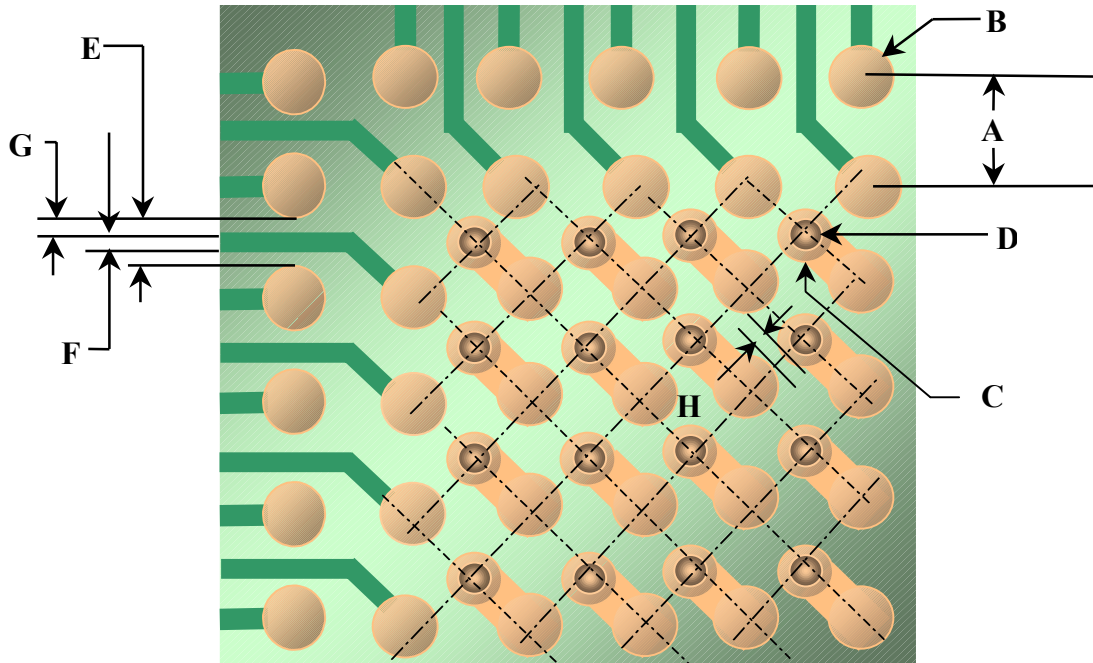
* Dependent on foil thickness & via plating requirements.

In-Line & Quad Flat Packs (QFP's)



	Parameter	Standard	Advanced
P	Min. Pitch	.0197	.009
S	Min. Space (pad to pad)	.009	.004
W	Min. Pad Width	.010	.005
L	Min. Pad Length	.020	.010

Outer Layer BGA Geometry

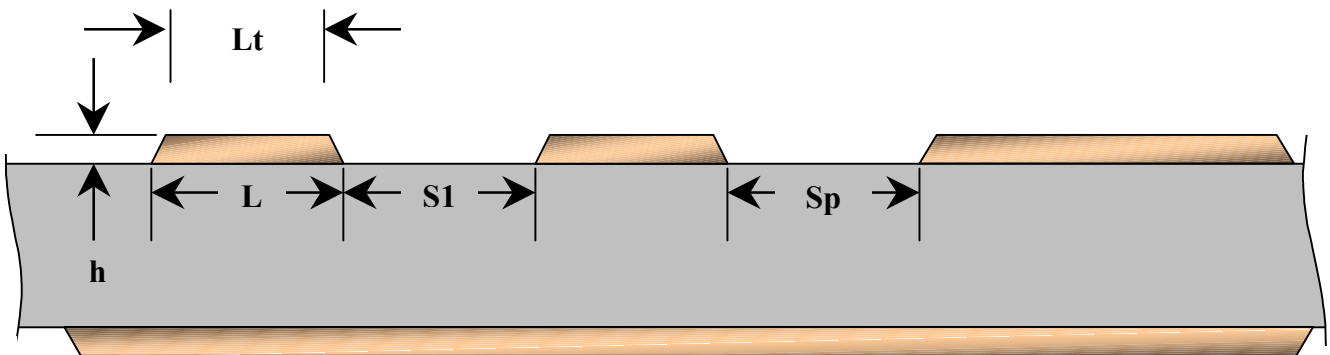


Parameter Identifier	Parameter Name (Units = inches)	1.27 mm BGA	1 mm BGA	.8 mm BGA	.65 mm BGA ⁶	.5 mm BGA
A	Pitch	0.0500	0.0394	0.0315	0.0256	0.0197
B	Solder Pad Dia.	0.0250	0.0260	0.0220	0.0118	0.0118
C	Drill Land Dia.	0.0210	0.0210	0.0140	0.0140	0.0098
D	PTH Drill Dia.	0.0110	0.0110	0.0060	0.0060	0.0050
E	Space, Solder Pad to Solder Pad	0.0250	0.0134	0.0094	0.0138	0.0079
F	O/L Line Width (1 line/channel)	0.0050	0.0040	0.0030	0.0040	0.0028
G	Space, Solder Pad to Line	0.0100	0.0047	0.0032	0.0049	0.0026
H	Space, Drill Land to Solder Pad	0.0124	0.0044	0.0042	0.0052	0.0031

⁶ Use of .65mm and .5mm guidelines May lead to violation of drill annular ring or plating aspect ratio.

Inner Layer

Line Width and Spacing

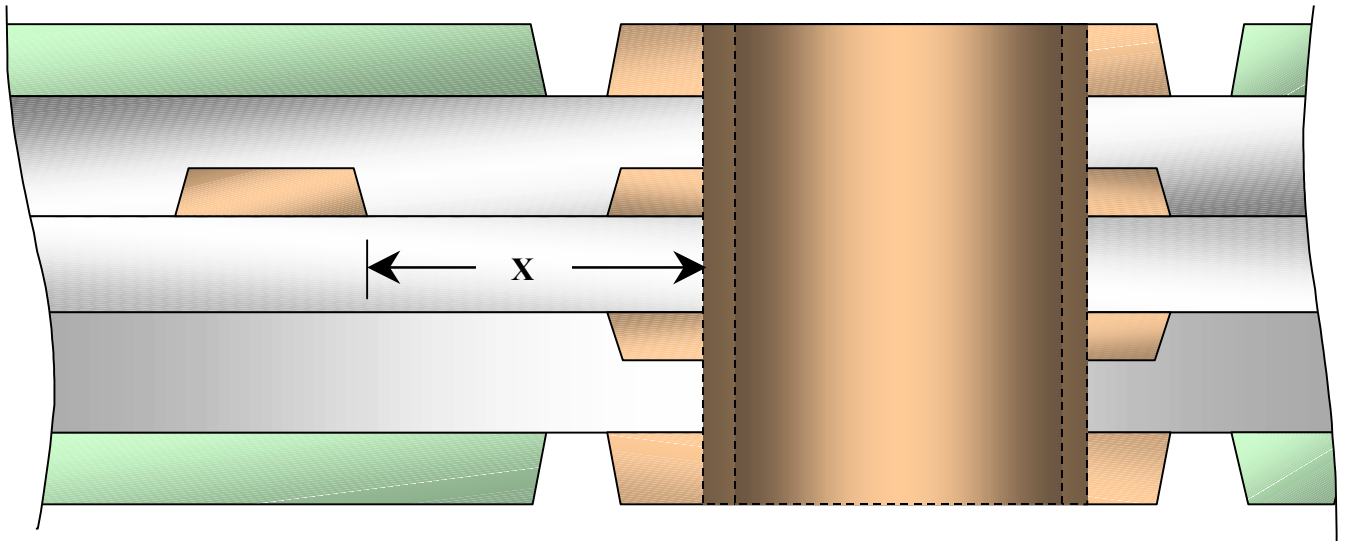


	Parameter	Standard	Advanced
L	Min. Line Width	.004	.003
S1	Min. Space (line to line)	.004	.003
Sp	Min. Space (line to via land)	.005	.004
Lt	Top of Line (½ oz. copper)	L - .00025	L - .00025
Lt	Top of Line (1 oz. copper)	L - .0005	L - .0005
h	Height of Line (½ oz. copper)	.0006	.0006
h	Height of Line (1 oz. copper)	.0012	.0012



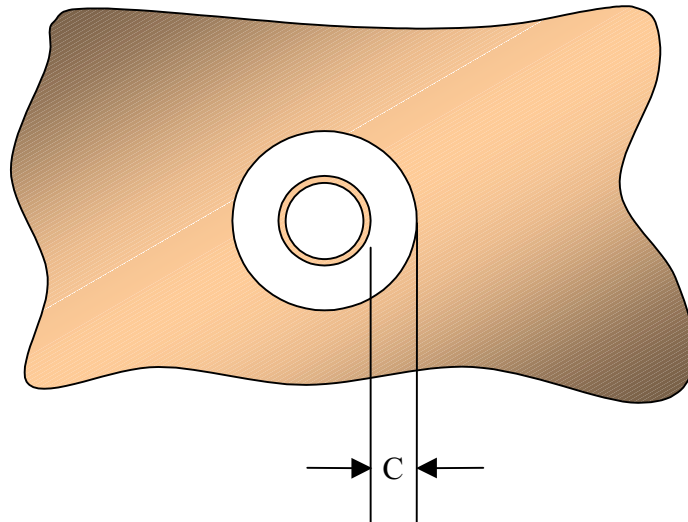
MULTEK

Inner Layer PTH to Copper



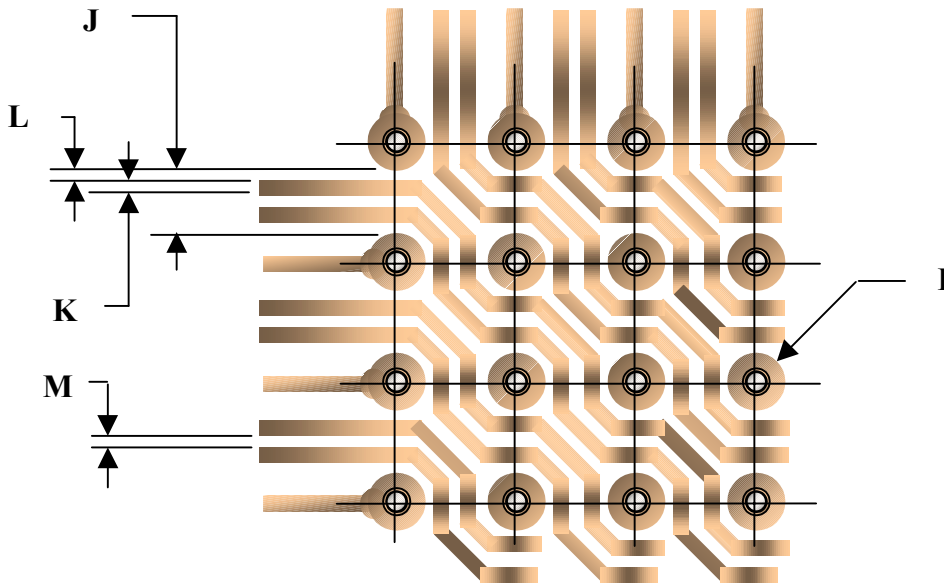
	Parameter	Standard	Advanced
X	Drilled PTH to Copper Feature	.010	.009

Inner Layer PTH to Plane



	Parameter	Standard	Advanced
C	Drilled PTH to Plane	.010	.009

Inner Layer BGA Geometry 2 Lines per Channel

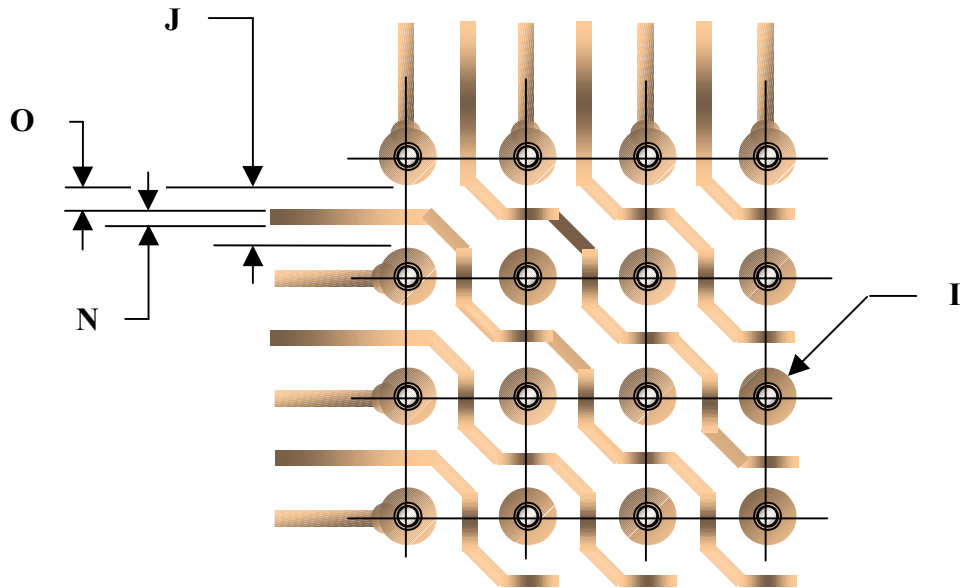


Parameter Identifier	Parameter Name (Units = inches)	1.27 mm BGA	1 mm BGA	.8 mm BGA	.65 mm BGA ⁷	.5 mm BGA
I	I/L Land Diameter	0.0240	0.0210	0.0167	0.0160	0.0118
J	I/L Space, Land to Land	0.0260	0.0184	0.0148	0.0096	0.0079
K	I/L Line Width (2 lines / channel)	0.0052	0.0036	0.0030	0.0019	0.0016
L	I/L Space, Pad to Line (2 lines/channel)	0.0052	0.0036	0.0030	0.0019	0.0016
M	I/L Space, Line to Line (2 Lines/Channel)	0.0052	0.0036	0.0030	0.0019	0.0016

⁷ Use of .65mm and .5mm guidelines May lead to violation of drill annular ring or plating aspect ratio.



