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| REV DATE | DFM GUIDELINES | F7303 |
| 12-01-03 | | REV B |



**Design Guidelines
For
Manufacturability**

**Released
03-31-04**

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MANUFACTURING CAPABILITIES

Standard Multilayer Panel Sizes -12x18, 16x18 and 18x24
 Custom Multilayer Panel Sizes - 21x24 and 24x30

Single-Sided FR4-170Tg, Advanced High Tg Epoxy, GETEK, BT, Gore/Speedboard, Polyimide, Rogers 3000series and Rogers 6000 series Teflon and Taconic RF-35, 35P, 60

Double-Sided FR4-170Tg, Advanced High Tg Epoxy, Nelco 4000-13 series High Speed Epoxy, GETEK, BT, Gore/Speedboard, Polyimide, Rogers 3000 series and 6000 series Teflon, Rogers 4000 series hydrocarbon, Nelco 8000 Cynate Ester and Taconic RF-35, 35P, 60

Multilayer FR4-170Tg, Advanced High Tg Epoxy, Nelco 4000-13 series Epoxy, GETEK, BT, Gore/Speedboard, Polyimide, Rogers 3000series and 6000 series Teflon, Rogers 4000 series hydrocarbon, Nelco Cynate Ester and Taconic RF-35, 35P, 60

CNC Drilling (high speed and flip drilling available) and Routing

Minimum drilled hole size:

Standard 0.008"

Custom 0.006"

Minimum drilled via size:

Standard 0.006"

Custom 0.0047"

Back drilled via dimension:

Standard 0.010" over via drill size

Custom 0.006"

Type vias:

Through hole, blind, buried, Silver/Epoxy Paste filled Via-in-Pad, back drilled

Surface finishes:

SMOBC, HAL, Electroplated Gold over Nickel, Electroless Nickel/Immersion Gold, Immersion Silver, OSP

Use the following specifications for metal finishes:

Edge Connectors:

Electroplated Nickel: 100-200 μ inches standard

Electroplated Gold: 30-80 μ inches standard

Solderable Surfaces:

Electroplated Nickel: 50-200 μ inches standard

Electroplated Gold: 3-30 μ inches standard

Electroless Nickel: 50-150 μ inches standard


Immersion Gold: 3-10 μ inches

Immersion Silver: 3-4 μ inches

Maximum panel size for plating:

Hard Gold over Nickel over Copper –18 x 24

Immersion Gold over Nickel over Copper – 18 x 24

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Connector Gold over Nickel over Copper – Edge length of 24”
 Wire Bondable Soft Gold over Nickel over Copper - 18 x 24”

Aspect Ratio (finished PTH)
 Standard: To 20:1
 Custom: To 31:1 (with Silver-Filled Vias)

Dielectric spacing between layers 0.0035” minimum

Circuit width 0.004”

Conductor to conductor spacing 0.004”

Impedance Control:
 Single ended $\pm 5\%$
 Edge coupled differential $\pm 7.5\%$
 Broadside differential $\pm 10\%$


Minimum silkscreen aperture 0.0065” with a minimum height of 0.035”

Scoring

Electrical Test – Dual Sided Clam Shell Testing. 100% Netlist Extraction or CAD NETLIST,
 Flying Probe with 0.005” center to center test points.

MECHANICAL TOLERANCES AND CHARACTERISTICS

| | |
|--------------|--|
| Thickness | +/-7% of board finished thickness; thickness is assumed to be over plating unless otherwise specified. |
| Profile | +/- 0.010” for overall dimensions, |
| Holes | +/-0.003” PTH standard. |
| Back Drill | +0.014”/-0.0” standard +0.007”/-0.0” custom |
| Radius | Cutouts will have 0.046” radius unless otherwise specified (down to 0.012” is available). |
| Bevel | 20°, 30° or 45° on gold plated edge connectors. |
| Chamfer | 45° x 0.050” on gold tab boards. |
| Countersinks | 82°, 90° or 100° available as standard. |
| Warpage | Standard down to 0.0015” per inch Custom down to 0.0005” per inch. |


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TYPICAL PLATED THICKNESS

| | |
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| Copper Plating | 0.001” nominal plating in hole. |
| Gold Plating (Tabs) | 30-50 μ inches over 100-200 μ inches nickel. |
| Gold Plating (Full Body) | 5-15 μ inches over 100-200 μ inches nickel. |
| Hot Air Solder Level (HAL) | 63/37 250 μ inches nominal over copper. |

