

Flexible Printed Wiring Board (PWB) P-Flex Specifications

Ver. 5.1.0

Last updated on: October 10th, 2018

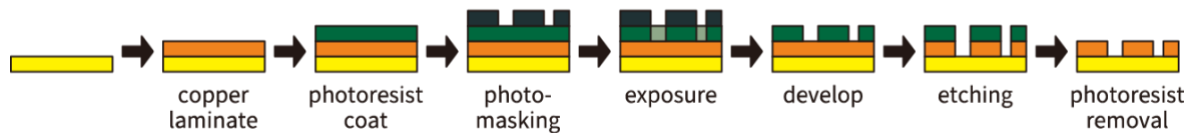
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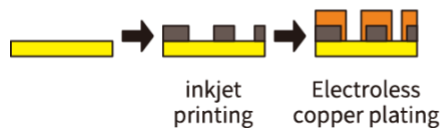
1. OVERVIEW

P-Flex™ is a flexible printed wiring board (“PWB”) that is manufactured using ink jet printing and electroless copper plating processes. Unlike conventional PWBs that are manufactured using photolithography, this novel type of PWB does not require any initial manufacturing set-up cost, so it can be supplied to customers at significantly lower prices with far shorter lead time compared to conventional PWBs, especially in small-volume production lots.

Conventional process (Subtractive process)



Our process (Pure Additive™ process)



Conventional inkjet printing has the disadvantage of causing relatively high resistance values and requiring dies to produce soldermask. However, by using electroless copper plating to reduce resistance values and by adopting inkjet printing to omit the need to use dies, Elephantech has succeeded in achieving product quality that is virtually identical to that of prototypes of regular flexible PWBs, with shorter lead time and at reduced cost.

Unless otherwise specified, the various descriptions in the specifications are of common matters that do not depend on the material and layer composition. The base materials are specified when base material based exceptions apply. Guidelines relating to the design and necessary data are specified separately in the appended guideline [P-Flex Design Guideline]; please check this guideline when designing or placing an order. Data for the various tests will be added sequentially.

2. PRECAUTIONS

When using the product, please follow the precautions that are provided below to properly store and use the product.

- As for the inspection specifications, please refer to the Inspection Specifications that are separately provided.
- Please note that there may be probe marks on the pads that were left during open/short testing.
- When only a small quantity is processed, traces of burn and/or discoloration may appear near the cutting surface, as it involves the use of a laser to cut along the outline. However, these have no negative effect on conductivity or insulating performance.
- Overall warpage may occur in some cases, which is a common issue with any flexible PWB but this will not have any negative effect on the connection with the connectors or any other electrical characteristics. If, however, it is necessary to keep a levelled surface, it might be better to attach stiffeners, etc. For more details, please consult our staff.
- As touching the circuit patterns with bare hands will leave fingerprints, we recommend wearing gloves when handling the product. In addition, please make sure that components are mounted onto the product within three months.

3. MANUFACTURING SPECIFICATIONS AND VARIOUS CHARACTERISTICS

3.1. MANUFACTURING SPECIFICATIONS

Table 3-1: Manufacturing Specifications

Substrate	Transparent heat-resistant PET film: 50 μm thick, 125 μm thick PI (Polyimide) film: 25 μm thick
Line width / interval	200/200 μm min., 200/150 μm min. (option)
Hole diameter	0.5 mm min.
Outline-pattern interval	Standard Precision: 0.5 mm min. High Precision: 0.3 mm min.
Copper foil thickness	3 μm , (6 μm -thick copper foil may be also applied on a case-by-case basis. Please consult us to see if this option is available.)
Panel size	180 \times 270 mm max.
Wiring layer	Single-sided
Soldermask application	UV inkjet printing (green) (waterproof graded soldermask coating is possible for special items)
Legend printing	UV inkjet printing (black)
Surface treatment	Oxidation prevention treatment, Electroless nickel gold plating (option)
Outline trimming	Laser cutting
Hole processing	Laser cutting
Stiffeners	When specifying the thickness of the connector part, film stiffeners can be used to adapt to connectors of 200 μm or 300 μm in total thickness. Component mounted parts and such can be adapted by using FR-4 stiffeners of 0.1, 0.3, 0.5, 1.0, and 1.6mm in thickness. More solutions upon consultation.
Inspection	Optical inspection + opens/shorts test

*Please consult Elephantech if other manufacturing specifications are preferred to those described above.

3.2. LAYER COMPOSITION

The layer compositions of P-Flex™ PET as well as P-Flex™ PI are as specified in **Figure 3-1** below. The thickness data shown below are provided for reference purposes only and are not guaranteed values. The basic layer composition is shown in the illustration on the left. While the substrate for the P-Flex™ PET is rather thick, there is no adhesive layer for copper foil or soldermask and so the total thickness is roughly the same as that of a flexible PWB with a substrate that is 25 μm thick. P-Flex™ PI uses an even thinner substrate that is 25 μm thick.

