ADVANCED SOLUTIONS

Semi-Flex Printed Circuit Technology

Innovative Solutions for 3D Assembly

ABOUT TTM

TTM Technologies, Inc. is a leading global manufacturer of technology solutions, including mission systems, radio frequency ("RF") components, RF microwave/microelectronic assemblies, and quick-turn and technologically advanced printed circuit boards ("PCB"s). TTM stands for time-to-market, representing how TTM's time-critical, one-stop manufacturing services enable customers to shorten the time required to develop new products and bring them to market. Additional information can be found at www.ttm.com.

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INNOVATIVE SOLUTIONS FOR DIVERSE MARKETS

One-Time Flex for Easy Installation

ENABLING THREE-DIMENSIONAL DESIGN

Overview

- FR-4 material processing parameters
- The material in 'bend-area' is reduced in thickness by depth controlled routing
- Suitable for flex to install (1-time bend) applications only (no dynamic flex)
- No expensive flex materials and process-flow required
- One PCB replacing two PCBs + interconnects (connectors, solder-joints)
- PCB is mechanically fixed after bending
- Flexible soldermask applied in bending area

TTM Technologies ("TTM") offers semi-flex circuit boards manufactured with conventional rigid FR-4 base materials. These boards are suited for one-time flex-to-install applications. The technology can be used for double-sided and multilayer boards. Because only standard materials and processing are used, this technology offers a low-cost alternative for applications with flexible or bendable areas in a printed circuit board ("PCB"). A semi-flex board most often replaces two PCBs and the required connectors and cables or allows a three-dimensional design and placement of the PCBs in a device.

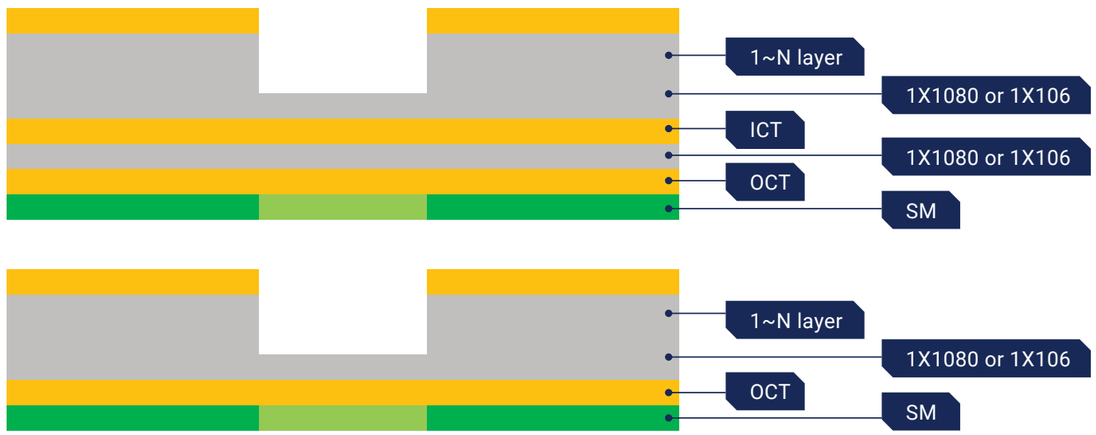
The flexible segment in a semi-flex PCB is generated by controlled depth milling of the PCB in the required area. TTM's newest routing machines with z-Axis technology and integrated measuring and mapping functions is critical to the consistent and high-quality fabrication of semi-flex.

The flexible area is covered with a flexible soldermask. The materials and glass style are chosen so that the bending can be done without an impact on the reliability of the circuit board.

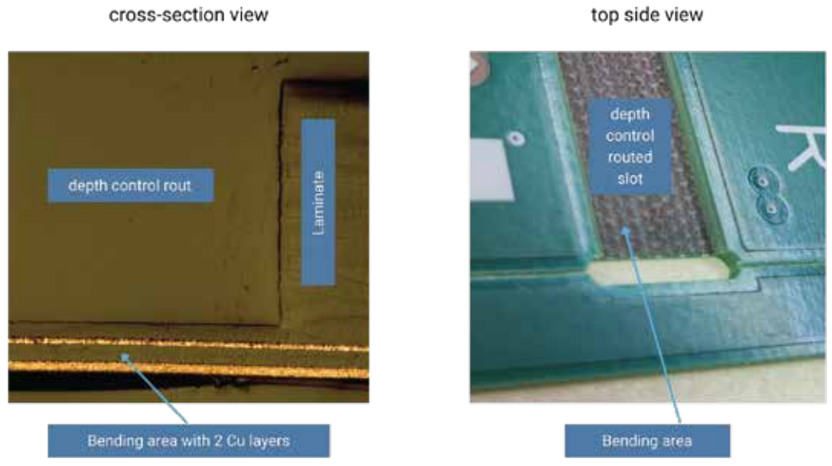
Reliability testing shows good results and the ability to have multiple bends without damage to the bending area. TTM recommends, in general, not more than five cycles. Details are to be defined based on the stackup.