LEGEND & SOLDERMASKS

| | | |
|------------------------|---------------|--|
| Solder mask | LPI Available | <p>Electra in Green, Red, Blue, Black and clear, 0.001-0.002” thick over metal surface (0.0007” over knee if Class 3 required).</p> <p>Lea Ronal in Green, 0.001-0.002” thick over metal surface (0.0007” over knee if Class 3 required).</p> <p>Coates in Green, 0.001-0.002” thick over metal surface (0.0007” over knee if Class 3 required).</p> <p>Vantico Probimer 77 in Green, 0.001-0.002” thick over metal surface (0.0007” over knee if Class 3 required).</p> |
| | Dry Film | <p>Dupont 8130- Green, 0.002-0.004” thick over metal surface (0.0007” over knee if Class 3 required).</p> |
| Solder mask Clearances | | <p>0.004” oversize pads for liquid photo-imageable soldermask are typical, which equates to a 0.002” annular ring. With liquid photo-imageable soldermask the annular ring can be reduced to zero to match the technology of the printed circuit design.</p> |
| Screen Ink | | <p>Hysol Cat A Link Epoxy 50 -100R (White), 50-102BR (Yellow), 50-508R (Red) and 50700R (Black)</p> |

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MATERIALS CARRIED ON THE SHELF

FR-4 laminates are UL approved and meet IPC specification.

**SINGLE AND DOUBLE-SIDED (thickness INCLUDES COPPER)
FR4s are UL approved and meet IPC 4101A/24**

| | | | | |
|-----------|-----------|-----------|-----------|-----------|
| .031" 1/1 | .059" 1/1 | .059" 3/3 | .093" 2/2 | .125" 2/2 |
| .059" H/H | .059" 2/0 | .059" 5/5 | .093" 3/3 | .125" 3/3 |
| .059" 1/0 | .059" 2/2 | .093" 1/1 | .125" 1/1 | .125" 5/5 |

**MULTILAYER CORES (thickness is of LAMINATE ONLY)
Polyclad 370 Turbo/HR FR-4 is UL approved and meets IPC 4101A/24**

| | | | | | |
|-----------|-----------|-----------|------------|-----------|-----------|
| .004" H/H | .006" H/H | .008" 2/2 | .012" 1/1 | .020" H/H | .031" H/H |
| .004" 1/1 | .006" 1/1 | .010" H/H | .0145" H/H | .020" 1/1 | .031" 1/1 |
| .005" H/H | .008" H/H | .010" 1/1 | .0145" 1/1 | .024" 1/1 | .040" H/H |
| .005" 1/1 | .008" 1/1 | .012" H/H | .0145" 2/2 | .024" 2/2 | .040" 1/1 |

Polyclad 370 Turbo/HR PRE-PREG meets IPC 4101A/24

| | |
|------|--|
| 106 | approximate thickness when pressed 2.2mils |
| 1080 | approximate thickness when pressed 2.6mils |
| 2116 | approximate thickness when pressed 4.5mils |

**GETEK MULTILAYER CORES (thickness is of LAMINATE ONLY)
GETEK Epoxy PPO is UL approved and meets IPC 4101A/25**


| | | | | |
|------------|-----------|-----------|-----------|-----------|
| .0027" 1/1 | .005" 1/1 | .008" H/H | .012" H/H | .021" 1/1 |
| .004" H/H | .006" H/H | .008" 1/1 | .012" 1/1 | .030" 1/1 |
| .004" 1/1 | .006" 1/1 | .010" H/H | .014" H/H | .031" H/H |
| .005" H/H | .007" 1/1 | .010" 1/1 | .014" 1/1 | .040" 1/1 |

GETEK PRE-PREG meets IPC 410A1/25

| | |
|------|--|
| 106 | approximate thickness when pressed 2.2mils |
| 1080 | approximate thickness when pressed 2.7mils |

ROGERS LAMINATE MATERIALS R04003 AND 4350 meets IPC 4103/10 and IPC4103/11 respectively.

RO4003 RO4003 RO4350 RO4350

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| | | | |
|----------|----------|-----------|----------|
| .008 H/H | .020 1/1 | .0066 H/H | .010 H/H |
| .008 1/1 | .032 1/1 | .0066 1/1 | .020 1/1 |
| .012 1/1 | .060 1/1 | | |

ROGERS RO4403 PRE-PREG meets IPC 4103/10.

4403 (based on 1080 glass style) approximate thickness when pressed 4 mils

Materials not stocked in house usually require between 5 to 15 working days to order and receive. To expedite production we will accept customer-supplied material for processing.

