Phase C

Fabrication Plan (Electrical)

Prepared by:

Fabien Jordan

Checked by:

Approved by:

•

Space Center

Lausanne

Switzerland

•

22/03/2008

•

RECORD OF REVISIONS

ISS/REV	Date	Modifications	Created/modified by
1/0	09/07/07	Initial Issue	Fabien Jordan
1/1	28/12/07	Update	Fabien Jordan
1/2	13/01/07	Update	Fabien Jordan
1/3	16/01/07	Add Muriel Noca Comments	Fabien Jordan
1/4	14/03/07	Adjust the fabrication costs	Fabien Jordan
1/5	18/03/07	Add pictures and updates	Fabien Jordan

1 REFERENCES

1.1 Normative references

[N1] ECSS-Q-70-01A Cleanliness and contamination

[N2] ECSS-Q-70-10A Qualification of printed circuit boards

[N3] ECSS-Q-70-11A Procurement of printed circuit boards

[N4] ECSS-Q-70-18A Preparation, assembly and mounting of RF coaxial cables

[N5] http://workmanship.nasa.gov

1.2 Informative reference

[R1] S3-C-19-0-Electrical Block Diagram

[R2] S3-C-SET-1-6-Fabrication and Test Planning 2008

[R3] S3-C-1-0-Cabling Plan (to be published)

2 TERMS, DEFINITIONS AND ABBREVIATED TERMS

2.1 Abbreviated terms

CB	Connection Board
EQM	Engineering Qualification Model
FM	Flight Model
FM1	Flight Model 1
FM2	Flight Model 2
FR-4	Flame Retardant 4
HASL	Hot Air Solder Leveling
ICD	Interface Control Document
P-POD	Poly Picosatellite Orbital Deployer
PCB	Printed Circuit Board
PWA	Printed Wiring Assembly
TBC	To be confirmed
TBD	To be defined

3 INTRODUCTION

The present document aims to describe the fabrication operations and processes of each electrical assemblies of SwissCube. Before reading this document it is recommended to have a look at the Electrical block Diagram [R1] in order to understand the overall electrical design.

4 PCBs FABRICATION

There are 16 PCBs in the satellite. All of them have 6 layers of copper and they can be manufactured with a similar substrate by two companies. These companies are:

- Photochemie AG,
- Micro-PCB AG.

Photochemie has already worked for the space field but the fabrication prices are very expensive. Most of the PCBs will probably be manufactured by Micro-PCB. This question is actually in discussion.

The PCBs for the EQM, FM1 and FM2 will be manufactured in only three batches in order to reduce the starting costs.

The recommendations of ECSS-Q-70-11A [N3] have been followed as well has possible.

4.1 Material

4.1.1 Substrate (Photochemie)

The chosen substrate is a specific halogen free FR-4 (R1551W - R1566W, see Appendix A). It was recommended by Photochemie regarding to the thermal environment of SwissCube.

The typical glass transition temperature is 152.7 °C when the laminate thickness is less than 0.5 mm

4.1.2 Substrate (Micro-PCB)

Micro-PCB recommends using a standard FR-4 with a typical glass transition temperature of 175°C.

4.1.3 Surface Finish

A standard chemical Nickel/Gold surface finish has been chosen for the 6 faces of SwissCube because gold is needed to perform the wire bonding of the sunsensor. The wire bonding requires a gold thickness of 50 to 100 nm.

Here are the values given by the manufacturer:

- Nickel thickness: 5.177 um

- Gold thickness: 76 nm

This operation is made by another company: Markus Hofstetter AG.

For the other boards, a HASL surface finish with pure tin will be used if the fabrication is performed by Photochemie. This surface finish has been recommended by Jason Page, electronics engineer at ESTEC.

Micro-PCB is not able to do a good HASL finish on 0.8 mm thick PCBs. So, if the fabrication is performed by Micro-PCB. It has been decided to use a standard chemical Nickel/Gold surface finish on every board.

4.1.4 Solder Mask

The solder mask (see Appendix B) will be used only where it is really necessary. As shown below, the solder mask will be used around the wire connection in order to facilitate the soldering because the copper pads are close to each other.

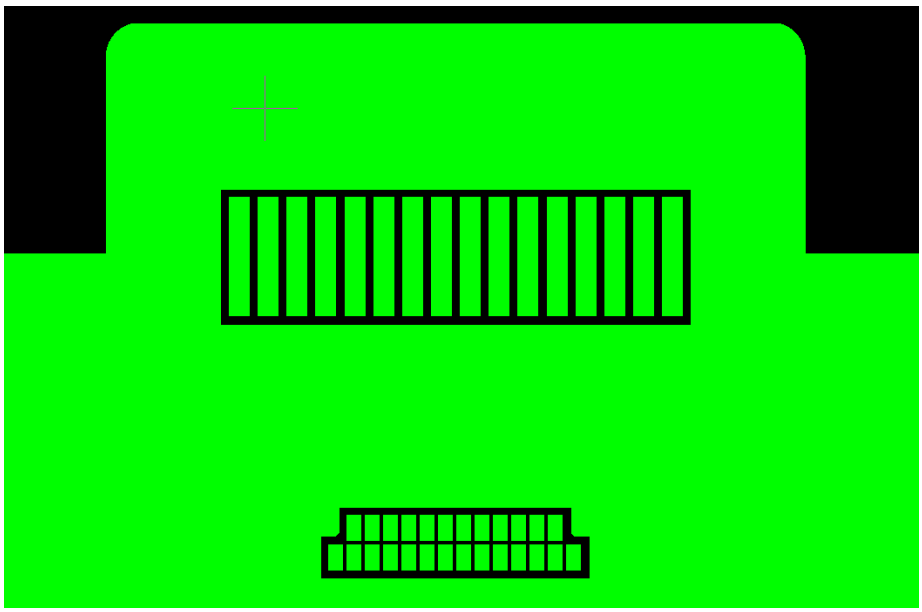


Figure 4-1 : Solder mask (in black) around the connection of the CB

The soldermask outgassing will be limited by the use of a conformal coating after soldering the wires.

4.1.5 Layers Thickness

Number of layers: 6

Laminate thickness: 150 um (3 layers)

Prepreg thickness: 118 um (2 layers)

Copper thickness: 35 um (6 layers)

Nickel/Gold thickness: 5 um (on the copper, both sides)

Solder mask thickness: 12 um (only on specific zones)

Total thickness (end of fabrication process): 0.8 mm

4.2 Schedule

Please refer to the general planning [R2].

4.3 Workforce

The fabrication files are prepared by the persons in charge of the routing of each subsystem. So it is important to keep these people in contact in case of problem or in case of last minute modifications. Here are their names and the subsystems on which they work.