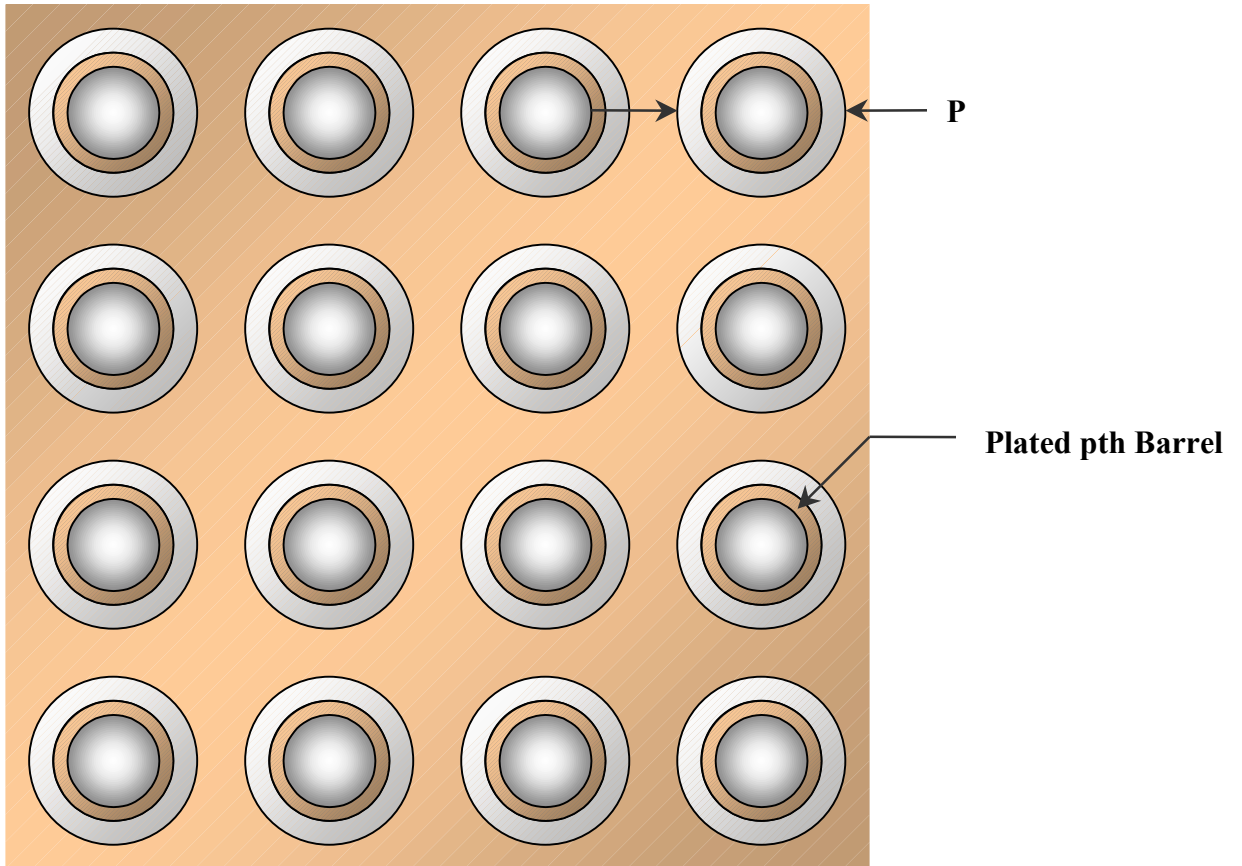
Inner Layer BGA Geometry 1 Line per Channel



Parameter Identifier	Parameter Name (Units = inches)	1.27 mm BGA	1 mm BGA	.8 mm BGA	.65 mm BGA ⁸	.5 mm BGA
I	I/L Land Diameter	0.0240	0.0210	0.0167	0.0160	0.0118
J	I/L Space, Land to Land	0.0260	0.0184	0.0148	0.0096	0.0079
N	I/L Line Width (1 Line / Channel)	0.0087	0.0061	0.0049	0.0032	0.0026
O	I/L Space, Pad to Line (1 Line / Channel)	0.0087	0.0061	0.0049	0.0032	0.0026

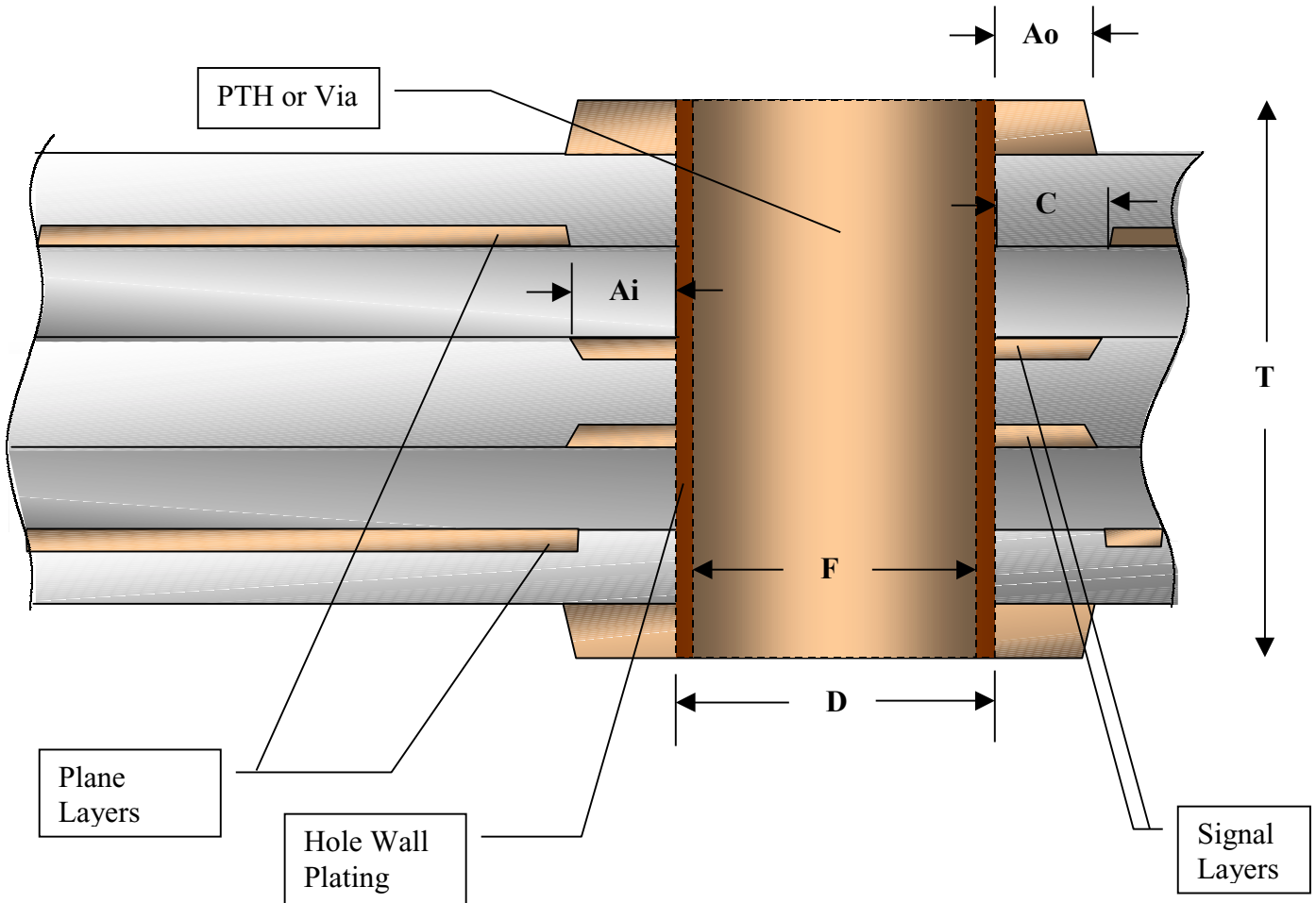
⁸ Use of .65mm and .5mm guidelines May lead to violation of drill annular ring or plating aspect ratio.

**Inner Layer BGA Geometry
PTH to Plane**



Parameter Identifier	Parameter Name (Units = inches)	1.27 mm BGA	1 mm BGA	.8 mm BGA	.65 mm BGA ⁹	.5 mm BGA
P	Plane Clearance (anti-pad)	0.0310	0.0310	0.0280	0.0260	0.0250

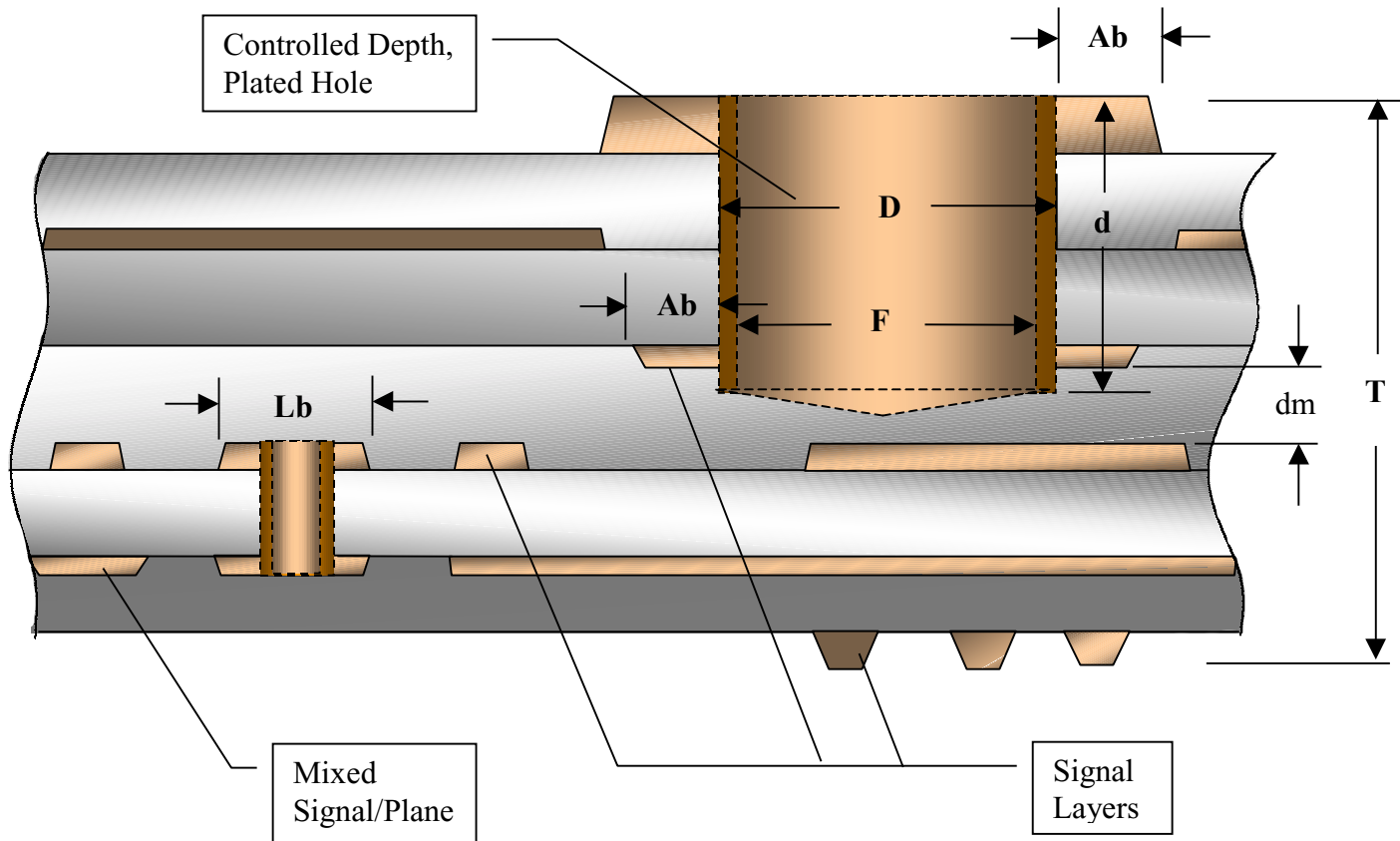
⁹ Use of .65mm and .5mm guidelines May lead to violation of drill annular ring or plating aspect ratio.