Nickel gold plating and FR-4 stiffeners are also available as options. The illustration on the right shows the layer structure when all these options have been added. The film stiffeners can be used as a liner that backs the connectors with specified thicknesses of 200 or 300 μm .

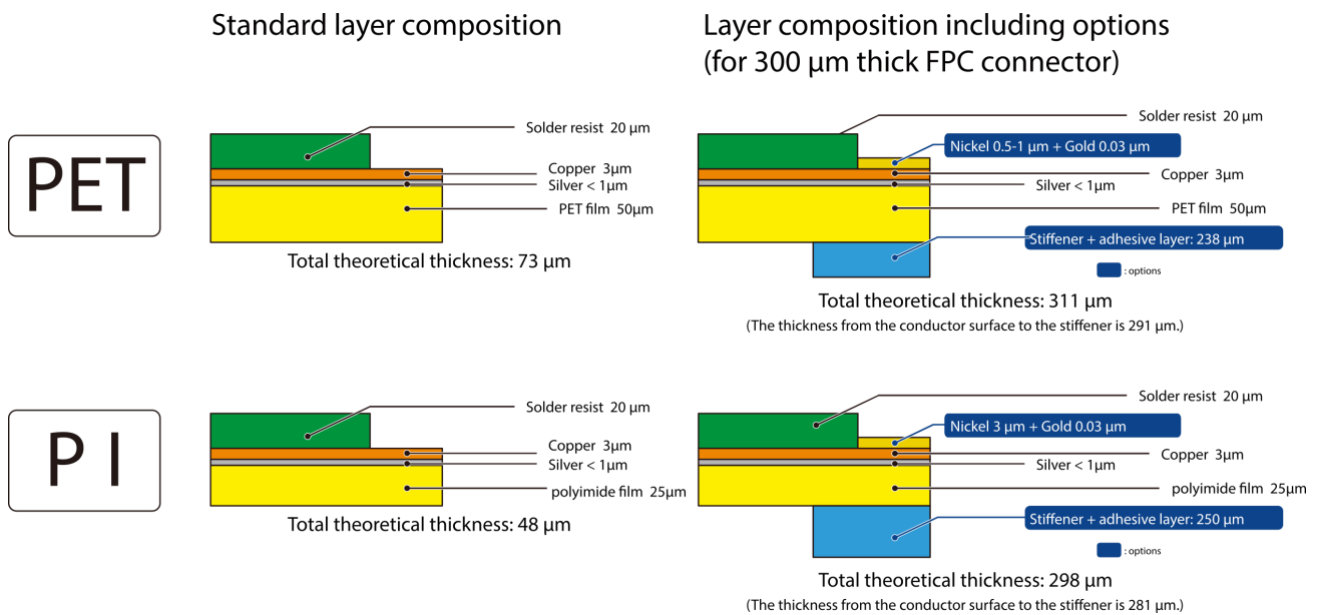


Figure 3-1: Layer composition of P-Flex™

3.3. VARIOUS CHARACTERISTICS

Table 3-2: Various Characteristics

Thickness tolerance of copper foil	It should not be less than the specified foil thickness.
Sheet resistance	6.7 m Ω / Sq. (at a copper foil thickness of 3 μm), which is inversely proportional to the copper foil thickness.
Temperature during continuous use	Between -20°C and +105°C
Reflow heat resistance	PET: 200°C for five seconds PI: 260°C for ten seconds

3.4. REFERENCE DATA ON AMPACITY

The data that show the relation between the current and the increase in temperature are provided in **Figure 3-2** below, as reference data regarding ampacity. The thickness of the copper foil is 3 μm . However, please note that these values are provided for reference purposes only and should not be viewed as guaranteed values.

As for the testing method that was used to gather the data, voltage was applied starting at room temperature so that the specified rise in temperature could be achieved (i.e., +10–+40°C), while the

current was measured and recorded. To run an electric current, a test piece was set up on top of two fixation jigs like a bridge. Then it was made sure that nothing was contacting the area where measurements would be taken, with a cover put over the area to shield it from any air movements caused by air-conditioners, etc., so that only natural heat-induced convection could occur.