Peter Brühlmeier (EPFL)

- Payload
- ADCS
- ADS
- Battery Board
- Faces

Steve Maillard (HEIG-VD)

- Power Management Board
- Connection Board

Claude Guinchard (HEIG-VD)

- Mother Board

Michel Gremaud and Sylvain Decastel (HES Fribourg)

- BEACON

Frederic Chastellain (UNINE)

- COM

Olivier Walpen (HEVs)

- CDMS

The PCBs fabrication is done by an external company but during the first week this work will be followed by an electrical engineer at EPFL.

4.4 Costs

For the EQM and the FMs it will be necessary to produce 2 series of PCBs per model (6 series in all). Here is an estimation of the PCBs fabrication costs for the EQM and FMs:

4.4.1 PCBs fabrication costs EQM

EQM (2 series of PCB)

Price each series: CHF 5000.-

Starting costs: CHF 2000.-

Electrical testing: CHF 1000.-

Total price for the EQM: approx. CHF 13'000.-

4.4.2 PCBs fabrication costs FM1 and FM2

FM1 (4 series of PCB)

Price each series: CHF 5000.-

Starting costs: CHF 4000.-

Electrical testing: CHF 2000.-

Total price for the FM1: approx. CHF 26'000.-

4.5 Contact

4.5.1 Photochemie

Eduard Heinrich
Sales Manager

Photochemie AG
Gewerbestrasse 1
Postfach 361
CH-6314 Unteraegeri

Tel. +41 (0)41 754 45 30
Fax: +41 (0)41 754 45 59
ed.heinrich@photochemie.ch
www.photochemie.ch

Michel Grangier
Manager Technologie & Consulting

Photochemie AG
Gewerbestrasse 1
Postfach 361
CH - 6314 Unterägeri

Tel. + 41 (0)41 754 45 06
Fax. + 41 (0)41 754 45 95
m.grangier@photochemie.ch
www.photochemie.ch

4.5.2 Micro-PCB

José Luis Mendes

Micro-PCB AG
Hauptstrasse 2
8512 Thundorf

Tel. +41 (0)52 369 41 32
Fax: +41 (0)52 369 41 37
j.l.mendes@micro-pcb.ch

4.5.3 Markus Hofstettler

Markus Hofstetter AG

Leiterplattenlohngalvanik
Fännring 10
CH-6403 Küssnacht am Rigi

Tel. + 41 41 850 50 50
Fax + 41 41 850 55 50
Email: info@markus-hofstetter.ch

4.5.4 Persons in charge of PCB routing

Peter Brühlmeier

EPFL STI ACI
INM 013 (Bâtiment INM)
Station 14
CH-1015 Lausanne
Tel: [+41 21 69] 37544, 32644
peter.bruehlmeier@epfl.ch

Claude Guinchard

HEIG-VD Département TIC
Route de Cheseaux 1
Bureau A03
1401 Yverdon-les-Bains
Suisse
claude.guinchard@heig-vd.ch
Tél. 024 / 55 76263

Steve Maillard

HEIG-VD Département TIC
Route de Cheseaux 1
Bureau A03
1401 Yverdon-les-Bains
Suisse
steve.maillard@heig-vd.ch
Tél. 024 / 55 76263

Michel Gremaud

Ecole d'Ingénieurs de Fribourg
Bureau de Construction
BD de Pérolles 80
Bureau G10.12
1705 Fribourg
Téléphone +41 26 429 6572
Fax +41 26 429 6600
michel.gremaud@hefr.ch

Sylvain Decastel

Ecole d'Ingénieurs de Fribourg
BD de Pérolles 80
CP 32
CH-1705 Fribourg
Téléphone +41 26 429 68 71
Sylvain.decastel@hefr.ch

Frédéric Chastellain

ESPLAB - IMT UniNE
2, A.-L. Breguet
CH-2000 Neuchâtel
Tél. +41(0)32 718 34 10
Fax +41(0)32 718 34 02
frederic.chastellain@unine.ch

Olivier Walpen

027 606 8730
olivier.walpen@hevs.ch

5 COMPONENTS MOUNTING AND SOLDERING

5.1 Stock of components

All components are stocked in the clean room before mounting. Two documents are used to manage the stock of components:

- ***S3-C-1-0-Electrical-Components-List*** (list of all components for one satellite)
- ***S3-C-1-0-Cleanroom-Electrical-Component-List*** (list of component stocked in the clean room)

Before mounting and soldering the electrical assemblies of the EQM, the cleanroom must contain at least 2 times the needs for 1 satellite.

Before mounting and soldering the electrical assemblies of the FM1 and FM2, the cleanroom must contain at least 4 times the needs for 1 satellite.

These documents are regularly checked and updated.

5.2 Components mounting

5.2.1 Component cleaning and tinning

Before soldering, smd components will be cleaning in an isopropyl alcohol bath. After drying, a rosin-based, halide-free flux will be applied on the components pins (this will be performed with a bath of flux for the small components). Then they will be tinning in two different solder pots. These two solder baths are regulated at 260°C. The first bath removes the unleaded layer of tin already applied on the pins and provides a rough leaded tinning. And the second bath, cleaner than the first, finalizes the tinning process by adding lead to the solder joints.

In brief, the process for a typical smd component:

1) Clean the component with isopropyl alcohol
2) Let it dry
3) Apply the flux
4) Dip the component in the first solder bath (approx. 3 seconds)
5) Dip the component in the second solder bath (approx. 3 seconds)
6) Clean component with isopropyl alcohol

The solder pots are manufactured by PLATO. Here is a picture of one of these facilities:

Figure 5-1 : Porcelainized Solder Pots for tinning

5.2.2 Soldering process

Before soldering the PCB is heated at approx. 90 °C with a heating plate designed especially for our application. This heating process recommended by Jason Page will reduce the mechanical constraints on the substrate and the solder joint.