Drills: Mechanical


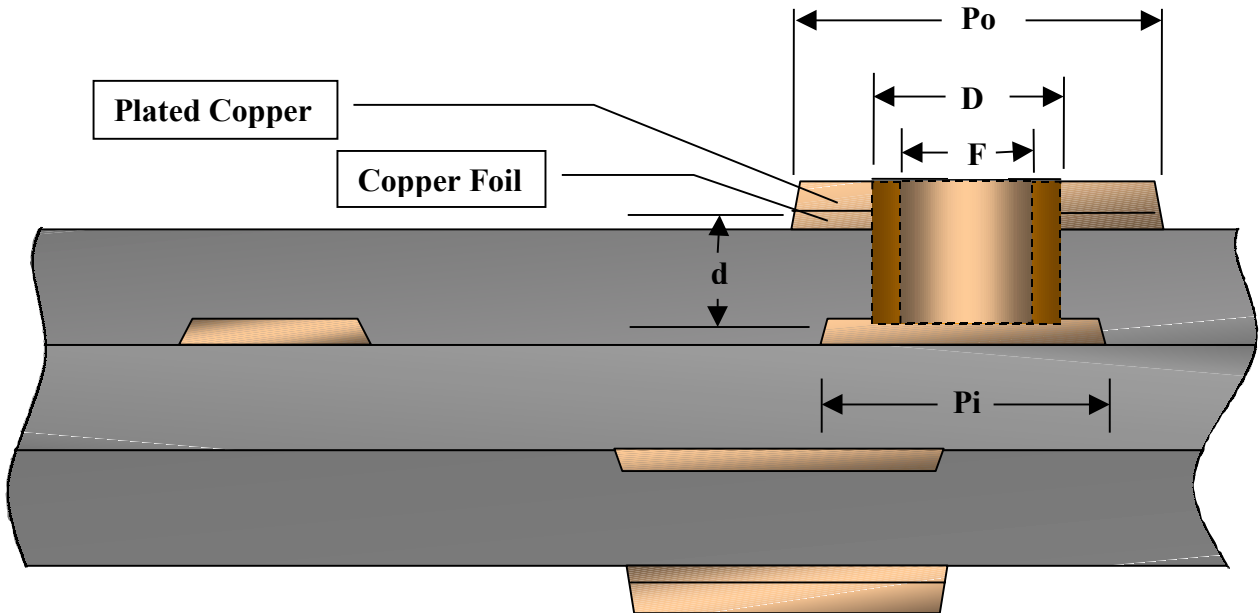
	Parameter	Standard	Advanced
T	Board Thickness (min/max)	.020 / .200	.020 / .250
D	Min. Drilled Hole Diameter	.010	.008
F	Min. Finished Hole Diameter	.008	.006
Ao	Min. Outer Layer Annular Ring	.006	.005
	O/L Land = Drill + 2(Ao)	.022	.018
Ai	Min. Inner Layer Annular Ring	.005	.004
	I/L Land = Drill + 2(Ai)	.020	.016
C	Clearance, Drill to Plane	.012	.009
	Min. Antipad = Drill + 2C	.034	.026
AR*	Max. Aspect Ratio = T/D	10:1	12:1

* Aspect Ratio is frequently the limiting factor for drill selection.

Mechanical Blind (Controlled Depth) and Buried Vias



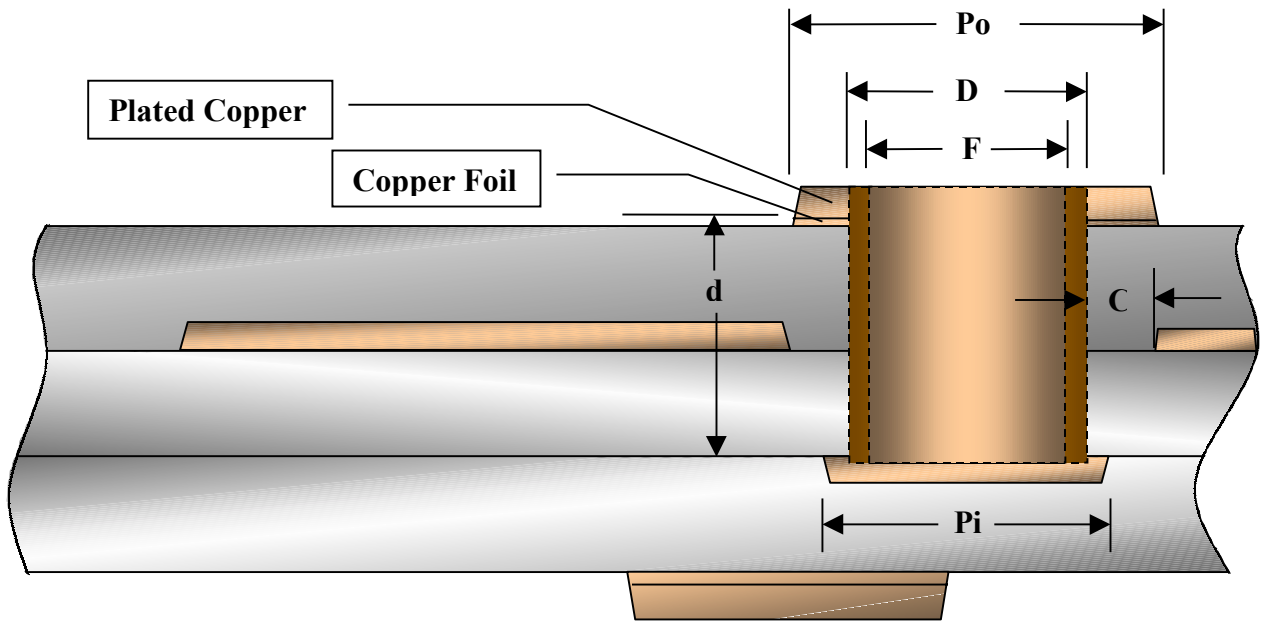
	Parameter	Standard	Advanced
T	Board Thickness (min/max)	.020 / .200	.020 / .250
D	Min. Blind/Buried Via Drill	.010	.006
F	Blind/Buried Finished Dia.	.008	.004
d	Controlled Depth	AR Dependent	AR Dependent
dm	Controlled Depth Margin (min.)	.005	.005
AR	Blind AR = d/D (max.)	.5	.75
Ab	Min. Blind/Buried Annular Ring	.005	.004
Lb	Min. Blind/Buried Land	.020	.014

Laser Drilled Micro-Vias
One Layer Deep


	Parameter	Standard	Advanced
D	Laser Drill Diameter	$\geq .005$	$\geq .004$
F	Finished Hole Diameter	$\leq .004$	$\leq .003$
Po	Min. Outer Layer Pad Dia.	$D + .008$	$D + .004$
	Min. O/L Annular Ring	$.004$	$.002$
Pi	Min. Inner Layer Pad Dia.	$D + .006$	$D + .004$
	Min. I/L Annular Ring	$.003$	$.002$
d	Drill Depth	AR Dependent	AR Dependent
AR	Max. AR = d/D	$.5$	$.75$
	Surface Copper Foil	$\frac{1}{4}$ ounce preferred	$\frac{1}{4}$ ounce preferred
	Surface Copper Plating	$\geq .0005$	$\geq .0005$
	Inner Layer Copper Foil	$\geq \frac{1}{2}$ ounce	$\geq \frac{1}{2}$ ounce

Laser Drilled Micro-Vias

Two Layers Deep



	Parameter	Standard	Advanced
D	Laser Drill Diameter	$\geq .005$	$\geq .004$
F	Finished Hole Diameter	$\leq .004$	$\leq .003$
Po	Min. Outer Layer Pad Dia.	$D + .008$	$D + .004$
	Min. O/L Annular Ring	$.004$	$.002$
Pi	Min. Inner Layer Pad Dia.	$D + .006$	$D + .004$
	Min. I/L Annular Ring	$.003$	$.002$
C	Drill to Plane Clearance	$.010$	$.006$
	Min. Anti-Pad = $D + 2C$	$.025$	$.016$
d	Drill Depth	AR Dependent	AR Dependent
AR	Max. AR = d/D	$.5$	$.75$
	Surface Copper Foil	$\frac{1}{4}$ ounce preferred	$\frac{1}{4}$ ounce preferred
	Surface Copper Plating	$\geq .0005$	$\geq .0005$
	Inner Layer Copper Foil	$\geq \frac{1}{2}$ ounce	$\geq \frac{1}{2}$ ounce



Mechanical Drill Tolerance Table

Parameter	Standard	Advanced
PTH: Diameter	+/- 0.003	+/- 0.002
NPT: Diameter	+/- 0.002	+/- 0.001
Location, Diameter True Position	0.0085	0.0028
Mechanical Depth Control	+/- 0.005	+/- 0.003

Laser Drill Tolerance Table

Parameter	Standard	Advanced
Laser Via Diameter	+/- 0.0005	+/- 0.0005
Location, Diameter True Position	0.0011	0.0011
Registration to I/L Pad	+/- 0.0015	+/- 0.0015

Positional Tolerance

Positional tolerance may be referenced by Cartesian coordinates and expressed as +/- 0.00x” in the X and +/- 0.00y in the Y axis or it may be expressed in terms of Diameter True Position or Radius True Position.

The relationship between Diameter True Position (DTP) and Radius True Position (RTP) is:

$$DTP = 2 * RTP$$

The relationship between the Cartesian coordinates and Radius True Position is:

$$X = RTP * \sin 45^\circ$$

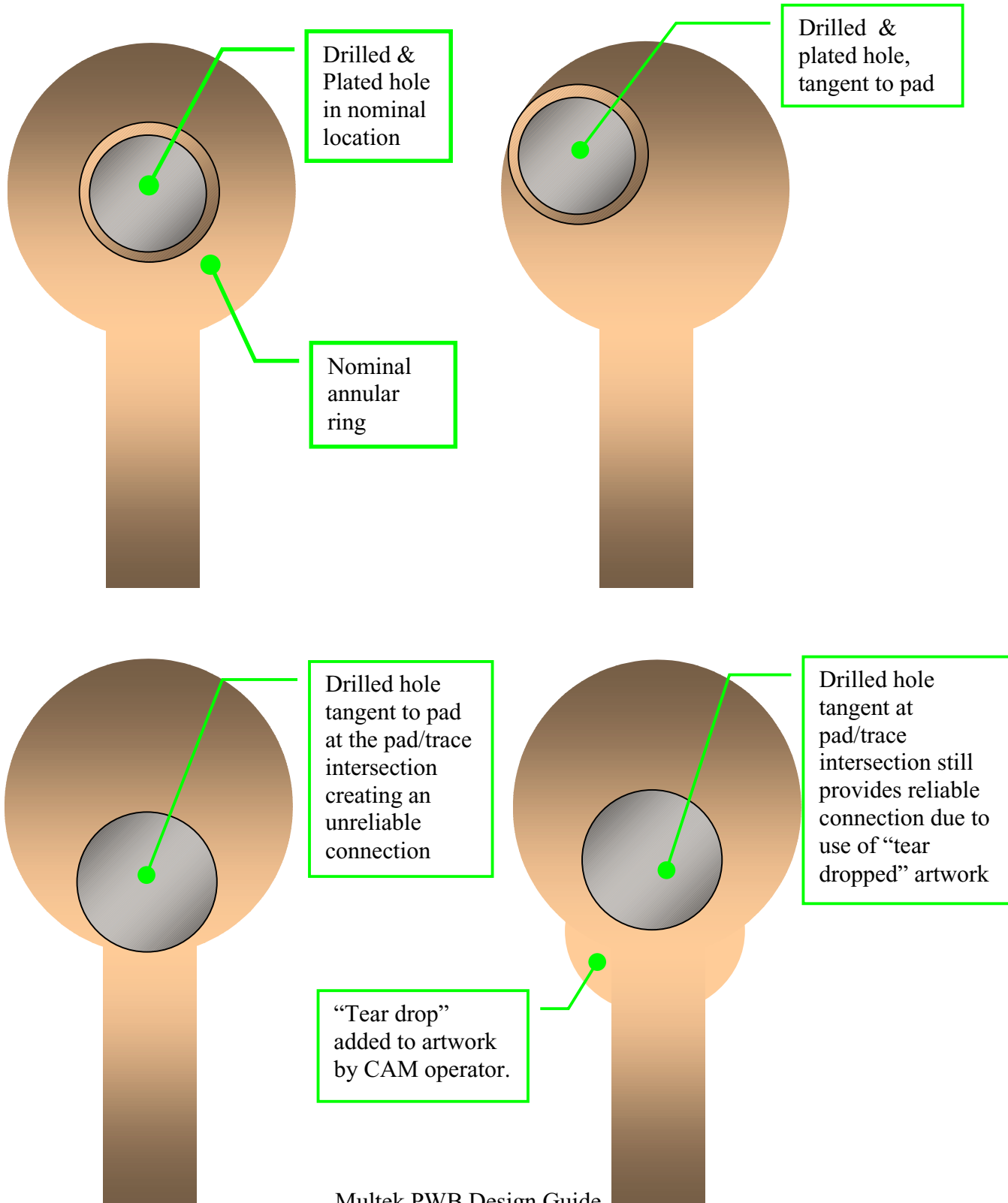
Where X is the Cartesian positional tolerance.

Example:

A product requires a positional tolerance of +/- 0.004” Radius True Position. To determine the equivalent Cartesian positional tolerance:

$$\begin{aligned}
 X &= RTP * \sin 45^\circ \\
 X &= +/- (0.004”) * (.707) \\
 X &= +/- (0.0028”)
 \end{aligned}$$

Drill Location and Inner Layer Annular Ring, Drill Tangency, and “Tear Dropped” Artwork





Controlled Impedance Configurations

Controlled impedance lines may be designed in many different configurations. The most common are microstrips and striplines. Variations of these basic forms include microstrips with and without soldermask, embedded microstrips, differential microstrips, and guarded microstrips. Striplines may be configured as single striplines, dual (offset) striplines, differential striplines, broadside differential striplines, and guarded variations of the above constructions.

Specify on the master drawing which signal layers are to be controlled impedance layers, the line width in the Gerber data that represents the controlled impedance lines, and the desired value and tolerance.

Example: “50 ohms impedance, $\pm 10\%$, on 4 mil lines on all internal signal layers and on 7 mil lines on outer layers.”

If more than one impedance value is required on a given layer and/or there are various controlled impedance structures within the same PWB, it may be beneficial to create an Impedance Table on the master drawing that indicates by layer, trace width & impedance value, reference planes, impedance structure type, and line width. If 5 mil lines are to be 50 ohm single ended and other 5 mil lines on the same layer are to be 100 ohm differential pairs it is best to rout the differential pairs at a slightly different width so CAM operators can make minor adjustments to the final etched line width to meet your requirements.