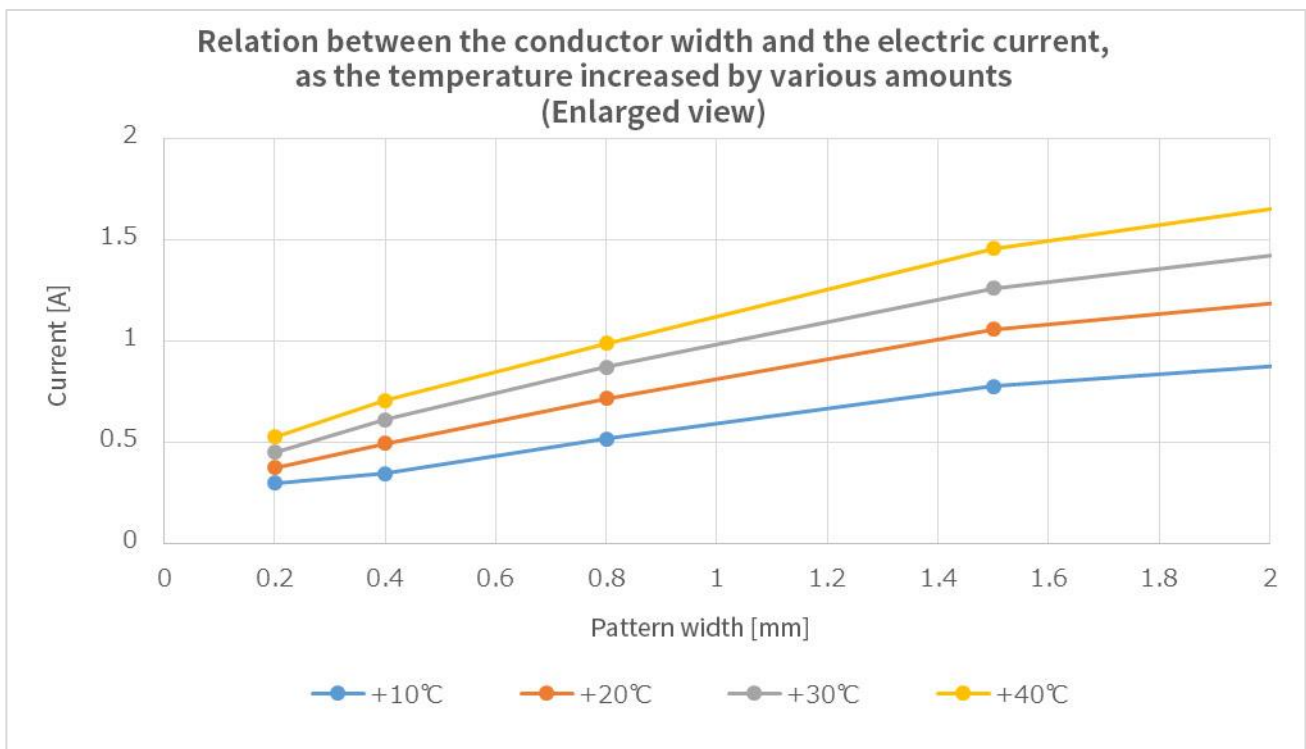
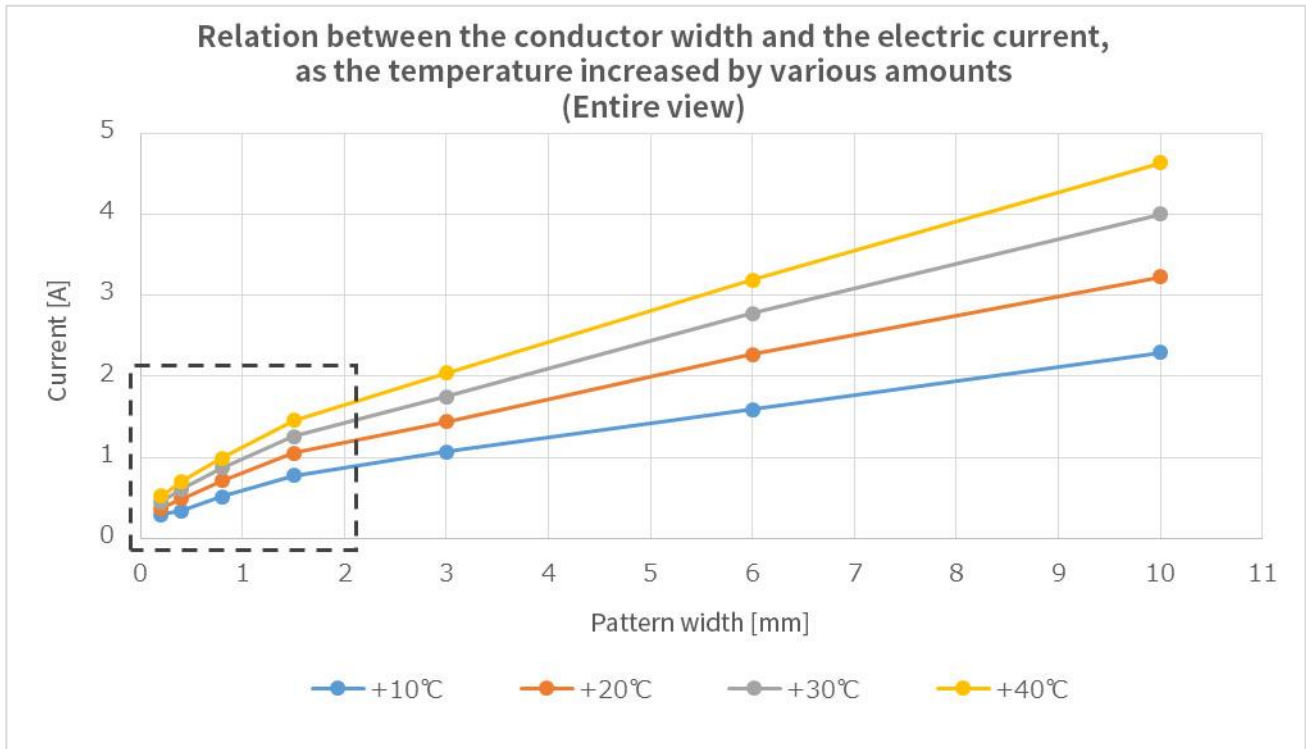