Type of solder used: ELSOLD Sn63Pb37

Soldering temperature: 260°C

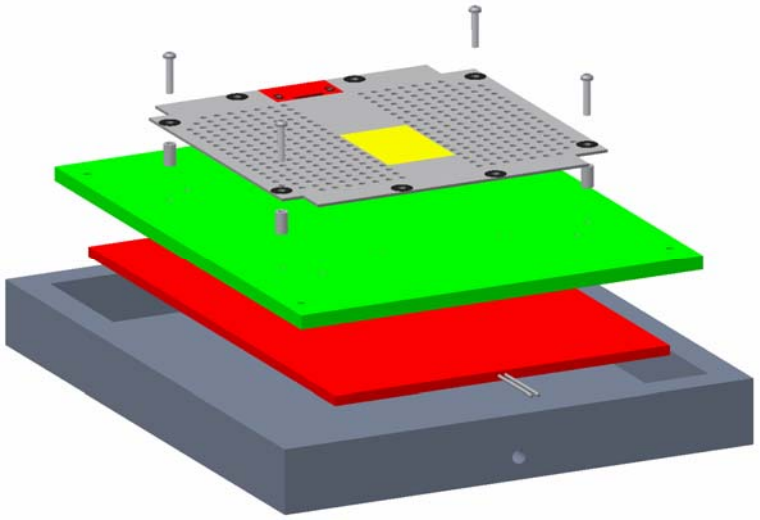


Figure 5-2 : Heating Plate

5.2.3 Soldering examination

As recommended in ECSS-Q-70-10A [N2]

The Pictorial Reference of the Nasa workmanship standards [N5] will be also used for the soldering examination.

5.2.4 Soldering facilities

The major part of the soldering work will be performed with the new soldering facilities of the Space Center, EPFL. These Weller tools are perfectly appropriate to solder the SwissCube components.

Figure 5-3 : Soldering facilities, WELLER (WD2M and WMRP)

5.3 Solar cells soldering

Triple junction solar cells are used on the SwissCube. The soldering process has been defined and tested at EPFL.

This process consists to depose a low temperature solder paste (Sn18PbBi50 - 98°C) on a specific footprint by a process of serigraphy (screen printing).

The solder paste is manufactured in France by MBO (Métaux Blancs Ouvrés).

After this deposition, the solar cells are placed by hand on the solder paste and then baked in a vacuum oven. The baking duration is approx. 20 min. At last, it is necessary to clean the panel in order to eliminate the residual flux with an isopropyl alcohol bath.

5.3.1 Silver strip cutting

The silver strips (silver contacts pads) are already welded on the solar cell on each terminals as shown below. Before the soldering, the silver strips of the solar cells must be adapted to the SwissCube design by cutting two out of four of them. This operation must be done by hand and very carefully with a high precision cutter.

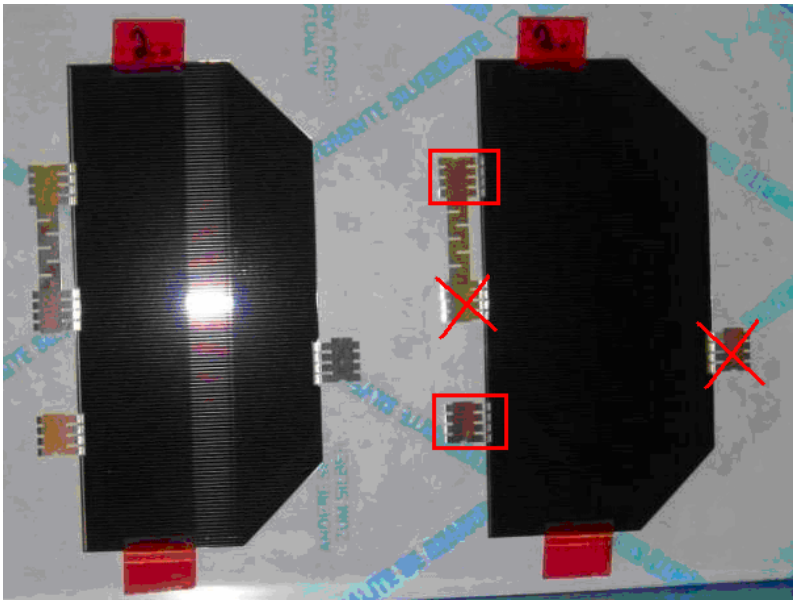
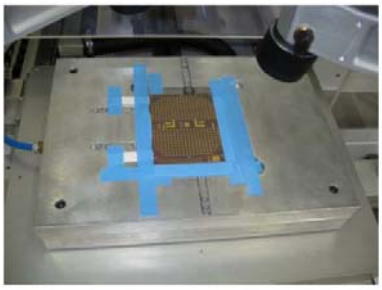


Figure 5-4 : Silver strips on the solar cells terminals

5.3.2 Soldering process

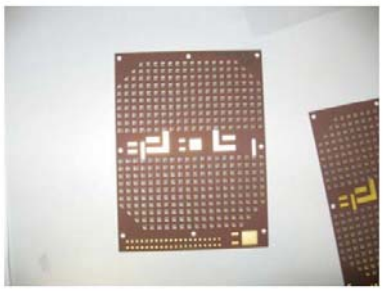
The Sn18PbBi50 solder paste is deposed by serigraphy on the footprints by using a grid with a mesh of 80 wires per inch (pictures 1-4). The footprint shape is performed with a light-sensitive resin layer. After this deposition, the solar cells must be placed very precisely by hand on the solder paste (picture 5). This is the critical operation of the process because it is not possible to modify the position of the solar cell when it has been put on the paste.

Picture 1

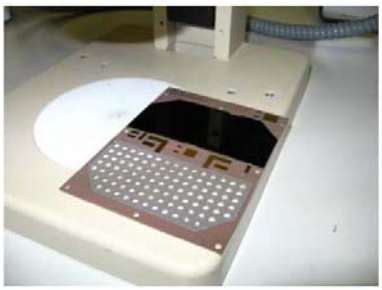


Picture 2

Picture 3

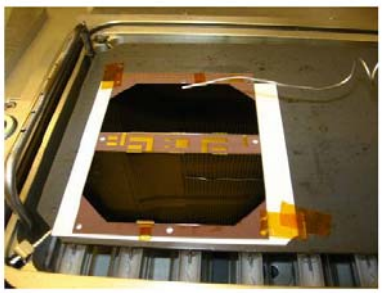


Picture 4

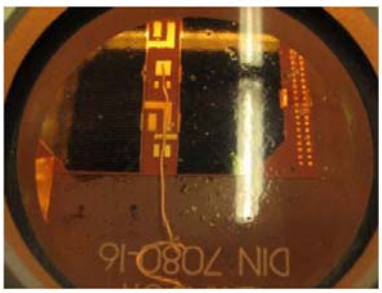


Picture 5

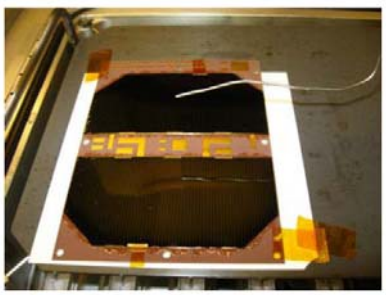
Picture 6



Picture 7



Picture 8



Picture 9

Figure 5-5 : Solar cells soldering process

Then the assembly is put inside an oven (picture 6). The temperature inside the oven must follow a defined profile, as it can be seen on Figure 5-3. This temperature is controlled and checked by two probes: the first is in the confine, and the second is a thermocouple on the surface of the PCB (the thermocouple can be seen on picture 7 and picture 9). After few seconds at the temperature of fusion, the vacuum is made to evacuate flux and air bubble (picture 8). Next, the confine is cooled by a flux of Nitrogen.