NELCO N4000-13 LAMINATES meet IPC 4101A/29

| | | | | |
|----------|----------|----------|----------|----------|
| .003 H/H | .005 H/H | .008 H/H | .012 H/H | .031 H/H |
| .003 1/1 | .005 1/1 | .008 1/1 | .012 1/1 | .031 1/1 |
| .004 H/H | .006 H/H | .010 H/H | .015 H/H | |
| .004 1/1 | .006 1/1 | .010 1/1 | .015 1/1 | |

N4000-13Si materials are not stocked and usually require 5 to 15 working days to order and receive.

NELCO N4200-13 PRE-PREG meets IPC4101A/29

106 approximate thickness when pressed 2.2mils
1080 approximate thickness when pressed 2.7mils

NELCO N8000 CYNATE ESTER LAMINATES meet IPC4101A/71

| | | |
|----------|----------|----------|
| .005 1/1 | .010 1/1 | .021 1/1 |
| .006 1/1 | .012 1/1 | .059 1/1 |
| .008 1/1 | .015 1/1 | |


NELCO N8305 CYNATE ESTER PER-PREG meets IPC4101A/71

106 approximate thickness when pressed 2.2mils
1080 approximate thickness when pressed 2.7mils

POLYIMIDE MATERIALS

0.059" 1/1

Other sizes are usually are not carried on the shelf and require between 5 to 15 working days to order and receive, depending on manufacture's off-the-shelf availability.

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GORE SPEED BOARD (BT Resin) PRE-PREG


1.5mil Approximate pressed thickness

3.4mil Approximate pressed thickness

OTHER LAMINATES

Nelco N4000-13Si, Rogers 3000series and 6000 series and Taconic RF-35, 35P, 60 are also used and are usually available within 5 to 15 days.


Other thickness in material listed above can be obtained with 5 to 15 day lead times also.

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STANDARD DRILL SIZES

The following is a list of standard drill sizes. Additional drill bit diameters are available. Contact the Production Manager or Engineering Manager for availability.

| | | | | |
|--------------|---------|---------|---------|---------|
| 0.0047"micro | 0.0430" | 0.0935" | 0.1457" | 0.1990" |
| 0.0060" | 0.0453" | 0.0945" | 0.1470" | 0.2010" |
| 0.0080" | 0.0465" | 0.0960" | 0.1495" | 0.2031" |
| 0.0100" | 0.0492" | 0.0995" | 0.1520" | 0.2055" |
| 0.0120" | 0.0512" | 0.1015" | 0.1540" | 0.2087" |
| 0.0130" | 0.0520" | 0.1024" | 0.1562" | 0.2090" |
| 0.0145" | 0.0531" | 0.1040" | 0.1570" | 0.2106" |
| 0.0160" | 0.0550" | 0.1065" | 0.1590" | 0.2130" |
| 0.0180" | 0.0571" | 0.1083" | 0.1610" | 0.2165" |
| 0.0200" | 0.0595" | 0.1110" | 0.1634" | 0.2185" |
| 0.0210" | 0.0610" | 0.1122" | 0.1654" | 0.2210" |
| 0.0225" | 0.0625" | 0.1130" | 0.1660" | 0.2244" |
| 0.0240" | 0.0630" | 0.1160" | 0.1673" | 0.2264" |
| 0.0250" | 0.0650" | 0.1181" | 0.1719" | 0.2283" |
| 0.0260" | 0.0670" | 0.1200" | 0.1730" | 0.2323" |
| 0.0280" | 0.0689" | 0.1222" | 0.1752" | 0.2340" |
| 0.0292" | 0.0700" | 0.1240" | 0.1770" | 0.2362" |
| 0.0310" | 0.0730" | 0.1250" | 0.1800" | 0.2380" |
| 0.0320" | 0.0760" | 0.1260" | 0.1811" | 0.2402" |
| 0.0330" | 0.0785" | 0.1280" | 0.1820" | 0.2421" |
| 0.0350" | 0.0810" | 0.1299" | 0.1831" | 0.2441" |
| 0.0360" | 0.0820" | 0.1319" | 0.1850" | 0.2460" |
| 0.0370" | 0.0846" | 0.1339" | 0.1875" | 0.2480" |
| 0.0380" | 0.0860" | 0.1360" | 0.1890" | 0.2500" |
| 0.0390" | 0.0886" | 0.1378" | 0.1910" | 0.2570" |
| 0.0400" | 0.0890" | 0.1405" | 0.1935" | 0.2480" |
| 0.0410" | 0.0906" | 0.1417" | 0.1960" | |
| 0.0420" | 0.0925" | 0.1440" | 0.1988" | |

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DRILL SIZE GUIDELINE

All holes in which positional tolerance is less than +/- .002" must be on 1st drill, including non-plated through holes.

To calculate drilled hole size use the formulas below. It does not apply to plated through vias that can be plated shut.