Figure 3-2: Relation between the conductor width and the electric current value, as the temperature increased by various amounts (3 μ m Copper foil thickness)

3.5. REFERENCE DATA ON FLEX RESISTANCE

Reference data on the flex resistant characteristic of the product is provided in **Table 3-3** below. The copper foil's thickness is 3 μm . Please note, however, that the data is provided for reference purposes only and these are not guaranteed values.

As for the testing method that was used to gather the data, the standard JPCA UB-1 titled 'Flex Resistance Testing Method for Flexible PWB - High speed' was applied. For testing purposes, samples with a wire width of 0.5mm were tested at a bending speed of 10 bends per second.

Table 3-3: Reference data on flex resistance

Substrate	Bending radius R [mm]	No. of bends until the resistance value of 1.2 times is achieved
PET	5	320,000
PI	5	120,000

3.6. REFERENCE DATA ON THE MINIMUM BENDING RADIUS

Reference data regarding the minimum bending radius is provided in **Table 3-4** below, which can be used when bending FPCs with a die, etc. The Copper foil thickness is 3 μm and the substrate is PET. However, it must be noted that the data is provided for reference purposes only and is not a guaranteed value.

Table 3-4: Reference data on the minimum bending radius

Minimum bending radius R [mm]	0.5
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3.7. REFERENCE DATA ON ANTI-IONIC MIGRATION

Reference data on the anti-ionic migration characteristic of the product is provided in **Table 3-5** below. Please note, however, that the data is provided for reference purposes only and these are not guaranteed values. The test pattern used consisted of interdigital electrodes placed at 0.5 mm intervals, to which a voltage of 50V was applied.

While silver is used in the seed layer, copper coating is subsequently applied using electroless plating all over the surface. Therefore, no ionic migration of silver will occur under normal circumstances.

Table 3-5: Reference data on anti-ionic migration

Condition	Observation of ionic migration
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3.8. ON ROHS AND REACH

All products we ship comply with the RoHS Directive as standard. Also, we do not use substances

that are listed as Substances of Very High Concern (SVHC) by the REACH regulation. If required, we will gladly provide certificates of compliance issued by RoHS and REACH upon request. Please contact us.

3.9. ON UL CERTIFICATION

The UL94 (flame retardant standard) conformity test has been carried out and the results are as follows.

Substrate	UL94
PI	VTM-0 equivalent (Pending certification number)
PET	None.

3.10. PATTERN PEEL STRENGTH REFERENCE DATA

Reference data on peel strength between the substrate and the copper pattern is shown in **Table 3-6**. However, the peel test is based on JIS-K5600 (cross cut method).

Table 3-6 Peel Strength Reference Data

Substrate	Peel strength
PI	Passed peel test
PET	Passed peel test

4. DATA ENTRY SPECIFICATION

Guidelines relating to the necessary data are specified separately in the appended guideline [P-Flex Design Guideline]; please check this guideline when designing or placing an order.

5. MANUFACTURING STANDARD AND PRODUCT RETURN RULES

5.1. GENERAL DIMENSIONAL TOLERANCE

The general dimensional tolerance is as shown in **Table 5-1**. This general dimensional tolerance shall apply to the distance between any given two separate points, such as the distance between circuit patterns, or the length of a line. In addition, Elephantech has a different set of specifications to be applied to certain parameters pertaining to out-of-bounds pattern width, outline dimensions, location of liners to be applied to the back of PWBs, etc.

However, this does not mean that we conduct dimensional measurements for all products using a dimensional meter with respect to the specified dimensions. Please contact us if you wish for the dimensions to be measured.