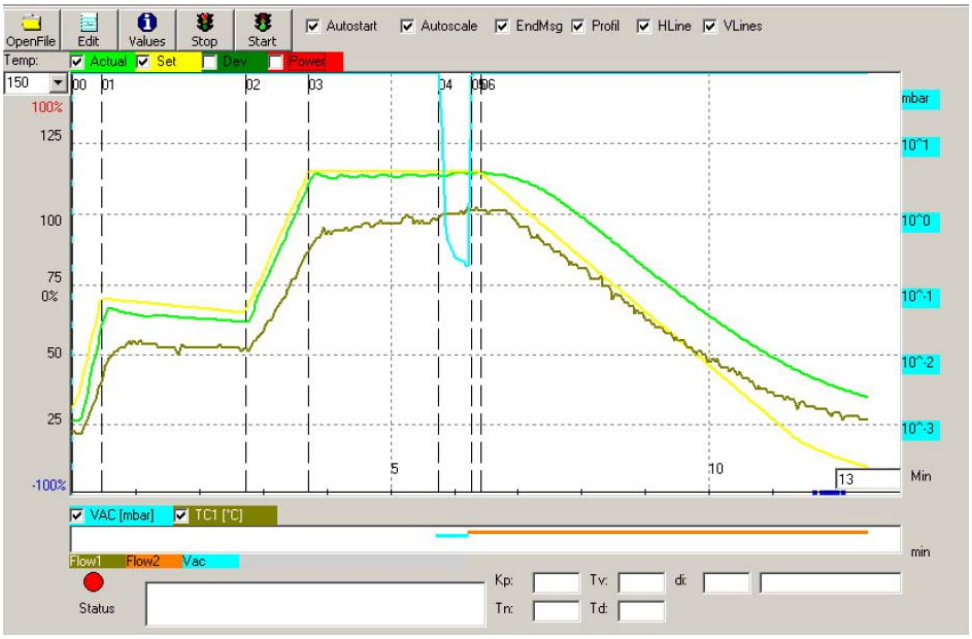


Figure 5-6 : Temperature profile for the solar cells soldering process

After baking, panels must be cleaned (due to projections of flux during the vacuum (picture 9)) in an ultrasonic bath of isopropyl alcohol and then dried with compress air.

5.3.3 Soldering examination

The soldering process has been tested and validated. A visual examination is sufficient.

5.3.4 Soldering facilities

The soldering process of the solar cells needs specific facilities (serigraphy process, oven with a vacuum system, etc.). These facilities are available at the "Laboratoire de Production Microtechnique" (EPFL - STI - LPM).

5.4 Connector soldering

Each face of SwissCube is connected to the satellite with a connector (see S3-C-1-2-Electrical ICD) as shown below:

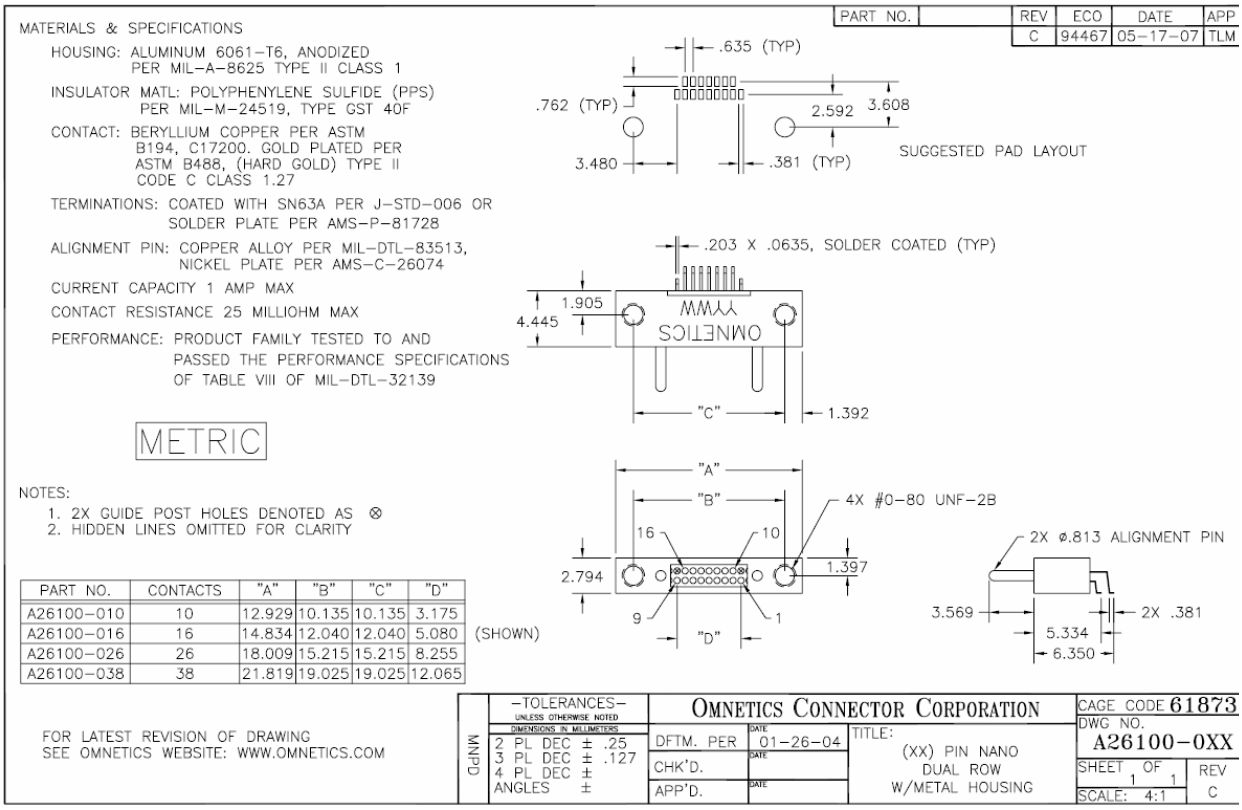


Figure 5-7 : SMD Connectors

This connector is soldered on the faces by hand with a very thin iron.

5.5 Sun Sensors wire bonding

There is one sun sensor on each face of the SwissCube. These sensors are welded on their footprints with gold wire bonds. Each pin of the sun sensor will be connected with 2 bonds in order to increase the reliability. This operation is not complicated and it is done at the LPM too.