Example Table:

Controlled Impedance Requirements

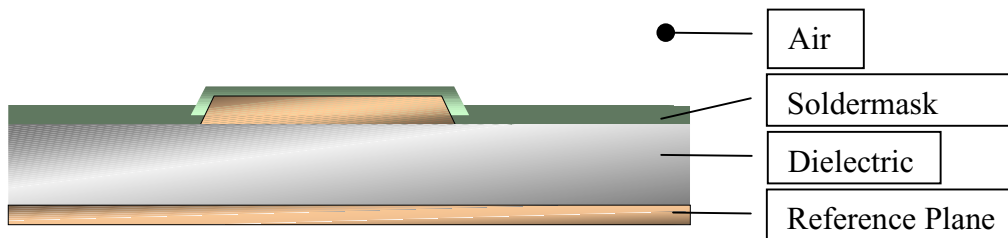
Layer	Lines	Pitch	Ref. Layer	Impedance (Ω)	Tolerance (%)
Top	0.007”	N/A	2	50	10
3	0.005”	N/A	2 & 4	50	10
3	0.0051”	0.015”	2 & 4	100 Diff.	10
6	0.005”	N/A	5 & 7	50	10
6	0.0051”	0.015”	5 & 7	100 Diff.	10
Bottom	0.007”	N/A	2	50	10

It is usually desirable to add a statement to the effect that final impedance values take precedence over line widths. Minor adjustments in dielectric layers and line widths are usually required to come as close as possible to your target values.

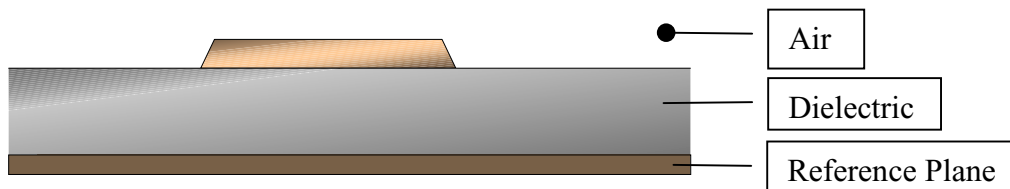
The variables of controlled impedance structures include the following:

- ❑ Thickness of the copper signal trace
- ❑ Width of the copper signal trace
 - ❑ Top
 - ❑ Bottom
- ❑ Thickness of the dielectric material between the trace and the reference plane
- ❑ Pitch of Differential Pairs
- ❑ Horizontal distance to ground guards

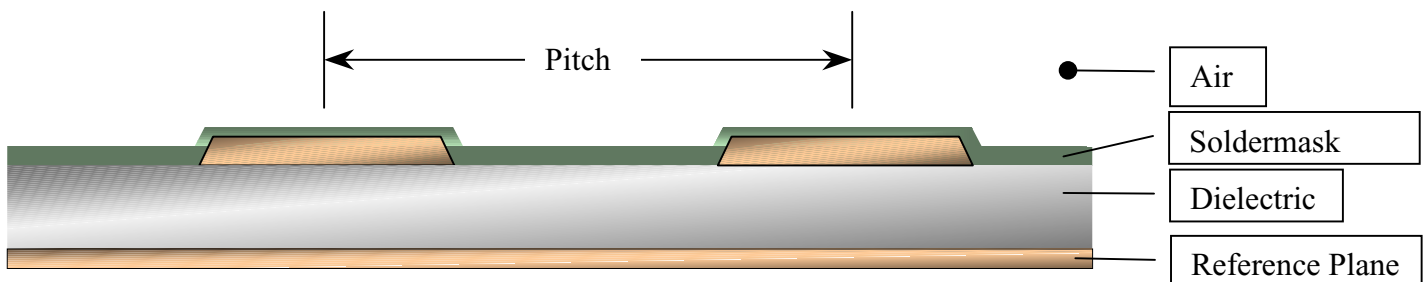
Microstrip with Soldermask



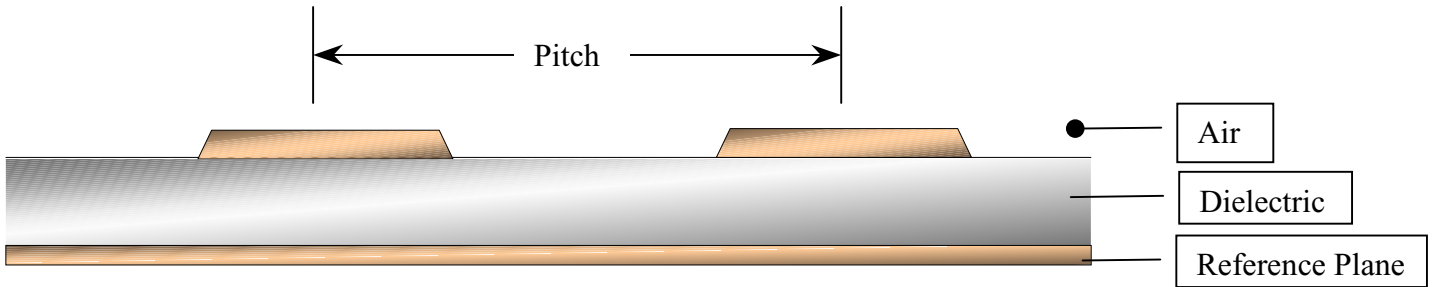
Microstrip without Soldermask



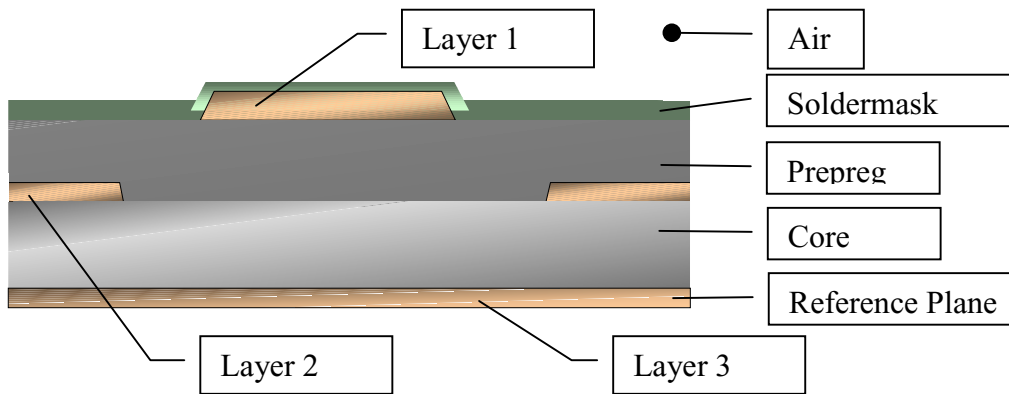
Differential Microstrip with Soldermask



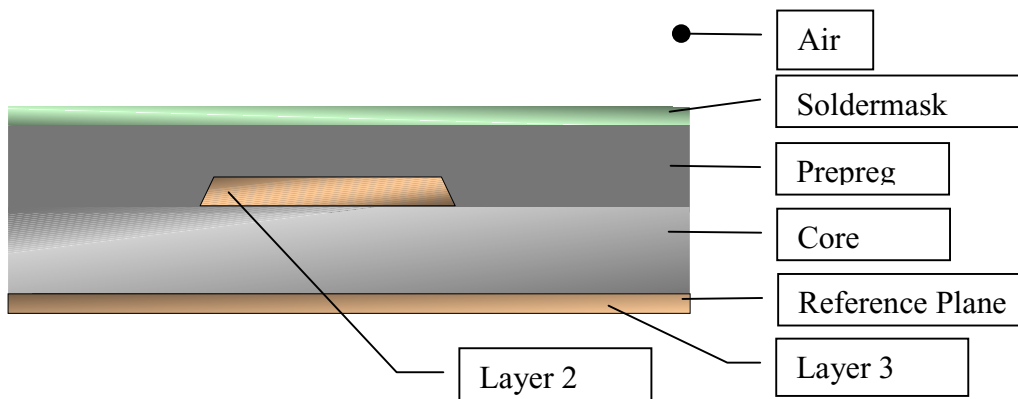
Differential Microstrip without Soldermask



Microstrip, Reference Layer 3, with Soldermask

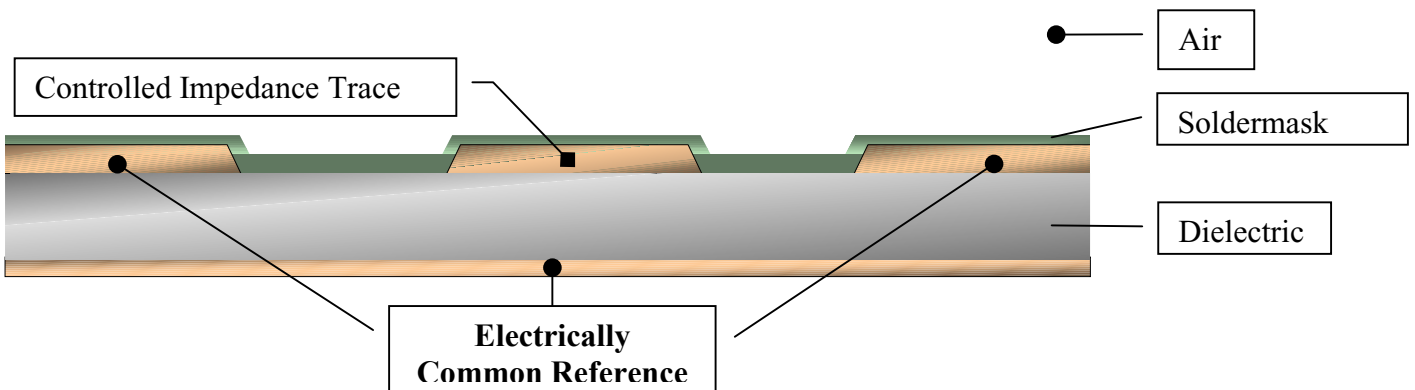


Embedded Microstrip, Reference Layer 3, with Soldermask

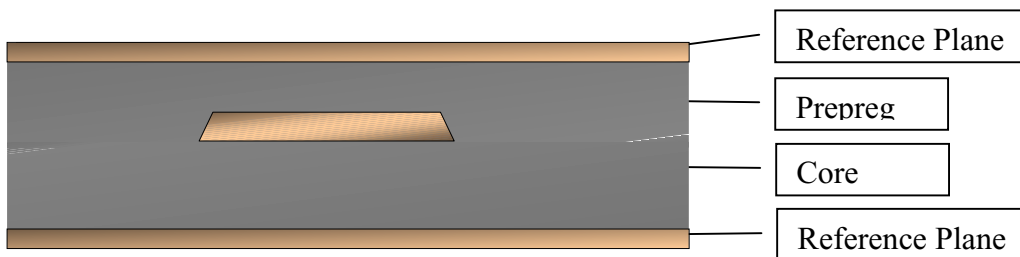




Guarded Microstrip with Soldermask

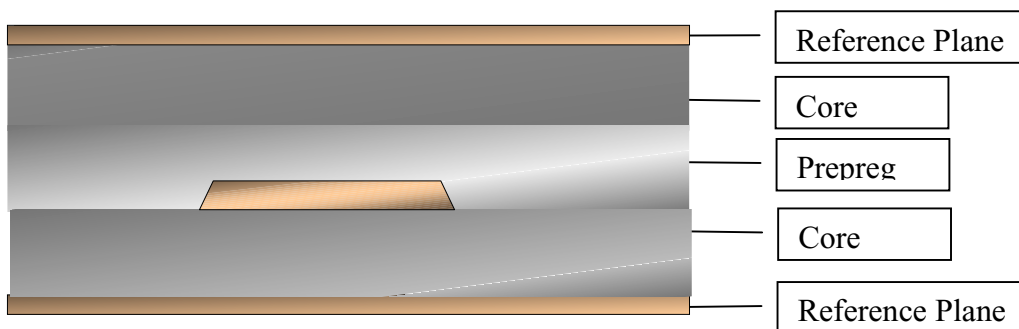


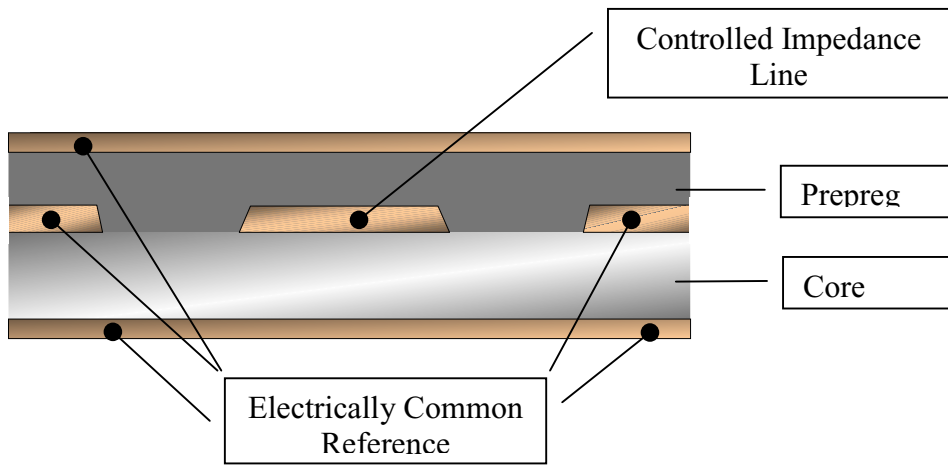
Stripline



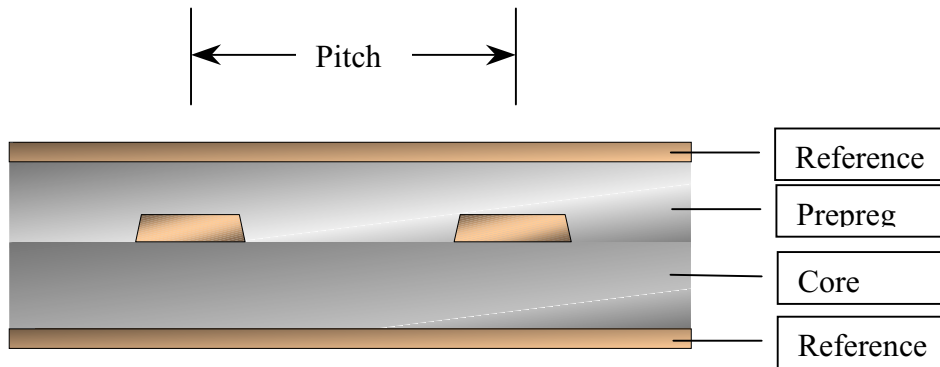
Offset (or Dual) Stripline

(Preferred construction for single ended, offset (or dual) striplines. Cores are easier to process with a signal layer on one side and a plane layer on the other. Scales are more predictable and there are fewer “false calls” at AOI.)