Table 5-1 Table of general dimensional tolerance

Distance	General dimensional tolerance
Less than 200mm	The larger value between $\pm 0.5\%$ and $\pm 0.05\text{mm}$
More than 200mm	The larger value between $\pm 0.3\%$ and $\pm 1.0\text{mm}$

5.2. OUT-OF-BOUNDS AND MISSING PATTERNS, PITS, AND PATTERN FLOATAGE

As the conductive patterns are created using inkjet printing and electroless copper plating processes, certain irregularities may occur such as out-of-bounds patterns and missing patterns, and also pits (i.e., bubble marks) and pattern floatage that may occur during the plating process. In this connection, slightly uneven plating finish may occur around any pits, but it should not be counted as part of those pits. Similarly, out-of-bounds and missing soldermask may also occur as it is created using inkjet printing. The tolerances for these irregularities are as specified in **Table 5-2** below, which are expressed as allowable length in proportion to the design dimension in the direction of the width.

However, if any of these types of irregularities should cause practical issues with correct product usage, they will be removed even if they are within the specified tolerance.

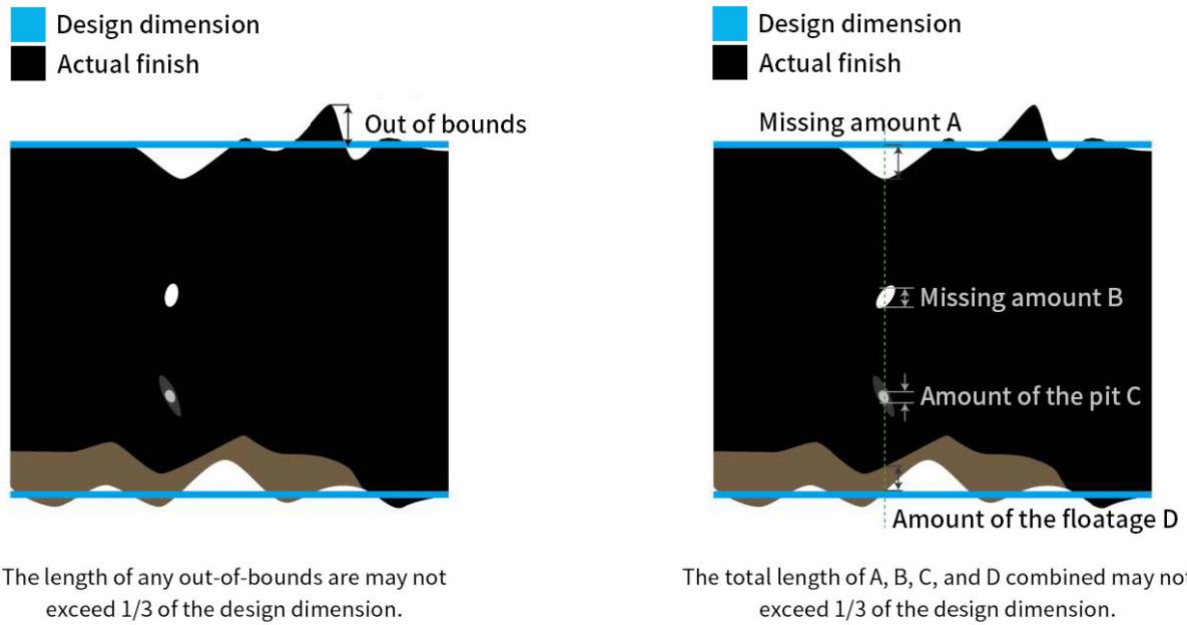


Figure 5-1: Illustrations of out-of-bounds and missing patterns, etc.

Table 5-2: Tolerances on out-of-bounds and missing patterns, etc.

Item	Tolerance
Out of bounds	The length of any out-of-bounds pattern should not exceed 1/3 of the design dimension
Missing pattern, pit, and pattern floatage	The total length of these irregularities combined should not exceed 1/3 of the design dimension or 0.1 mm, whichever value is larger.

5.3. PATTERN BREAKAGE AND SHORT CIRCUIT

No break in the circuit is allowed for any section of the product that is the same width or wider than the minimum pattern width as specified in **Table 3-1**. Likewise, no short circuit is allowed for any section of the product that is the same width or wider than the minimum pattern width as specified in **Table 3-1**.

5.4. INK SPLASH

The product is prone to having the kind of ink splash shown in Error! Reference source not found., due to the manufacturing process in which the conductive ink is applied by inkjet printing.

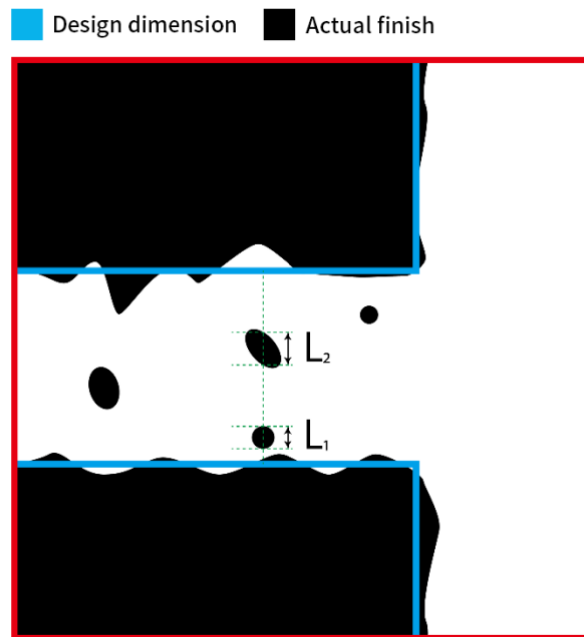


Figure 5-2: Ink splash

No short circuit between patterns that is caused by ink splash is allowed. In addition, with regard to the shortest line connecting any given point on one pattern to another pattern, the tolerance for ink splash is as specified in **Table 5-3** below.