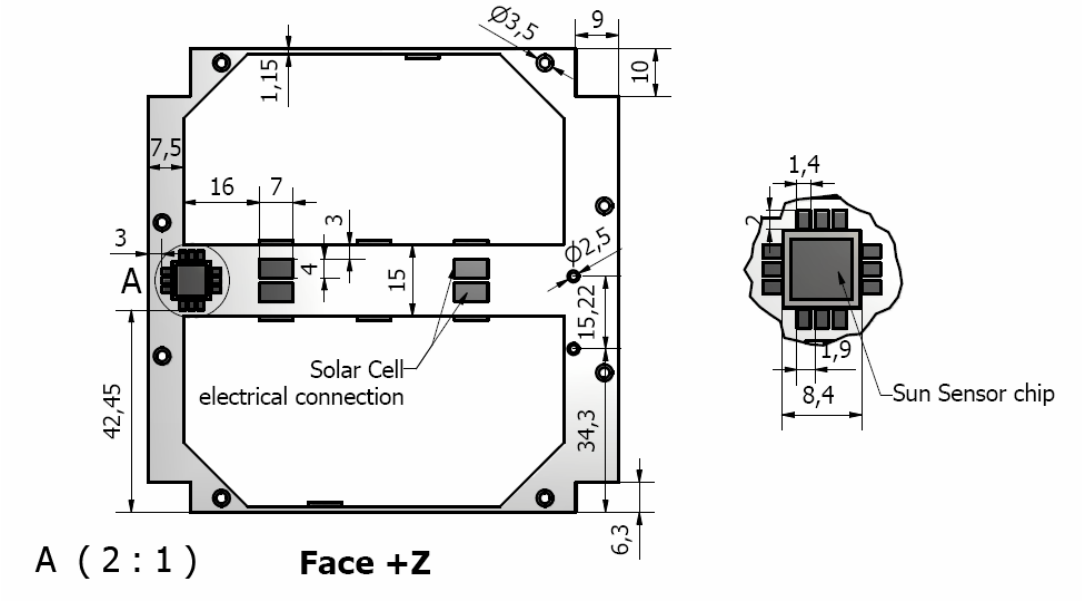


Figure 5-8 : Sun sensor footprint and location on the +Z Face

5.5.1 Facilities

The LPM laboratory has a manual wire bonder for the bonding of prototype devices and small series. The bonding technique used is "Au ball-wedge".

A picture of this facility is shown below.

Figure 5-9 : Manual wire bonder at LPM

5.5.2 Potting of the wire bonds

After bonding, the wire bonds are potted in a resin as shown below.

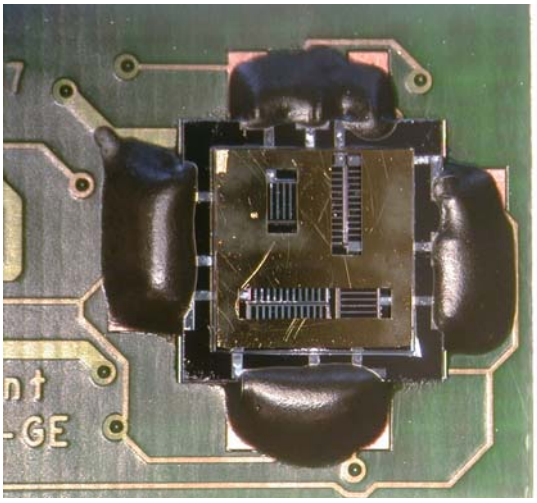


Figure 5-10 : Sun sensor wire bonds potted in the resin

The resin used for this application is the 3M Epoxy EC-2216.

5.6 Workforce

This work will need one electrical engineer of the team and will be supervised by a solder specialist of LPM (Nicolas Dumontier).

5.7 Schedule

Please refer to the general planning [R2].

5.8 Costs

The solar cells have been given for free by one of the SwissCube sponsors: EADS Astrium.

500 gr. of the solder paste Sn18PbBi50 costs approx. CHF 80.-

5.9 Contacts

André Badertscher
EPFL STI ACI
INM 020 (Bâtiment INM)
Station 14
CH-1015 Lausanne
Tel: [+41 21 69] 32653
andre.badertscher@epfl.ch

Jason Page
ESTEC
Principal Electronics Engineer
Tel: +31(0) 71 565 3826
Fax: +31(0) 71 565 3911
Jason.page@esa.int

Nicolas Dumontier
nicolas.dumontier@epfl.ch
bureau(x): BM0141
Tel: [+41 21 69] 37898

5.9.1 Contact for the solder paste for solar cells

MBO
François-Dominique LUTRAT
Directeur Technique Adjoint
Rue de la Fonderie
21800 CHEVIGNY-SAINT-SAUVEUR
Tel: 33 (0)3 80 46 12 58
Fax: 33 (0)3 80 46 66 59
www.mbosolder.com

6 BOARDS BURN-OUT AND TESTING

At the end of the soldering process each PCB will perform an electrical functional test in order to be sure that every components work correctly.

6.1 Test protocol

For each board a test protocol is defined. These protocols are indexed in this document:

- ***S3-C-1-0-Boards-BurnOut-Protocol*** (to be published)

6.2 Workforce

This work needs 2 electrical engineers of the team.

6.3 Schedule

Please refer to the general planning [R2].

6.4 Costs

No specific cost.

6.5 Contacts

No specific contact.

7 BAKEOUT

The Bakeout is an activity of increasing the temperature of hardware to accelerate its outgassing rates with the intent of reducing the content of molecular contaminants within the hardware. [N1]

The SwissCube electronics boards will be coated with a conformal coating in order to avoid the outgassing of the electronics plastic packages, FR-4 and solder mask. But before applying this conformal coating on the boards, they will be baked out a first time.

The highest bakeout temperature should be employed with a pressure less than 10-2Pa. The temperature used will be dictated by the sensitivity of the components present.

7.1 Materials

Bakeout should be applied for all materials that can be warmed, and more specifically to ([N1]):

- harness,
- MLI,
- carbon and glass fibre components,
- glued, coated or potted materials.

The PCBs of SwissCube are made of FR-4 (with glass fibre components) and they have a solder mask (coated materials).

7.2 Process description

During the bakeout process, the following relevant parameters shall be monitored:

- vacuum conditions (< 10-2 Pa),
- temperature (> 60 ºC),
- duration (> 72 h).

The temperature shall be linked to the outgassing material and the cleaning effect, but the lower the temperature (with given minimum of 60 ºC) the longer the duration [N1].

For the SwissCube electronics boards, it has been decided to use a bakeout duration of 24 h with a temperature of 70°C.