HOT AIR LEVELED BOARDS

Designed finished hole size + .006"

GOLD PLATED BOARDS (150 μ m NICKEL)

Designed finished hole size + .004"

NON-PLATED HOLES

Designed finished hole size + .001"


UL APPROVALS

Eagle Circuits (File # E11478) is UL approved at 94V-O for circuits down to 0.003" and operating temperatures to 130°C.

IPC SPECIFICATIONS

For workmanship, our goal is to meet or exceed the guidelines for the preferred criteria in IPC-A-600 for Fabrication.


For end-item requirements, our goal is to meet or exceed the criteria for Class 2 requirements in IPC-6012 (Class 3 available upon request)

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TECHNOLOGY ROAD MAP

| Product Feature | Standard 2003 | Advanced 2003 | 2004 | 2005 |
|---|----------------------|----------------------|-------------|-------------|
| IL Trace and Space 0.5 oz. copper | 4 | 3 | 2.5 | 2 |
| IL Trace and Space 1.0 oz. copper | 5 | 4 | 3 | 3 |
| IL Trace 2.0 oz. copper | 7 | 5 | 4 | 4 |
| OL Trace and Space | 4 | 3 | 3 | 3 |
| Drilled through via - min. size | 8 | 6 | 6 | 6 |
| Drilled blind via - min. size | 10 | 8 | 6 | 5 |
| Back drill via over hole size | | | 10 | 6 |
| Back drill depth tolerance | | | +7/-0 | +5/-0 |
| IL Pad over Drill Size (drill hole to pad tangency) | 9 | 8 | 7 | 7 |
| Antipad over Drill Size | 17 | 16 | 16 | 14 |
| Micro-via blind or buried - Via Size | 6 | 4 | 3 | 3 |
| Pad over Micro-via Size | 8 | 6 | 5 | 4 |
| Maximum layers of micro-via per side | 1 | 1 | 1 | 2 |
| Multi-depth micro-vias | N | Y | Y | Y |
| Maximum aspect ratio on 10 mil drilled hole | 15 | 20 | 25 | 25 |
| Maximum Aspect Ratio | 15 | 24 | 30 | 30 |
| Plated hole size tolerance | ± 2 | ± 2 | ± 1.5 | ± 1.5 |
| Solder mask registration | ± 2 | ± 2 | ± 1.5 | ± 1.5 |
| Via Cap Registration | ± 5 | ± 4 | ± 4 | ± 3 |
| Solder mask Encroached pads (drill +) | 6 | 4 | 4 | 4 |
| Layer Count | 16+ | 26+ | 30+ | 40+ |
| Material thickness | 2.7 | 2 | 2 | 2 |
| Impedance Control - single ended % | ± 8 | ± 5 | ± 5 | ± 4 |
| Impedance Control - edge coupled differential % | ± 10 | ± 7.5 | ± 5 | ± 5 |
| Impedance Control - broad side differential % | ± 10 | ± 10 | ± 8 | ± 8 |
| Inner-layer feature size control (0.5oz.) | ± 0.3 | ± 0.25 | ± 0.20 | ± 0.20 |
| Outer-layer feature size control | ± 0.7 | ± 0.4 | ± 0.4 | ± 0.3 |
| Board Thickness - Minimum 18 / Maximum 250 | | | | |

Note: measures in mils unless specified

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TECHNOLOGY ROAD MAP CONTINUED

| Product Feature | Standard 2003 | Advanced 2003 | 2004 | 2005 |
|---|------------------|------------------|------|------|
| Materials: | | | | |
| FR-4 170Tg | Y | Y | Y | Y |
| Advanced High Tg epoxy | Y | Y | Y | Y |
| Getek / | Y | Y | Y | Y |
| Nelco 4000-13 / Si | Y | Y | Y | Y |
| Gore / Speedboard | | Y | Y | Y |
| Rogers 3000,3200 series Teflon | Y | Y | Y | Y |
| Rogers 4003,4350,4403 prepreg | Y | Y | Y | Y |
| Rogers 4450 Prepreg | | Y | Y | Y |
| Taconic RF-35, 35P, 60 | | Y | Y | Y |
| Bromine Free Materials | | | Y | Y |
| Lead Free Materials | | | | Y |
| Special Capabilities: | | | | |
| Buried Via Cores (min. Thickness) | 8 | 6 | 5 | 5 |
| Buried Resistors (Low Cost) | | | Y | Y |
| Planar Distributed Capacitance (>2000/sq.in.) | | | Y | Y |
| Conductive Stepped Cavities | | Y | Y | Y |
| Mixed Dielectric Constructions | Y | Y | Y | Y |
| Silver Filled Vias | Y | Y | Y | Y |

Note: measures in mils unless specified