Table 5-3: Tolerance for ink splash

Item	Tolerance
Maximum length= $\max(L)$	0.05 mm
Total length= $L_1+L_2+\dots L_N$	No more than 1/2 of the spacing between conductive tracks
No. of splashes= N	Maximum of five splashes every 0.2 mm

5.5. OTHER TYPES OF IRREGULARITIES

Tolerances for other types of irregularities are as specified in **Table 5-4** below.

Table 5-4: Types of other irregularities and their tolerances

Item	Tolerance
Foreign objects	Foreign objects up to a maximum length of 1 mm are allowed so long as they do not cover multiple conductive or non-conductive areas.

Air bubble	Air bubbles up to a maximum length of 1 mm are allowed so long as they do not cover multiple conductive or non-conductive areas.
Scratch	Scratches are allowed so long as they do not cause any broken or short circuits.

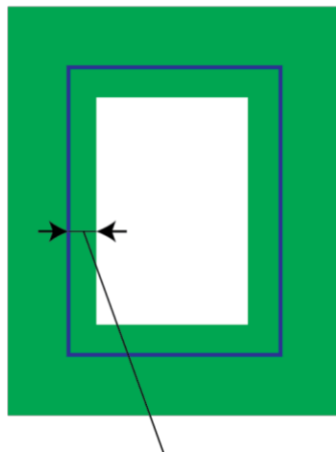
5.6. SOLDERMASK

The soldermask will be printed by UV ink-jetting method.

The soldermask shall be free from peeling or pinholes that could cause practical problems.

Regarding the splashes from soldermask, the tolerance values for ink splashes in **Table 5-3** shall apply mutatis mutandis. In regard to any printing misalignment between the conductive patterns and soldermask, general tolerances are as specified in **Table 5-5** below, so long as no practical issues are caused, such as a pad being completely covered and such. However, the broadening of soldermask is as shown in **Figure 5-3**.

- Designed solder resist aperture
- Actual solder resist



Broadening of solder resist

Figure 5-3: Broadening of soldermask

Waterproof graded soldermasks free of pinholes are possible as a special specification. There is a possibility that this waterproof graded soldermask may have lower bend resistance and the soldermask may broaden further than designed due to the pinholes being removed by the overcoating of the soldermask layer.

Design guidelines concerning the soldermask are specified separately in the appended guideline [P-Flex Design Guideline]; please check this guideline when designing.

5.7. LEGEND

This refers to the symbols that are printed on PWBs that are intended to serve as indications for

helping the mounting process, which is sometimes referred to as ‘silk-screen printing,’ etc. The tolerance for any symbols being printed off the correct locations in relation to the corresponding circuit patterns is as specified in **Table 5-5**. Design guidelines concerning the symbols are specified separately in the appended guideline [P Flex Design Guideline]; please check this guideline when designing.

5.8. EXTERNAL DIMENSIONS

As the outline of PWBs is cut using laser, the tolerances for the distance between the opposite sides of the outline and the outline-pattern distance are less than the general dimensional tolerances as shown in **Table 5-5**. It must be ensured by each customer that a minimum outline-pattern distance of 0.5mm exists. As the outline of PWBs is processed using laser, any laser-cut area and circuit pattern being too close to each other potentially risks leading to burnt or exposed patterns. If ‘high-precision’ option is selected for cutting precision, then ensure that there is a distance of at least 0.3mm between the outline and the outermost circuit pattern.

Any parts of PWBs that require especially high-precision processing, such as holes for mounting components and connector parts, can be created as shown in **5.10 SPECIAL SPECIFICATIONS OF CONNECTORS** below. Please send an inquiry to Elephantech for any order that involves such high-precision processing needs.

5.9. STIFFENERS

Stiffeners are used to prevent the component-mounted areas of PWBs from bending too much and also to achieve evenness in the thickness around the connector terminals. Concerning the part of connector terminals, the PWBs and the attached stiffeners are cut out together. For all other parts, the PWB and the stiffeners are cut out separately and visually aligned by hand. Tolerance for the deviation between the outlines, symbols and stiffeners are as shown in **Table 5-5**.

Design guidelines concerning the stiffeners are specified separately in the appended guideline [P-Flex Design Guideline]; please check this guideline when designing.