7.3 Facilities

This test will be performed in the vacuum chamber of Nyon (RUAG).

7.4 Schedule

Please refer to the general planning [R2].

7.5 Contacts

7.5.1 Contact for the vacuum chamber in Nyon

Didier Cerutti
Responsable spatial

RUAG Aerospace
ch. de la Vuarpillière 29
CH-1260 Nyon

Tel. +41 223 617 733
Fax +41 223 616 752
Mobile
Mailto:didier.cerutti@ruag.com
http://www.ruag.com

8 CONFORMAL COATING

Conformal coating is intended to provide electrical insulation and environmental protection to the PWA, eliminating or minimizing any performance degradation caused by humidity, handling, debris and/or contamination.

The conformal coating will be also used to avoid the outgassing of the solder mask and the components. A controlled volatility RTV silicone conformal coating CV-1152 has been selected (see Appendix D). This is a product of NUSIL Silicone Technology.

8.1 Applying method

Conformal coating is easy to apply by brushing with a small paintbrush. It is recommended to use a mask during applying even if this product is not toxic.

Layer thickness: approx. 100 um (both sides)

The Pictorial Reference of the Nasa workmanship standards [N5] will be used for the conformal coating applying control.

8.2 Schedule

Please refer to the general planning [R2].

8.3 Costs

Here is the price list from Nusil:

	100g	200g	0,47l (1pt)
CV-1144-0	263 €		949 €
CV-1144-2	258 €		1.411 €
CV-1145	250 €		904 €
CV-1146-2	375 €		1.356 €
CV-1152	242 €	397 €	866 €

200g of CV-1152 is enough for the EQM and the FMs.

8.4 Contacts

POLYTEC PT GMBH
Polymere Technologien

Stefanie Glatz
Assistant

POLYTEC PT GMBH
Polymere Technologien
Polytec-Platz 1-7
76337 Waldbronn
Germany

Phone: +49 7243 604-400
Fax: +49 7243 604-420
E-Mail: s.glatz@polytec-pt.de
Internet: www.polytec-pt.de

9 CABLES

9.1 Kapton wires (AWG 28)

9.1.1 Description

This first type of wire is used to connect the boards when no connector is needed. In order to simplify the design and integration, it has been decided to use the same AWG for all the power and data interfaces without connector (see Appendix E).

9.1.2 Wires preparation

9.1.2.1 Denuding

It is difficult to perform a very accurate denuding of the Kapton wires with a standard tool because Kapton is a very hard polymer. It is the reason why it has been decided to buy a specific tool. This tool has been recommended by RUAG for the preparation of Kapton wires. This tool was specially developed for thin cables. It features a four-blade system, which provides accurate and exactly repeated stripping of cables. It can be very easily and precisely adjust for each type of wire.

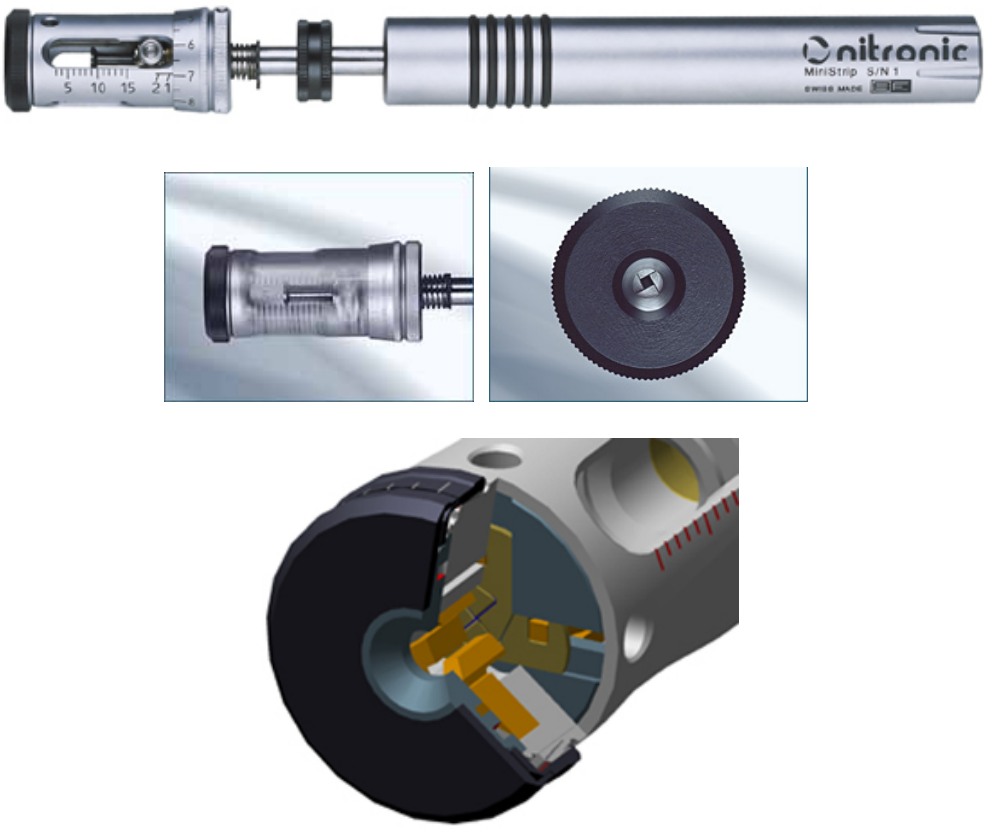


Figure 9-1 : Ministrip tool

Here are the features of this tool:

- Wire size range from 0.16 mm (0.006") to 1.5 mm (0.06") (15 – 34 AWG), depending on isolation-type down to 0.10 mm (0.004") 38 AWG
- Outer cable diameter max. 2.5 mm (0.1")
- Stripping length up to 15 mm (0.6")
- Four cutting blades on one plane
- Rotating cut
- No wire damage
- Fast and easy change of length and diameter settings
- Suitable for Teflon, PVC, Kynar and Kapton isolations

Here is the result with the Kapton wire used for SwissCube (AWG 28):