Assembly and Bending Recommendations

TTM recommends a board or multi-board bar or frame to stabilize the bending area in assembly. The assembly process can be standard because no additional tempering, preparation, or handling is necessary. Installation of semi-flex circuits should be done with a bending tool to guarantee that the minimum bending radius is not violated.



Typical stack-up for semi-flex



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LONG-TERM RELIABILITY TESTING

CAF TESTING CONDITION Preconditioning 3X lead free IR + 100VDC/85C/85RH, 1000Hrs

EVALUATION CRITERIA ≥20MΩ

BENDING CYCLE	TRACE - TRACE DESIGN				LAYER TO LAYER
	5/5 MIL	6/6 MIL	8/8 MIL	12/12 MIL	
0 cycle	Pass	Pass	Pass	Pass	Pass
3 cycles	Pass	Pass	Pass	Pass	Pass
5 cycles	Pass	Pass	Pass	Pass	Pass
10 cycles	Pass	Pass	Pass	Pass	Pass

THERMAL CYCLING TESTING CONDITION Preconditioning 3X lead free IR + TC4.2 (-40C~125C, 1000cycles)

EVALUATION CRITERIA ≤5% rising of resistance referring to reference resistance value

BENDING CYCLE	TRACE - TRACE DESIGN			
	5/5 MIL	6/6 MIL	8/8 MIL	12/12 MIL
0 cycle	Pass	Pass	Pass	Pass
3 cycles	Pass	Pass	Pass	Pass
5 cycles	Pass	Pass	Pass	Pass
10 cycles	Pass	Pass	Pass	Pass

DESIGN GUIDELINES FOR SEMI-FLEX PCB

Material (reference)	IT-158, Autolad1, SB170G, EM 825
Methodology	Z-Axis Routing / ZAR
Depth control routing tolerance	+/-75 µm (3mil)
Bending Layer	1 or 2
Bending Cycle	Max. 5 (depending on design)
Bending Radius	Min. 22T (T=the remaining thickness)
Bending Area Width (BAW)	Min. 0.02 θR (θ=Bending Angle)
Cu thickness on bending layers	HOZ,1 OZ, 2OZ, 3OZ
Trace width and spacing on the bending layers	Min. 0.2mm for HOZ, 0.25mm for 1OZ
Glass type	Fine glass e.g. 106, 1080

MINIMUM THICKNESS

A minimum bending radius (R) needs to be taken into account because semi-flex is based on glass-reinforced rigid base material. The bending radius mainly depends on the 'Remaining Thickness' (RT) in the bend-area.

A guideline to calculate:

The minimum Radius (R): R = 22 * RT

The Bend Area Width (BAW) depends on the

Bending Angle (α) and Radius (R): BAW = (0.017 * α * R)

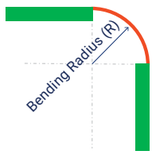
Example based on Remaining Thickness (RT) = 0.25mm;

R = 22 * 0.25 = 5.5mm

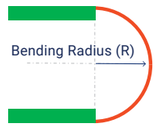
BAW = 0.017 * 90 * 5.5 = 8.4mm for 90˚ Bending Angle

BAW = 0.017 * 180 * 5.5 = 16.83mm for 180˚ Bending Angle

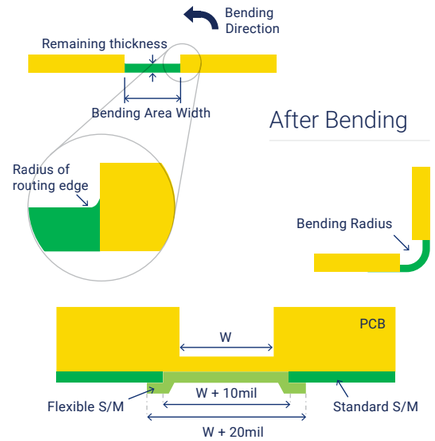
90° Bending Angle



180° Bending Angle



Before Bending



TTM recognizes our opportunity to positively impact the world around us by managing our operations in a sustainable manner. We believe that sustainable practices are essential to the long-term success of our business and that we have a responsibility to consider how our business interacts with society and impacts the environment. To learn more about our sustainability efforts, view our CSR report at ttm.com.