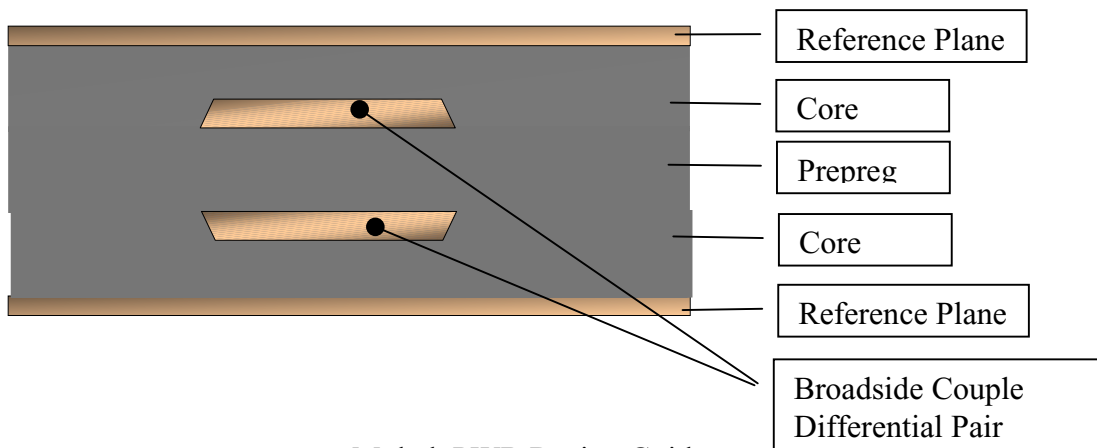


Differential Stripline, Edge Coupled



Differential Stripline, Broadside Coupled

(Preferred construction for Broadside Differential Pairs. Both signal layers are on the same core providing the best control for signal to signal registration and dielectric spacing.)





Planar Resistor Geometry

It is desirable to place planar resistors on plane layers rather than signal layers to maximize heat dissipation. Planar resistors may also be employed on signal layers if desired.

To minimize the effect of etch tolerance on the resistor's value, the physical dimensions of the resistor should be as large as the design will allow. A larger resistor will have a tighter tolerance than a smaller resistor with the same ohmic value on the same material.

The simplest and most common resistor design is a rectangle (or square). The value of the resistor can be determined by the following equation.

$$R = (\text{number of squares}) * (\text{material value per square})$$

$$R = (L/W) \square * (\Omega/\square)$$

Example 1:

Using $25 \Omega/\square$ material construct a 50Ω resistor.

Set $L = 20$ mils

Set $W = 10$ mils

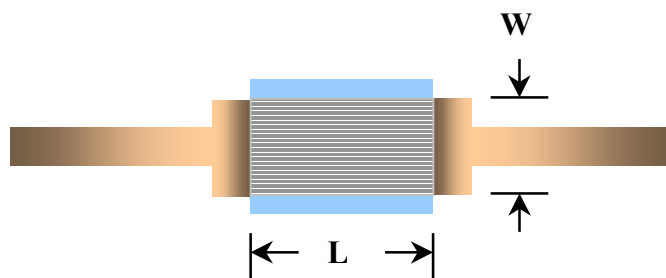
$$\text{Then: } R = (L/W) \square * (\Omega/\square)$$

$$R = (20/10) \square * (25 \Omega/\square)$$

$$R = (2) \square * (25 \Omega/\square)$$

$$R = 50 \Omega$$

Two artwork layers are required for each layer of the board that contains planar resistors. The first image is the standard artwork that transfers the signal or plane layer image to the core. This first artwork image (copper color) determines the width W of the resistor element. The second image (Blue & Grey rectangle) provides the window that defines the length L of the resistor element. The finished resistor element is depicted by the gray rectangle.

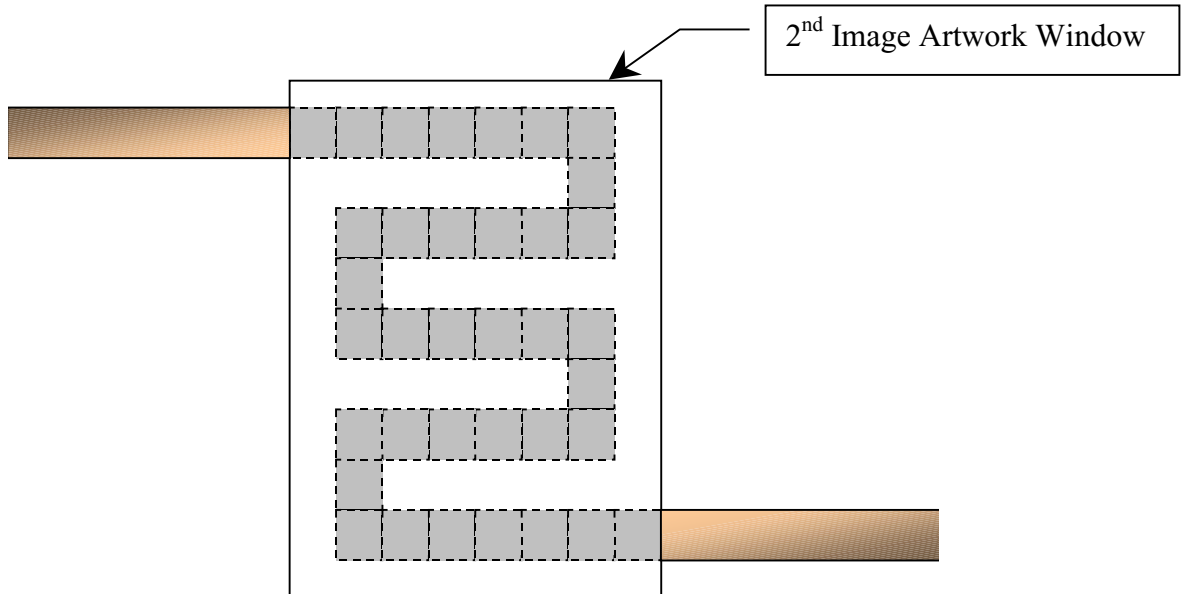


The overlapped regions to the left, right, top and bottom of the gray resistor element provide a registration tolerance allowance. Allow $0.005''$ to the left, right, above, and below the resistor element when designing planar resistors.



For resistors of higher value, serpentine geometry is often utilized. As in square and rectangular geometries, the final value of the resistor element is determined by the number of squares of exposed planar resistor material with one exception. The squares at the corners of the serpentine pattern are rated at 0.559 of the Ω/\square value of the material.

Example 2: The serpentine resistor element is composed of 36 squares. Eight of these squares are on corners.



Given material with $25 \Omega/\square$,

The value of this resistor is:

$$R = (\# \text{ of } \square\text{'s not on corners} * 25 \Omega/\square) + ((0.559)*(\# \text{ of } \square\text{'s on corners} * 25 \Omega/\square))$$

$$R = (28*25 \Omega) + ((0.559)*(8*25 \Omega))$$

$$R = 811.8 \Omega$$

The second image artwork window is at least 5 mils larger than the serpentine image. The first and last squares in the resistor element are designed to extend beyond the rest of the serpentine form, thus making registration in the x axis less critical.

The dashed lines delineating the squares of the resistor element are for illustration only. The shape of the serpentine element is simply a drawn trace on a signal layer.

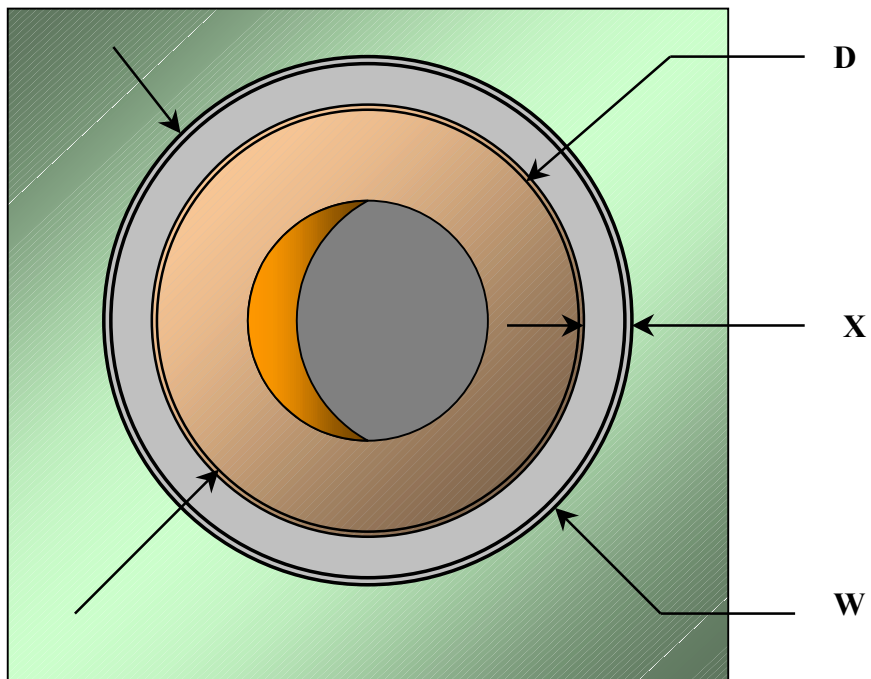
For more information you may access the Ohmega Ply web site at: www.ohmega.com

Solder Mask

Multek's preference for liquid photo-imageable solder mask (LPI SM) is Taiyo PSR-4000 BN. It provides good resistance to surface finish applications including electroless nickel / immersion gold while providing minimum web dimensions as small as 0.003 inches. The following design parameters are based on Multek's use of Taiyo PSR-4000.

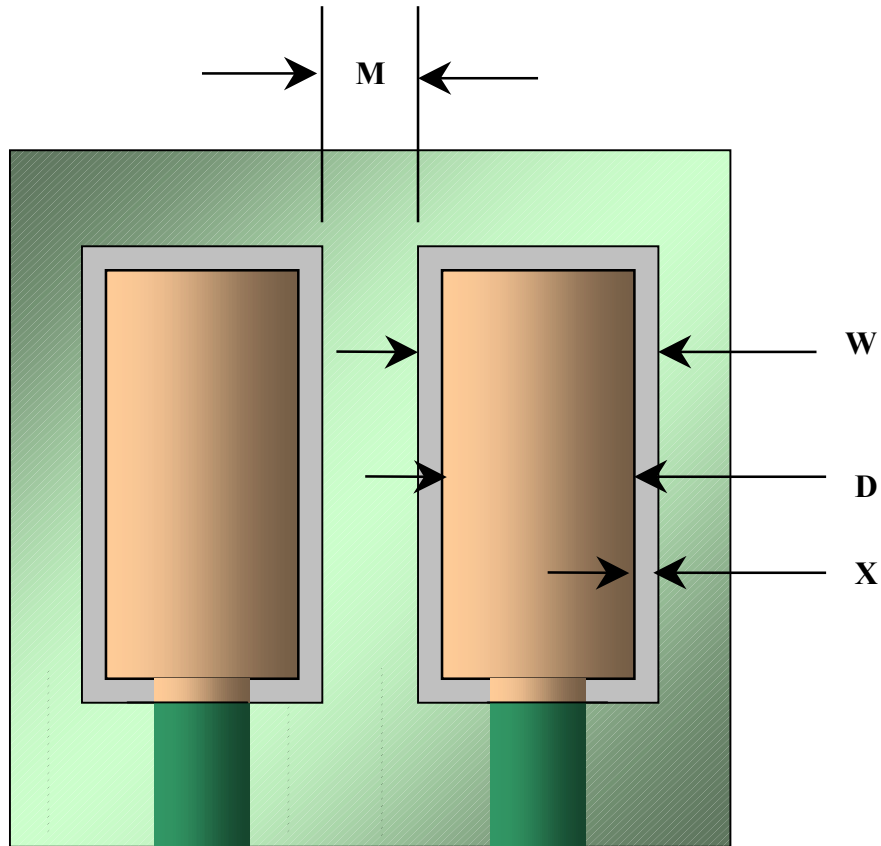
In addition to green, LPI SM is available in clear, red, black, yellow and blue. Please contact a Multek Applications Engineer for applicability and availability of these products.