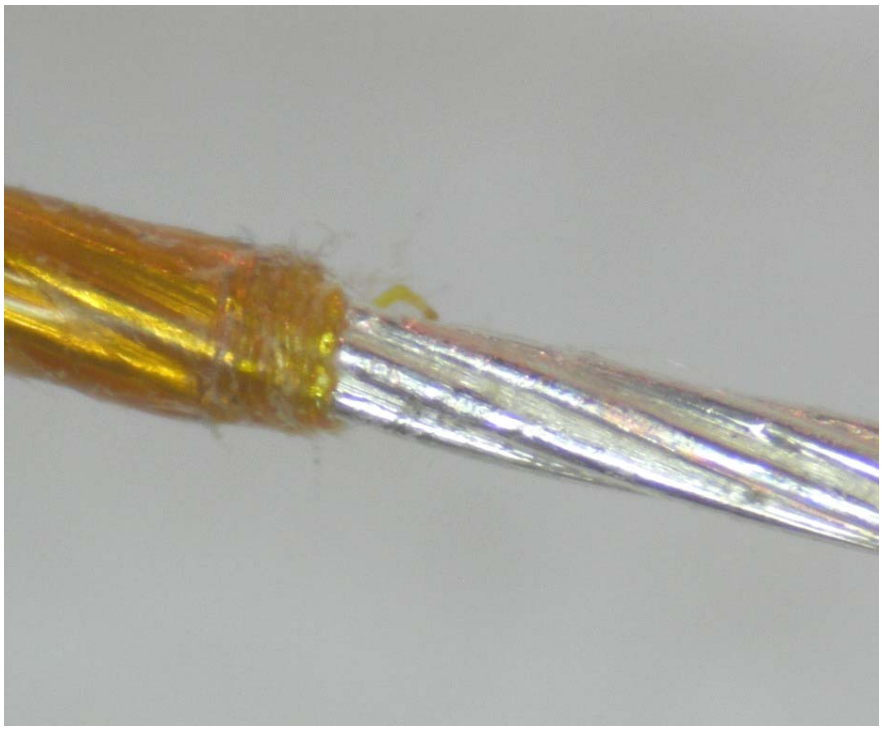


Figure 9-2 : Denuded Kapton wire (AWG 28)

Here are a few recommendations from the NASA workmanship pictorial reference [N5]:

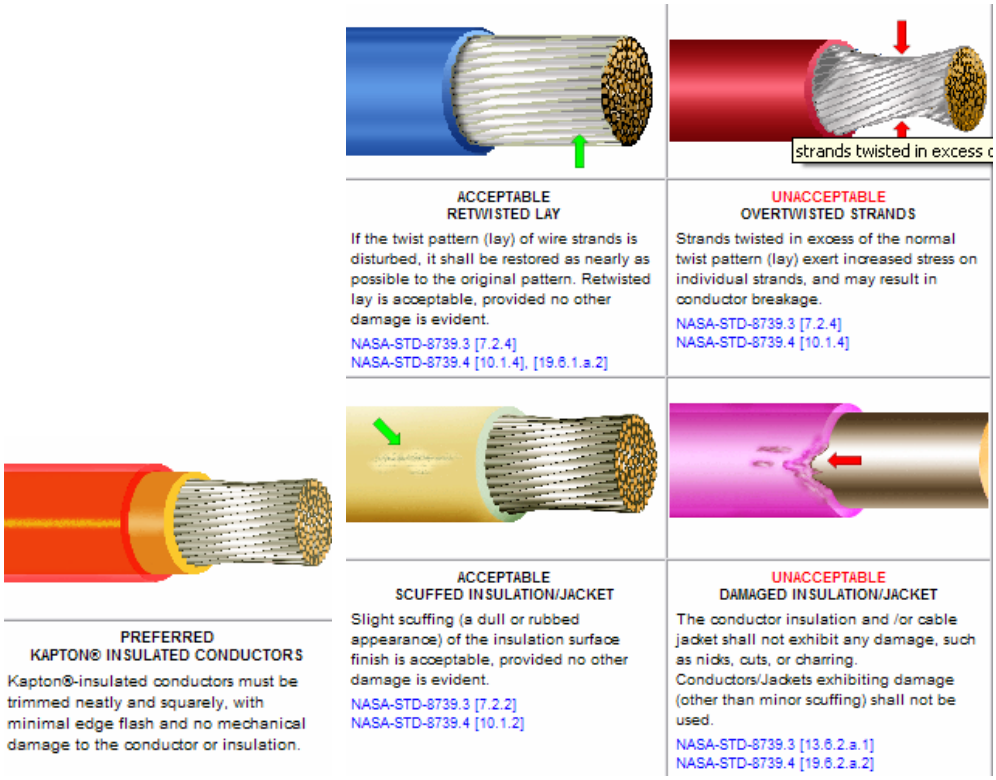


Figure 9-3 : Recommendations from the NASA workmanship pictorial reference [N5]

9.1.2.2 Tinning

It has been decided to use also the solder pots for the tinning of the wires.

9.2 PTFE wires (AWG 34)

9.2.1 Description

The second type of wire is used when the interfaces need a connector. In fact this PTFE wire is already welded to the connector by the manufacturer. The chosen connector (with its wires) is space qualified. Each connector has 26 **PTFE wires 34 AWG**, with a color code.

9.3 RF coaxial wires

9.3.1 Description

Every RF interfaces are performed with the same RF H.FL coaxial wire and connector (see Appendix G).

Figure 9-4 : H.FL connector

The connectors are retained on the PCBs with a specific mechanical piece.

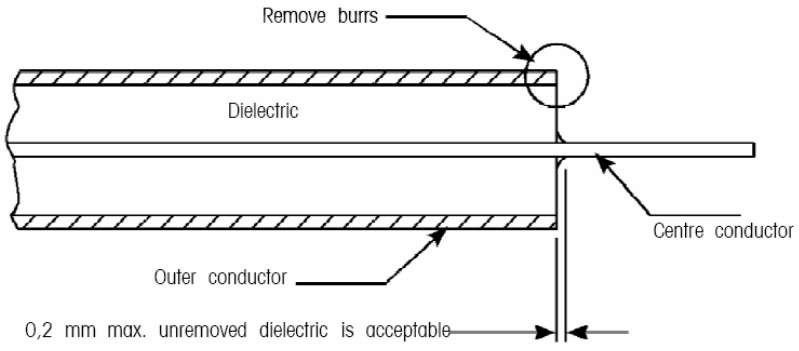
9.3.2 Wires preparation

9.3.2.1 Denuding and soldering

Denuding of the RF cable must be done very carefully as recommended in ECSS-Q-70-18A [N4]:

Inspection of stripped cable ends

Each of the stripped ends shall be subject to quality control inspection. There shall be no metal or foreign particles on the face of the dielectric. The outer conductor shall contain no burrs or major surface defects and shall be flush with the dielectric. Unremoved dielectric near the centre conductor not exceeding 0,2 mm is acceptable. The length of the wire inner conductor is dependent on the connector type and shall be specified.