Table 5-5: Tolerances on positional and dimensional precision, aside from circuit patterns

Item	Tolerance
Between any circuit pattern and soldermask	±0.2 mm
Between any circuit pattern and symbol	±0.7 mm
Outline size	±0.5 mm or ±0.3%, whichever is larger
Between the outline and any circuit pattern	Standard Precision: ±0.3% or ±0.5 mm, whichever is larger High Precision: 0.3% or ±0.3 mm, whichever is larger
Between the outline or any symbol and	±0.7 mm

a stiffener	
Soldermask broadening	0.1mm, (waterproof grading of 0.3mm)

5.10. SPECIAL SPECIFICATIONS OF CONNECTORS

If high-precision is required for properly aligning any connector parts, etc. with the external dimensions and stiffeners, the options as shown in **Table 5-6** below are available for manufacturing the connector parts, etc. with the indicated tolerances. For example, when using a connector with a 1.0mm pitch or a 0.5 mm pitch, an outline tolerance of ± 0.12 mm or ± 0.07 mm respectively is recommended.

Please consult us beforehand if an even higher precision requirement, such as ± 0.05 mm tolerance in external dimensions, is needed for the connector. Design guidelines concerning the connectors are specified separately in the appended guideline [P-Flex Design Guideline]; please check this guideline when designing.

Table 5-6: Special specifications for connectors

Item	Tolerance
Outline size	± 0.07 mm
Between the outline and any circuit pattern	± 0.07 mm

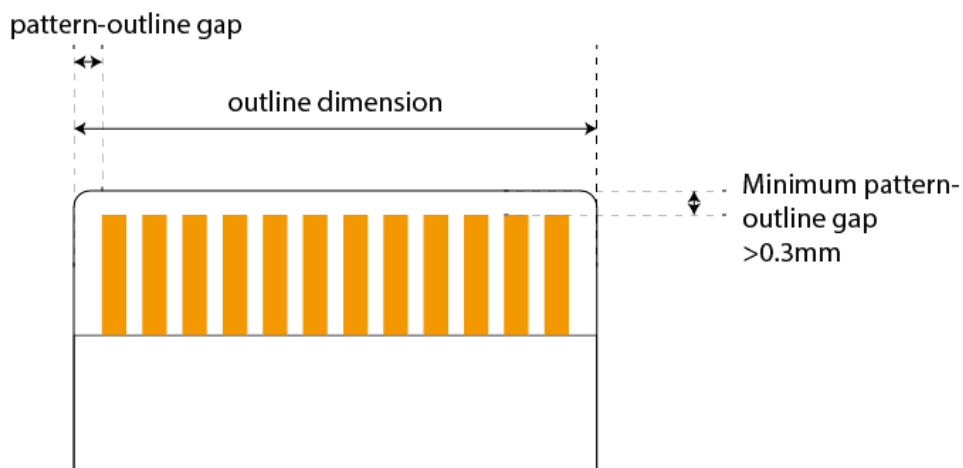


Figure 5-4: Dimensions of the connector part

5.11. PRODUCT RETURN AND REPLACEMENT RULES

If any product unit does not conform to any of the manufacturing specifications provided above, it can be replaced with a new unit, free of charge. In such case, please contact Elephantech to report the defect using the contact information that is included in the product package, within 30 days of

the product delivery date. Elephantech will ship a replacement unit within two business days after receiving the report on the defect.

6. DISCLAIMERS

- These Specifications have been prepared by Elephantech with utmost care. However, Elephantech does not provide any guarantee that the Specifications are completely free of error. Elephantech shall not be held responsible for any damage that is suffered by a customer as a result of any incorrect information that may be included in these Specifications.
- Any part of these Specifications is subject to change without prior notice for technical or quality improvement purposes, etc. Such being the case, please note that the information provided in these Specifications may not be perfectly consistent with the specifications of the particular product being used by each customer.

7. REVISION HISTORY

Ver.	Revision date	Description of revision
1.0	January 6 th , 2017	Newly drafted and issued.
1.1	January 10, 2017	The data entry specifications, inspection items in the manufacturing specifications, comments on ink splash, soldermask printing specifications, and bending test data (for reference purposes only) were added.
1.2	January 26 th , 2017	Supplementary information on the external outline cutting and stiffeners was added.
1.3	January 30 th , 2017	Information on the maximum instantaneous heat-resistant characteristic of the product was added. Other minor expressions, etc. were also edited.
1.4	February 19 th , 2017	Data on the minimum hole diameter and external-minimum pattern interval was added.
1.5	March 23 rd , 2017	The maximum film thickness was changed from 20 μ m to 10 μ m.
1.6	April 4 th , 2017	The soldermask material was changed to one with higher solvent resistance. Information on the copper foil thickness options was added.
1.7	April 24 th , 2017	The copper foil thickness options were modified. The color of the soldermask was changed from green to transparent.
1.8	May 11 th , 2017	The result of the product test conducted under conditions of 85°C and 85% was added to the Q&A section. The precautions on stiffener application were added to the data entry procedure.
1.9	May 17 th , 2017	With regard to the specification of the copper foil thickness tolerance, change was made to guarantee the minimum foil thickness.
1.10	May 30 th , 2017	The precautions to be followed at the time of data entry were added. The word “silk” was changed to “legend.”
1.11	June 23 rd , 2017	The material of the soldermask was changed, and its color was also changed from transparent to green. Restrictions on the use of the product for medical devices, etc. were deleted from the disclaimers. Reference data on the anti-ionic migration characteristic of the product were added.