LPI SM Window for PTH Lands

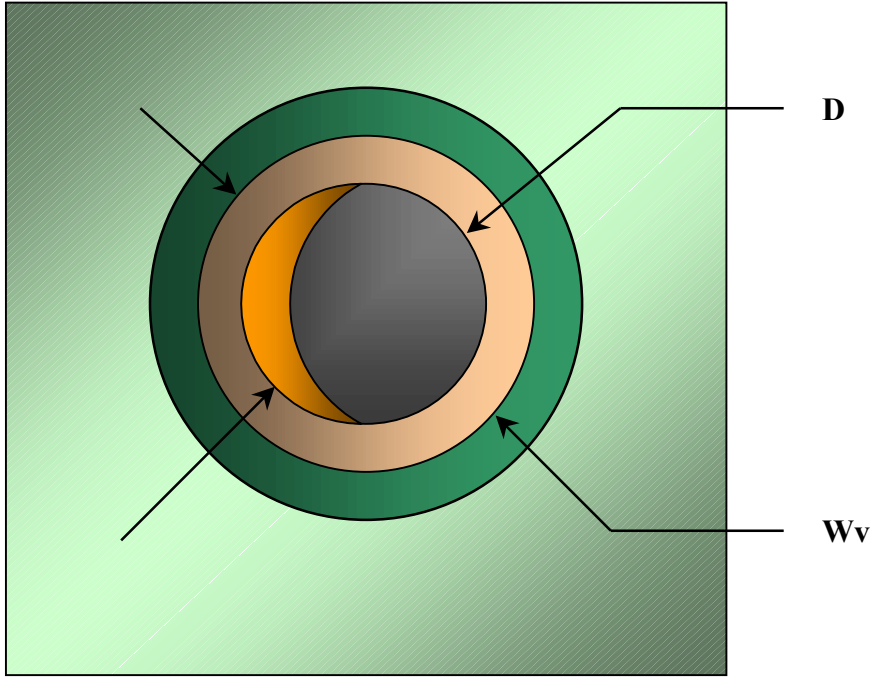


	Parameter	Standard	Advanced
D	PTH Land Diameter		
X	LPI SM Registration Tolerance	0.003"	0.002"
W	LPI SM Window = D + 2X		

LPI SM Window for SMD Pads

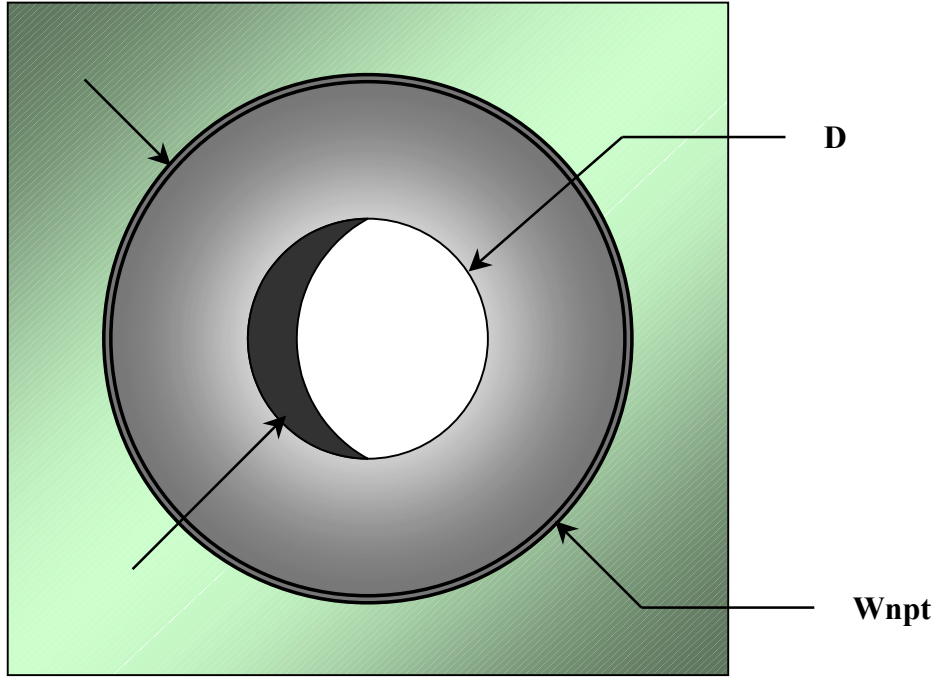


	Parameter	Standard	Advanced
D	SMD Pad Dimension		
X	LPI SM Registration Tolerance	0.003"	0.002"
W	LPI SM Dimension = $D + 2X$		
M	Min. LPI SM Web	.004"	.003"

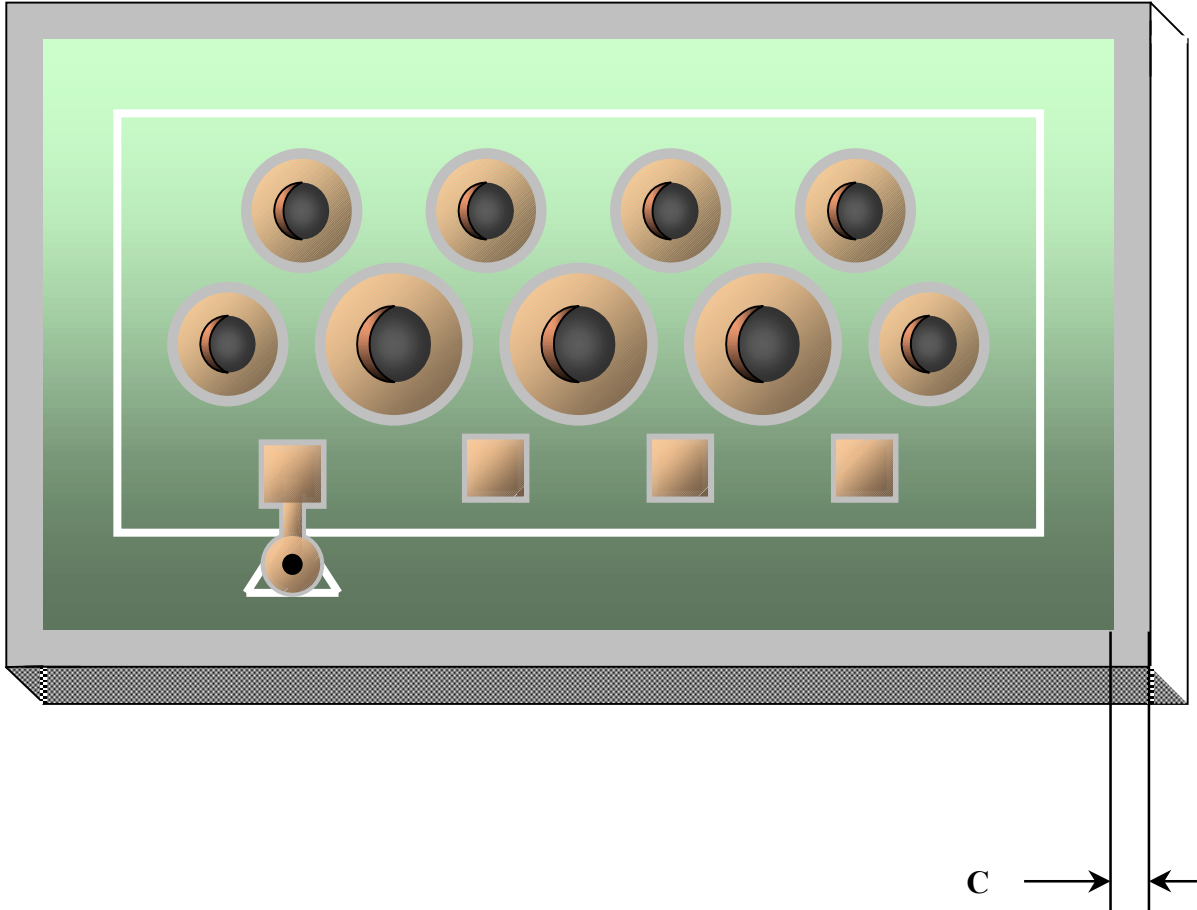
LPI Solder Mask Windows for Plated Vias


	Parameter	Standard	Advanced
D	PTH Drill Diameter		
X	LPI SM Registration Tolerance	0.003"	0.002"
W_v	LPI SM Window = D - 2X		

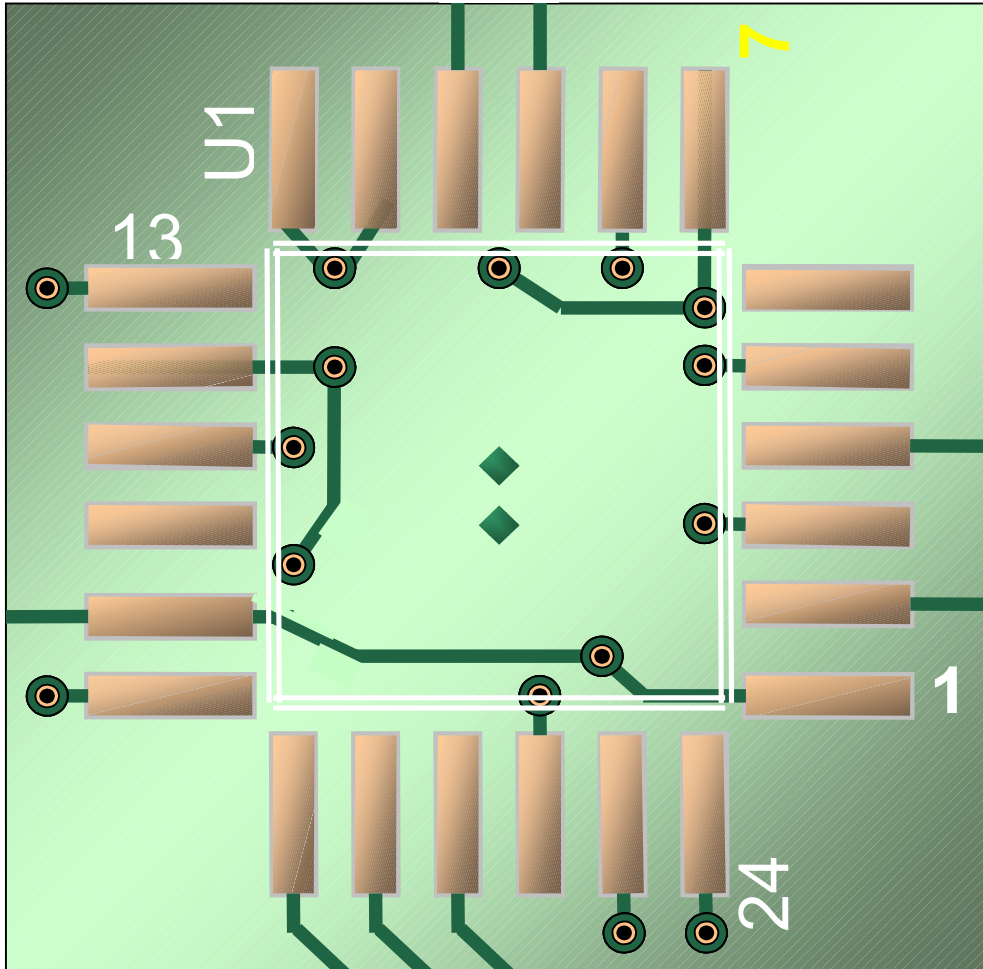
LPI SM Window for Non-Plated Through Holes (NPT's)



	Parameter	Standard	Advanced
D	NPT Drill Diameter		
X	LPI SM Registration Tolerance	0.005"	0.004"
Wnpt	LPI SM Window = D + 2X		

LPI SM Clearance for Rout Lanes


	Parameter	Standard	Advanced
C	Clearance from Routed Edge	0.015"	0.015"

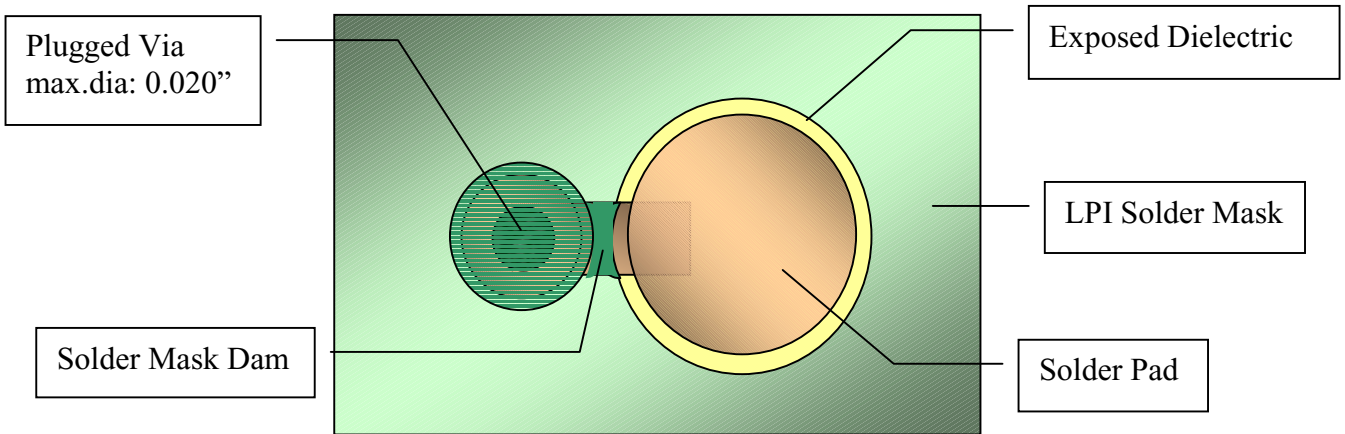
Legend (I.D., Silk Screen)


	Parameter	Standard	Advanced
	Min. Stroke Width	.006	.005
	Min. Spacing to Copper Pads	.006	.006
	Standard Colors	White or Yellow	N/A

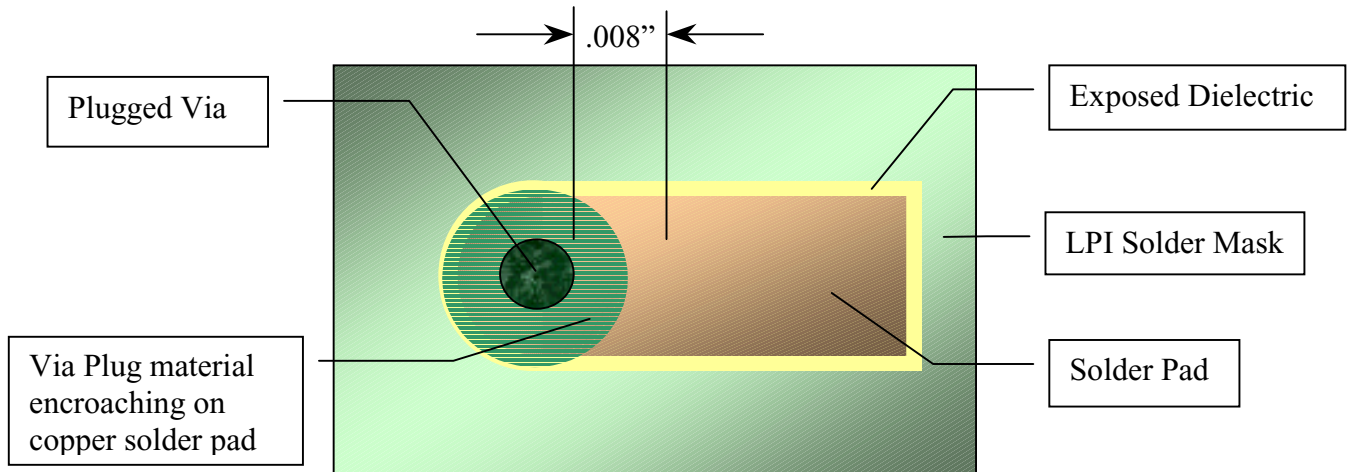
Legend that violates the 0.006" clearance to a copper pad will be clipped to provide the required clearance.