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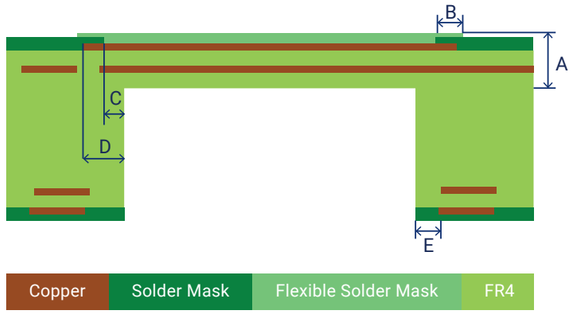
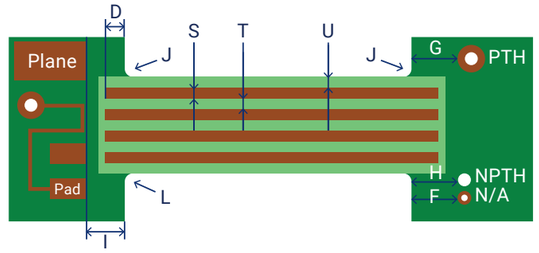
Semi-Flex (ZAR) Design Rules

Side View



Top View



DESCRIPTION	VALUE	UNIT	
Minimum nominal thickness of bending area for one copper layer	0.20	mm	A
Minimum nominal thickness of bending area for two copper layers (NOT Preferred)	0.25	mm	A
Minimum flexible solder mask overlap onto solder mask	0.50	mm	B
Minimum solder mask clearance from semi flex area	0.15	mm	C
Minimum length of copper extending beyond the semi flex area (non functinal tracks)	1.00	mm	D
Minimum rigid area copper clearance from semi flx area	0.50	mm	E
Minimum microvia pad clearance from semi flex area	0.50	mm	F
Minimum PTH pad clearance from semi flex area	0.50	mm	G
Minimum NPTH clearance from semi flex area	0.50	mm	H
Minimum component pads clearance from semi flex area	1.00	mm	I
Minimum radii in the area of transition from rigid to semi flex area	N/A	mm	J
Minimum routing depth	N/A	mm	K
Minimum routing diameter	N/A	mm	L
Minimum track width (18µm)	0.20	mm	S
Minimum track spacing (18µm)	0.20	mm	T
Minimum track width (35µm)	0.25	mm	S
Minimum track spacing (35µm)	0.25	mm	T
Minimum track spacing to Semi Flex area side edge	0.50	mm	U

For more information on Semi-flex technologies, please speak with your TTM Sales representative or contact us by:

CorporateMarketing@ttm.com

ttm.com/contact

TTM GLOBAL LOCATIONS

CORPORATE LOCATIONS /REGIONAL OFFICE

LOCATION	PHONE
NORTH AMERICA	
Global Headquarters (HQ)	+1.714.327.3000
TTM St. Louis (STL)	+1.314.727.2087
ASIA PACIFIC	
Commercial Sector Headquarters (CS HQ)	+852.2272.2222
TTM Japan (JP)	+81.050.5306.2122 050.5306.2123 (Japan Domestic Only)
EMEAI	
TTM Germany (DE)	+49.171.285.4994
TTM India (IN)	+91.9980.047.215
TTM United Kingdom (UK)	+44.2392.232392

COMMERCIAL FACILITIES

LOCATION	PHONE
NORTH AMERICA	
TTM Chippewa Falls (CF)	+1.715.720.5000
TTM Logan (LG)	+1.435.753.4700
TTM San Jose (SJ)	+1.408.280.0422
TTM Santa Ana (SA)	+1.714.327.3000
TTM Syracuse (SYR-W)	+1.315.233.5510
TTM Toronto (TOR)	+1.416.208.2100
ASIA PACIFIC	
TTM Dongguan (DMC)	+86.769.8622.8000
TTM Guangzhou (GZ)	+86.20.6287.8777
TTM Huiyang (HY)	+86.752.261.7136
TTM Penang (PNG)	+60.4565.7788
TTM Suzhou (SUZ)	+86.512.6274.9282
TTM Zhongshan (ZS)	+86.760.2226.9805