2.0	July 28 th , 2017	The brand name was changed from AP-2 to P-Flex™. A note on burn traces that could be left after the laser cutting process was added to the precautions. Electroless Ni-Au plating was added to the surface treatment.
3.0	September 5 th , 2017	The company name was changed from AgIC Inc. to Elephantech Inc.
3.1	September 6 th , 2017	Typographical errors were corrected.
4.0	December 11 th , 2017	<p>As the standard substrate thickness was changed to 50μm, the following points have been revised.</p> <ul style="list-style-type: none"> • The standard substrate in the manufacturing specifications has been changed. • Stiffeners have been changed. • Explanation on the layer composition has been added. • Reference data regarding flex resistance have been changed. • Reference data regarding the minimum bending radius has been added. • Reference data regarding bendability at 125μm has been deleted. • Q&A on the flex resistance and bending resistance characteristics have been modifies. • The minimum pattern interval of 150μm has been made available through consultation on a case-by-case basis. • A copper foil thickness of 6μm has been made available through consultation on a case-by-case basis. • The maximum allowable temperature for continuous product usage has been changed to 100°C. • Reference data regarding ampacity have been added. • An explanation on stiffeners has been added to the data entry specifications. • An explanation on the outline data output has been added to the precautions for data entry. • An explanation on the legend printing for using stiffeners has been added to the precautions for data entry. • An illustration for explaining the minimum distance between the outline and circuit patterns has been added. • The general dimensional tolerances have been modified. • The tolerance for out-of-bounds circuit patterns has been modified.

		<ul style="list-style-type: none"> • The tolerance for missing circuit patterns has been modified to include any pits and pattern floatage. • The tolerances for missing circuit patterns, pits, and pattern floatage have been modified. • The tolerance for misalignment between circuit patterns and matching symbols has been newly specified. • The dimensional tolerance for the outline size has been newly specified.
4.0.1	February 8 th , 2018	<ul style="list-style-type: none"> • The temperature during continuous use is corrected.
4.2.0	June 25 th , 2018	<ul style="list-style-type: none"> • Mention of RoHS and REACH accordance regarding standard specifications • DXF, PDF, and CADLUS added to accepted file formats • Added explanation for recommended design method of soldermask opening • Updated number of bends (R=5) for which operation has been tested to 20 million bends • Mention of reference values for the adhesiveness of copper foil • Modified thickness of gold plating to 0.03 μm • Modified the gold plating process regarding soldermask opening • Modified the gap between the outline component and the pattern to 0.3 mm • Modified the pattern symbol for parts without soldermask to “Do not print” • Modified general dimensional tolerance • Modified external dimensional tolerance • FAQ was deleted and unified to FAQ from the WEB
5.0.0	July 23 rd , 2018	<ul style="list-style-type: none"> • Added PI specification • Corresponds to data entry by drawings with instructions • Added FR-4 stiffener types
5.0.1	August 10 th , 2018	<ul style="list-style-type: none"> • Modified the sheet resistance • Added the method for measuring copper foil thickness. • Modified the tolerance between the outline and any circuit pattern • Corrected typographical errors • Added that, if the distance between pads are 0.7mm or less, the soldermask apertures must be fully open. • Added that, even if no soldermask is needed by a customer, it must still provide data specifying where the pad areas are so that tests can be performed on them using a flying probe tester.

		<ul style="list-style-type: none"> • Added that no drill data is accepted in usual cases, and that data on any holes that must be created should be also included in the outline data. • Updated the illustration explaining the layer structure as the silver layer was previously missing.
5.1.0	October 10 th , 2018	<p>Following the establishment of the Design Guideline, the items below were moved to the Design Guideline</p> <ul style="list-style-type: none"> • The data submission specification needed when placing an order • Clearance information concerning each data • Explanation concerning the broadening of the soldermask • Explanation on overlapping symbols and pads • A portion of the explanation on stiffeners • A portion of the explanation on connector parts <p>Other</p> <ul style="list-style-type: none"> • Modified minimum hole diameter to 0.5mm • Added explanation on waterproof soldermask • Modified thickness of PI stiffeners • Added reference data for flex resistance of PI