Via Plug

Via plugging is the liquid photo imageable solder mask equivalent of tenting vias with dry film soldermask. Via plugging is a screen process in which a UV curable epoxy is applied to customer defined vias to aid the assembly process. Via plugging should always be done from only one side of the board in order to prevent trapping process chemicals which could cause latent defects. Via plugging is done after the final surface finish is applied except in the case of an OSP finish which is applied after via plugging.



In many via plug applications, the via pad will be completely isolated from other copper features on the surface. In other cases, the via to be plugged will be separated from a solder pad by a solder mask dam as shown above. The solder mask dam prevents the possibility of via plug material from contaminating the solder pad.



When the via to be plugged is not separated from the solder pad by a solder mask dam, the minimum spacing between the solderable surface and the via to be plugged should be 0.008".



Surface Finishes

Individual Types

Suggested Parameters

Hot Air Solder Level (HASL)

Electrolytic Nickel / Gold	Ni: 200 ± 50 μ”	Flash Au (hard or soft): 3 to 8 μ” Hard Au: 3 to 50 μ” Soft Au: 3 to 50 μ”
Electroless Ni / Immersion Au	Ni: 200 ± 50 μ”	Au: 3 to 8 μ”
Immersion Tin	Sn: 8 ~ 12 μ”	
Immersion Silver	Ag: 8 ~ 12 μ”	
OSP (Entek 106A)	0.2 ~ 0.5 microns	
OSP (Entek Cu 56)	0.2 ~ 0.5 microns	

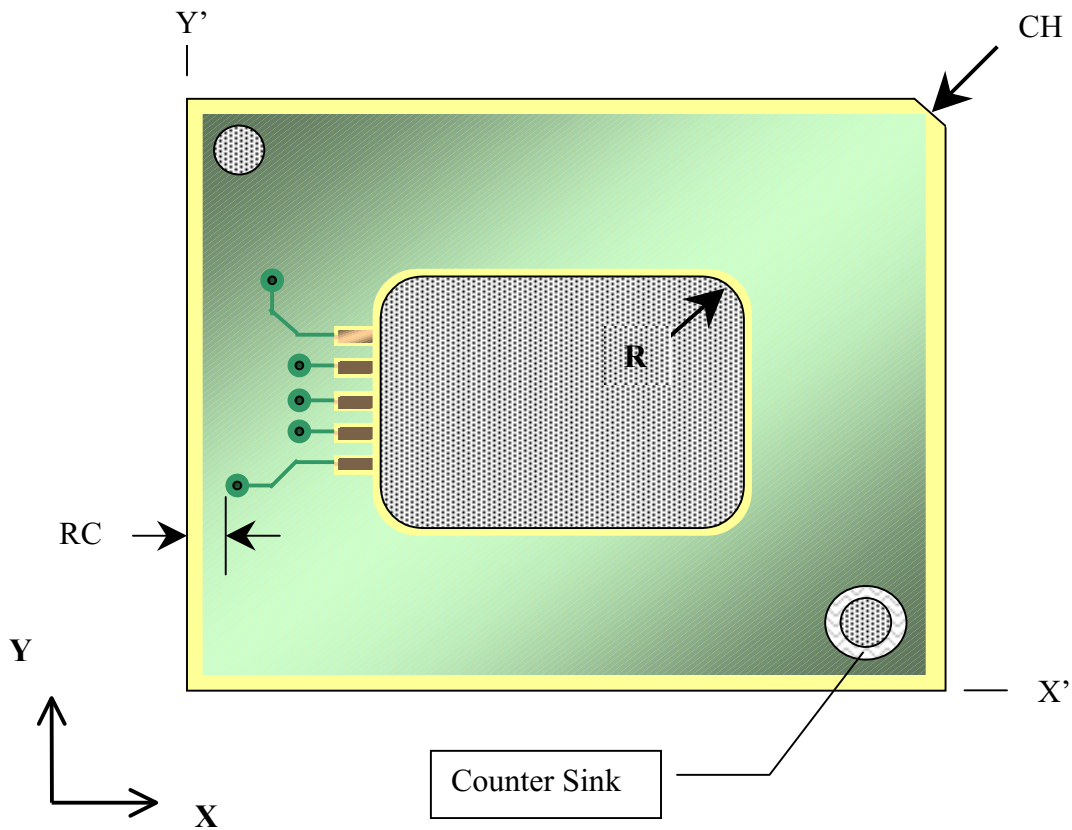
Combination Finishes

Suggested Parameters

HASL & Selective Electrolytic Ni / Au (HASL for solder pads with Ni/Au on contact pads)	Ni: 200 ± 50 μ”	Hard Au: 35~50 μ”
Selective Electrolytic Ni / Au (Thin Au for soldering, thick for wire bonding)	Ni: 200 ± 50 μ”	Soft Au: 3 to 8 μ” & 35~50 μ”
Selective Electrolytic Ni / Au (Thin Au for soldering, thick for contact pads)	Ni: 200 ± 50 μ”	Hard Au: 3 to 8 μ” & 35~50 μ”
Selective Electrolytic Ni / Au and OSP Wire Bond or Contact Pads Solder Pads	Ni: 200 ± 50 μ” OSP: 0.2 ~ 0.5 microns	Soft or Hard Au: 35~50 μ”

NC Rout

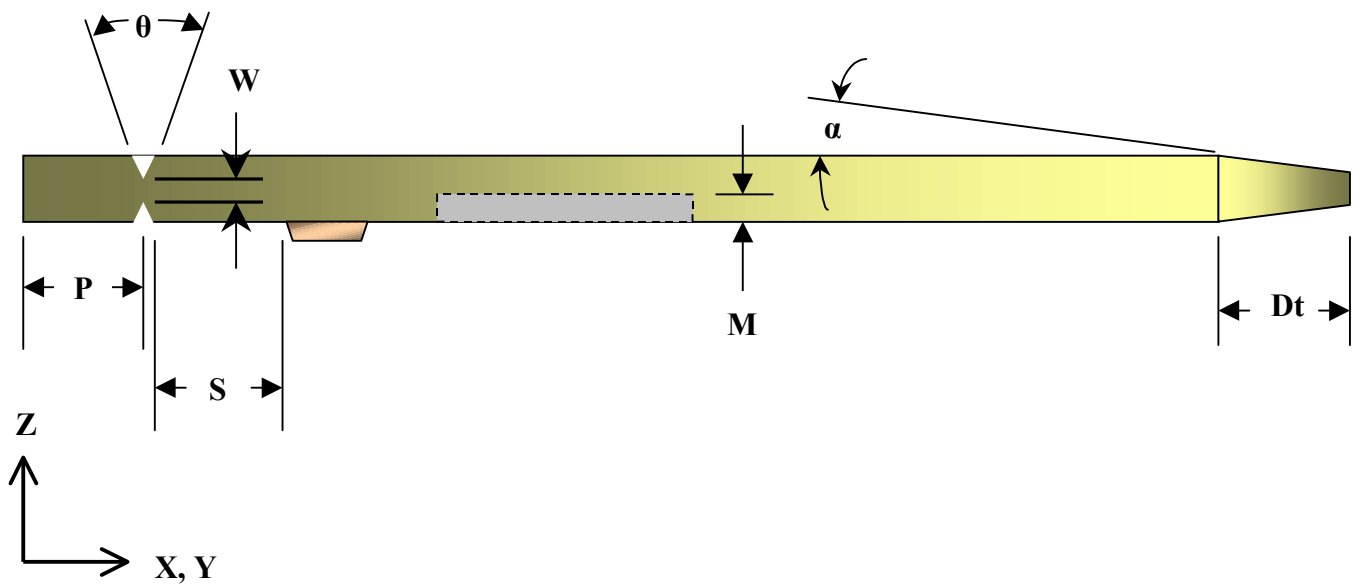
Fabrication



	Parameter	Standard	Advanced
R	Fabrication Radius	0.0155", 0.0235", 0.031", 0.0465", 0.050"	0.0155", 0.0235", 0.031", 0.0465", 0.050"
RC	Min. Rout to Copper Spacing	0.015"	0.010"
CS	Counter Sink (included angle)	82°, 90°, 100°	Customer Req.
CH	Chamfer Tolerance to Nominal	±0.005"	±0.002"
X', Y'	Fabrication Tolerance to Nominal	±0.005"	±0.002"

NC Rout

Scoring and Beveling



	Parameter	Standard
θ	Score Included Angle	25°, 30°, 45°, 60°
P	X & Y Positional Tolerance	± 0.003"
W	Scored Web	≥ 0.005"
	Score Depth Tolerance	± 0.002"
S	Score to Nearest Copper Feature	0.025" + (score width/2)
	Jump Score Positional Tolerance	± 0.030"
	Bevel Angle	20°, 30°, 45°
Dt	Bevel Dimensional Tolerance	± 0.010"
M	Control Depth Mill Tolerance	± 0.005"



Electrical Test

Net List Testing

Multek offers a wide range of electrical test equipment and capabilities. Most raw card testing is done on universal grid testers with test fixtures built in-house. For small job lots or extremely fine pitch test configurations, flying probe testers may be used instead of universal grid testers.

Parameter	Standard	Advanced
Minimum Test Point Pitch	0.009"	0.005"
	Standard	Available Range
Continuity	10 Ω	5 Ω ~ 1K Ω
Isolation	10 M Ω	10K Ω ~ 100 M Ω
Isolation Stimulus Voltage	250 V	10 ~ 250 V

Buried resistors are also electrically tested during netlist test. The upper and lower limits of the resistor value provide a pass / fail result for each resistor. Plan vias and test points as close to each resistor element as possible for the most accurate test results.

High Pot Testing

High pot testing is conducted on finished raw PWB's to insure isolation between all power / ground planes. Testing may be conducted with respect to current leakage or megohms resistance between biased layers. With the trend toward decreasing thickness of dielectric layers it is necessary to re-think the traditional 500 volt high pot test. Boards designed with 2 mil (or less) dielectrics and nominal spacing between drilled vias and planes < 10 mils may not be able to withstand a 500 volt bias and meet required current leakage or megohm resistance standards. You may want to consider the actual working voltage of the board under test and the maximum expected transient voltage when deciding how best to design a high pot test for a given PWB.

Controlled Impedance

Multek uses time domain reflectometry, TDR, for testing impedance on raw PWB's. Testing is normally conducted from a coupon located on the border of the production panel. The coupon is designed to reflect the geometry of the PWB with respect to dielectric thickness, copper weights, and line widths, and configuration. It is important to specify your impedance requirements on the master drawing.

TDR reports are available with all controlled impedance orders. Please refer to Controlled Impedance Models on page 27 for more information.



Appendix A Available Drill Sizes

Drill Size	Decimal (in)	Drill Size	Decimal (in)	Drill Size	Decimal (in)	Drill Size	Decimal (in)	Drill Size	Decimal (in)
0.05 mm	0.0020	0.85 mm	0.0335	44	0.0860	27	0.1440	5.10 mm	0.2008
0.10 mm	0.0040	65	0.0350	2.20 mm	0.0866	3.70 mm	0.1457	7	0.2010
0.13 mm	0.0050	0.90 mm	0.0354	2.25 mm	0.0886	26	0.1470	5.15 mm	0.2028
0.15 mm	0.0059	64	0.0360	43	0.0890	3.75 mm	0.1476	13/64"	0.2031
97	0.0059	63	0.0370	2.30 mm	0.0906	25	0.1495	6	0.2040
96	0.0063	0.95 mm	0.0374	2.35 mm	0.0925	3.80 mm	0.1496	5.20 mm	0.2047
95	0.0067	62	0.0380	42	0.0935	3.85 mm	0.1516	5	0.2055
94	0.0071	61	0.0390	3/32"	0.0938	24	0.1520	5.25 mm	0.2067
93	0.0075	1.00 mm	0.0394	2.40 mm	0.0945	3.90 mm	0.1535	5.30 mm	0.2087
92	0.0079	60	0.0400	41	0.0960	23	0.1540	4	0.2090
0.20 mm	0.0079	59	0.0410	2.45 mm	0.0965	3.95 mm	0.1555	5.35 mm	0.2106
91	0.0083	1.05 mm	0.0413	40	0.0980	5/32"	0.1562	5.40 mm	0.2126
90	0.0087	58	0.0420	2.50 mm	0.0984	22	0.1570	3	0.2130
89	0.0091	57	0.0430	39	0.0995	4.00 mm	0.1575	5.45 mm	0.2146
88	0.0095	1.10 mm	0.0433	2.55 mm	0.1004	21	0.1590	5.50 mm	0.2165
0.25 mm	0.0098	1.15 mm	0.0453	38	0.1015	4.05 mm	0.1594	5.55 mm	0.2185
87	0.0100	56	0.0465	2.60 mm	0.1024	20	0.1610	7/32"	0.2188
86	0.0105	3/64"	0.0469	37	0.0140	4.10 mm	0.1614	5.60 mm	0.2205
85	0.0110	1.20 mm	0.0472	2.65 mm	0.1043	4.15 mm	0.1634	2	0.2212
84	0.0115	1.25 mm	0.0492	2.70 mm	0.1063	4.20 mm	0.1654	5.65 mm	0.2224
0.30 mm	0.0118	1.30 mm	0.0512	36	0.1065	19	0.1660	5.70 mm	0.2244
83	0.0120	55	0.0520	2.75 mm	0.1083	4.25 mm	0.1673	5.75 mm	0.2264
82	0.0125	1.35 mm	0.0531	7/64"	0.1094	4.30 mm	0.1693	1	0.2280
81	0.0130	54	0.0550	35	0.1100	18	0.1695	5.80 mm	0.2283
80	0.0135	1.40 mm	0.0551	2.80 mm	0.1102	4.35 mm	0.1713	5.85 mm	0.2302
0.35 mm	0.0138	1.45 mm	0.0571	34	0.1110	11/64"	0.1719	5.90 mm	0.2323
79	0.0145	1.50 mm	0.0591	2.85 mm	0.1122	17	0.1730	A	0.2340
1/64"	0.0156	53	0.0595	33	0.1130	4.40 mm	0.1732	5.95 mm	0.2343
0.40 mm	0.0157	1.55 mm	0.0610	2.90 mm	0.1142	4.45 mm	0.1752	15/64"	0.2344
78	0.0160	1/16"	0.0625	32	0.1160	16	0.1770	6.00 mm	0.2362
0.45 mm	0.0177	1.60 mm	0.0630	2.95 mm	0.1161	4.50 mm	0.1772	B	0.2380
77	0.0180	52	0.0635	3.00 mm	0.1181	4.55 mm	0.1791	6.05 mm	0.2382
0.50 mm	0.0197	1.65 mm	0.0650	31	0.1200	15	0.1800	6.10 mm	0.2402
76	0.0200	1.70 mm	0.0669	3.05 mm	0.1201	4.60 mm	0.1811	C	0.2420
75	0.0210	51	0.0670	3.10 mm	0.1220	14	0.1820	6.15 mm	0.2421
0.55 mm	0.0217	1.75 mm	0.0689	3.15 mm	0.1240	4.65 mm	0.1831	6.20 mm	0.2441
74	0.0225	50	0.0700	1/8"	0.1250	13	0.1850	D	0.2460
0.60 mm	0.0236	1.80 mm	0.0709	3.20 mm	0.1260	4.70 mm	0.1850	6.25 mm	0.2461
73	0.0240	1.85 mm	0.0728	3.25 mm	0.1280	4.75 mm	0.1870	6.30 mm	0.2480
72	0.0250	49	0.0730	30	0.1285	3/16"	0.1875	6.35 mm	0.2500
0.65 mm	0.0256	1.90 mm	0.0748	3.30 mm	0.1299	4.80 mm	0.1890	E	0.2500
71	0.0260	48	0.0760	3.35 mm	0.1319	12	0.1890	1/4"	0.2500
0.70 mm	0.0276	1.95 mm	0.0768	3.40 mm	0.1339	4.85 mm	0.1909	6.40 mm	0.2520
70	0.0280	5/64"	0.0781	3.45 mm	0.1358	11	0.1910	6.50 mm	0.2559
69	0.0292	47	0.0785	29	0.1360	4.90 mm	0.1929	F	0.2570
0.75 mm	0.0295	2.00 mm	0.0787	3.50 mm	0.1378	10	0.1935	6.60 mm	0.2598
68	0.0310	2.05 mm	0.0807	3.55 mm	0.1398	4.95 mm	0.1949	G	0.2610
1/32"	0.0312	46	0.0810	28	0.1405	9	0.1960	6.70 mm	0.2638
0.80 mm	0.0315	45	0.0820	9/64"	0.1406	5.00 mm	0.1968		
67	0.0320	2.10 mm	0.0827	3.60 mm	0.1417	5.05 mm	0.1988		
66	0.0330	2.15 mm	0.0846	3.65 mm	0.1437	8	0.1990		

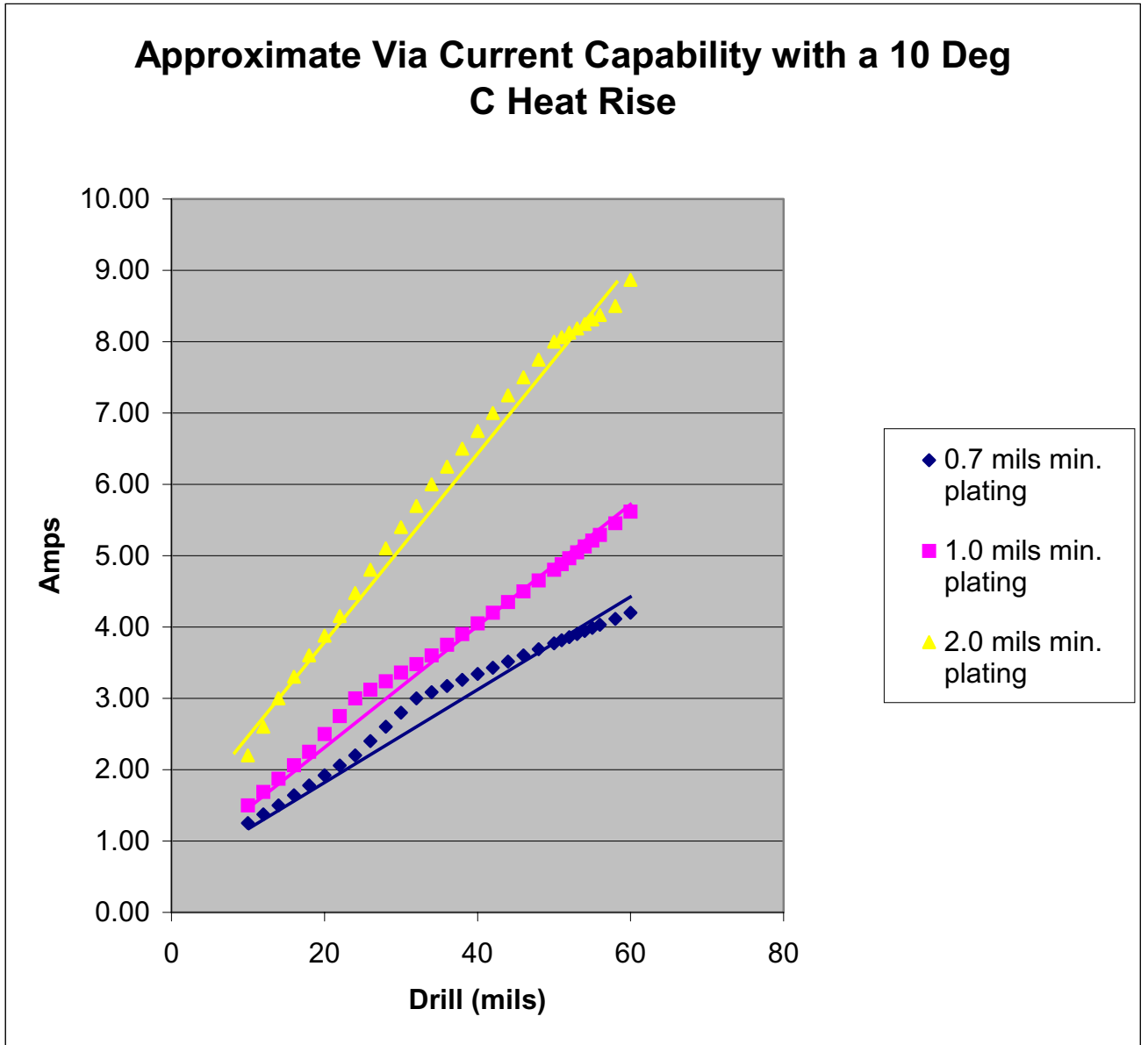


**Appendix B
Via Current Table**

Approximate Via Current Capability with a 10°C Heat Rise

Drill Dia. (mils)	0.7 mil min. plating			1.0 mil min. plating			2.0 mil min. plating		
	Finished Hole Dia. (mils)	Via X-Sec. Area (sq.mils)	Max Amps for 10 deg C Heat Rise	Finished Hole Dia. (mils)	Via X-Sec. Area (sq.mils)	Max Amps for 10 deg C Heat Rise	Finished Hole Dia. (mils)	Via X-Sec. Area (sq.mils)	Max Amps for 10 deg C Heat Rise
10	8.6	20	1.25	8	28	1.50	6	50	2.20
12	10.6	25	1.38	10	35	1.69	8	63	2.60
14	12.6	29	1.50	12	41	1.88	10	75	3.00
16	14.6	34	1.64	14	47	2.06	12	88	3.30
18	16.6	38	1.78	16	53	2.25	14	101	3.60
20	18.6	42	1.92	18	60	2.50	16	113	3.88
22	20.6	47	2.06	20	66	2.75	18	126	4.15
24	22.6	51	2.20	22	72	3.00	20	138	4.48
26	24.6	56	2.40	24	79	3.12	22	151	4.80
28	26.6	60	2.60	26	85	3.24	24	163	5.10
30	28.6	64	2.80	28	91	3.36	26	176	5.40
32	30.6	69	3.00	30	97	3.48	28	188	5.70
34	32.6	73	3.09	32	104	3.60	30	201	6.00
36	34.6	78	3.17	34	110	3.75	32	214	6.25
38	36.6	82	3.26	36	116	3.90	34	226	6.50
40	38.6	86	3.34	38	123	4.05	36	239	6.75
42	40.6	91	3.43	40	129	4.20	38	251	7.00
44	42.6	95	3.51	42	135	4.35	40	264	7.25
46	44.6	100	3.60	44	141	4.50	42	276	7.50
48	46.6	104	3.69	46	148	4.65	44	289	7.75
50	48.6	108	3.77	48	154	4.80	46	302	8.00
51	49.6	111	3.81	49	157	4.88	47	308	8.06
52	50.6	113	3.86	50	160	4.96	48	314	8.13
53	51.6	115	3.90	51	163	5.05	49	320	8.19
54	52.6	117	3.94	52	167	5.13	50	327	8.25
55	53.6	119	3.99	53	170	5.21	51	333	8.31
56	54.6	122	4.03	54	173	5.29	52	339	8.38
58	56.6	126	4.11	56	179	5.45	54	352	8.50
60	58.6	130	4.20	58	185	5.62	56	364	8.87
					200	6.00		400	9.90

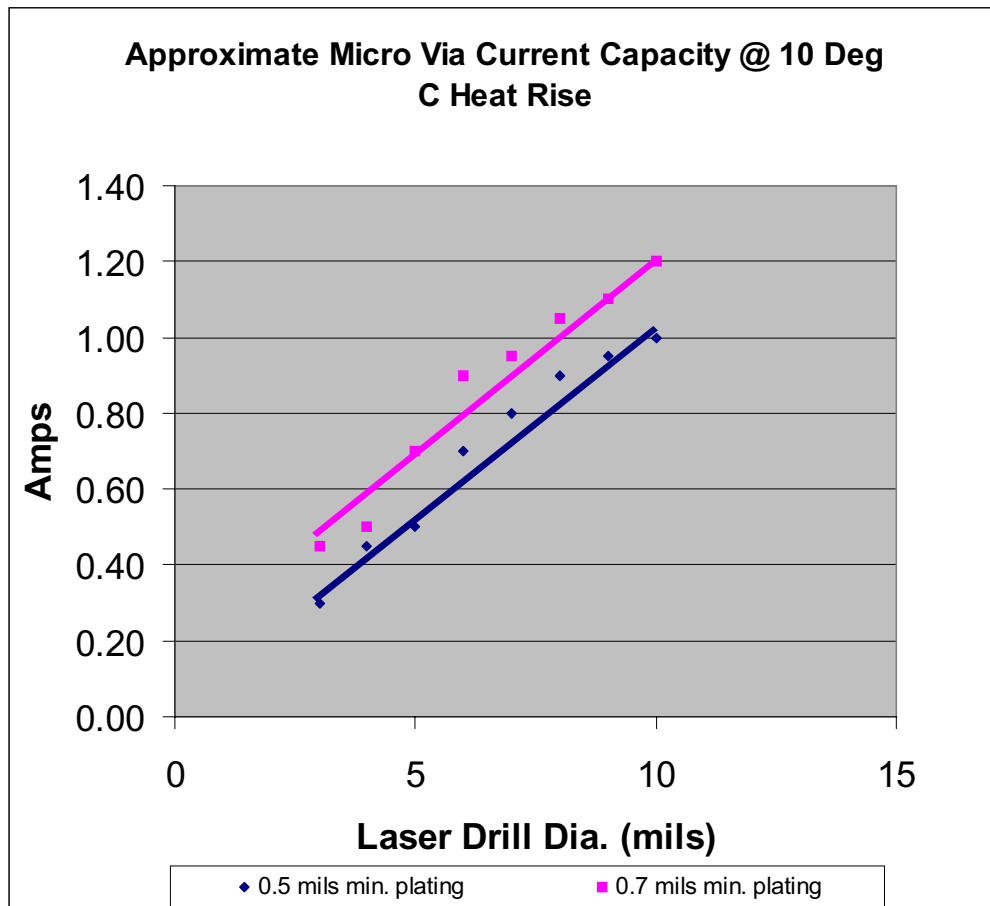
Source: Values in bold type from IPC-2221, Feb. 1998, Page 38, Figure 6-4. Values in standard type face are interpolated from bold values.





Appendix C
Micro Via Current Table For
10 Deg C Heat Rise Above Ambient

Drill Diameter (mils)	0.5 mil min. plating			0.7 mil min. plating		
	Finished Hole Diameter (mils)	Via Cross Sectional Area (sq.mils)	Max Amps for 10 deg C Heat Rise	Finished Hole Diameter (mils)	Via Cross Sectional Area (sq.mils)	Max Amps for 10 deg C Heat Rise
3	2	4	0.30	1.6	5	0.45
4	3	5	0.45	2.6	7	0.50
5	4	7	0.50	3.6	9	0.70
6	5	9	0.70	4.6	12	0.90
7	6	10	0.80	5.6	14	0.95
8	7	12	0.90	6.6	16	1.05
9	8	13	0.95	7.6	18	1.10
10	9	15	1.00	8.6	20	1.20



Source: Values derived from IPC-2221, Feb. 1998, Page 38, Figure 6-4.