And here are a few recommendations from the NASA workmanship pictorial reference [N5]:

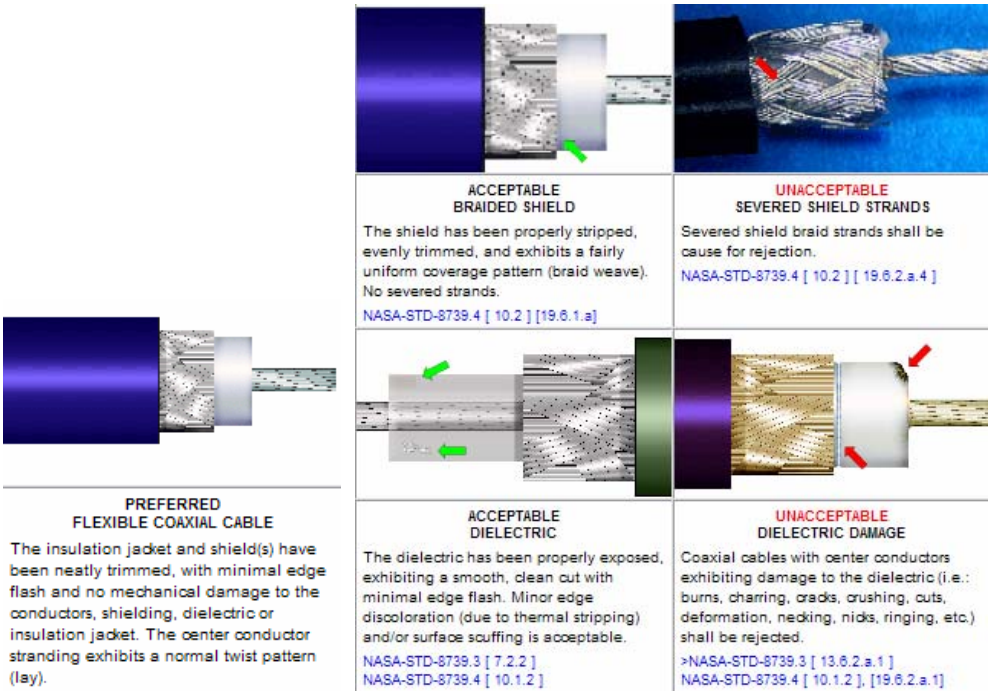


Figure 9-5 : Recommendations from the NASA workmanship pictorial reference [N5]

9.4 Cabling Plan

Detailed information about the cabling process can be found in the Cabling Plan [R3] (to be published).

10 BATTERY BOX INTEGRATION

10.1 Batteries

Two Lithium Ion Polymer batteries are used in the satellite. These batteries are manufactured by VARTA.

10.1.1 Type

Figure 10-1 : PLF 503759

10.1.2 Preparation

A PCM (protection circuit module) with two wires is already mounted on the batteries by the manufacturer. Theses two parts (PCM and wires) will be removed because the satellite has already its own PCM and the wires are replaced by space qualified wires.

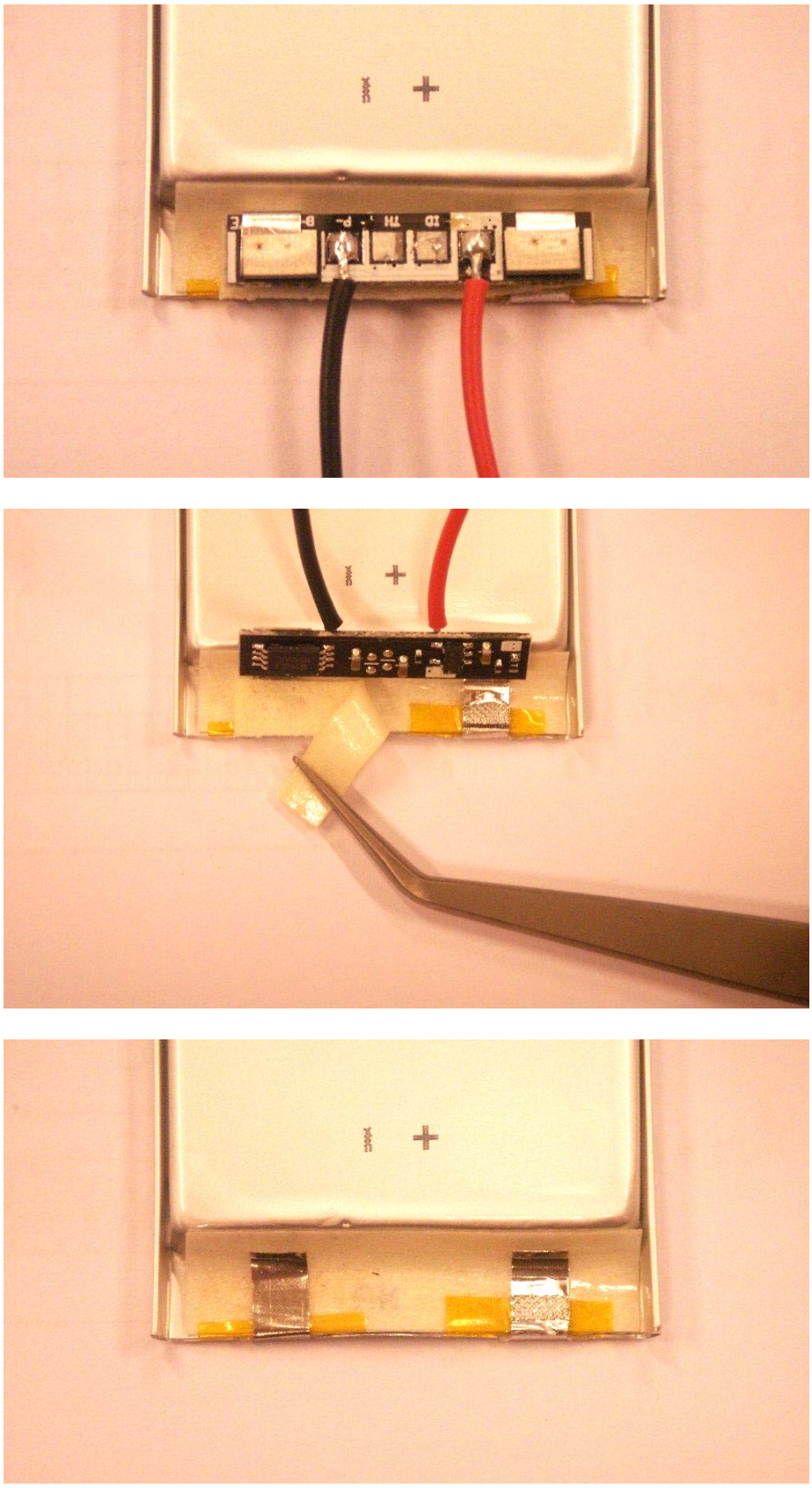
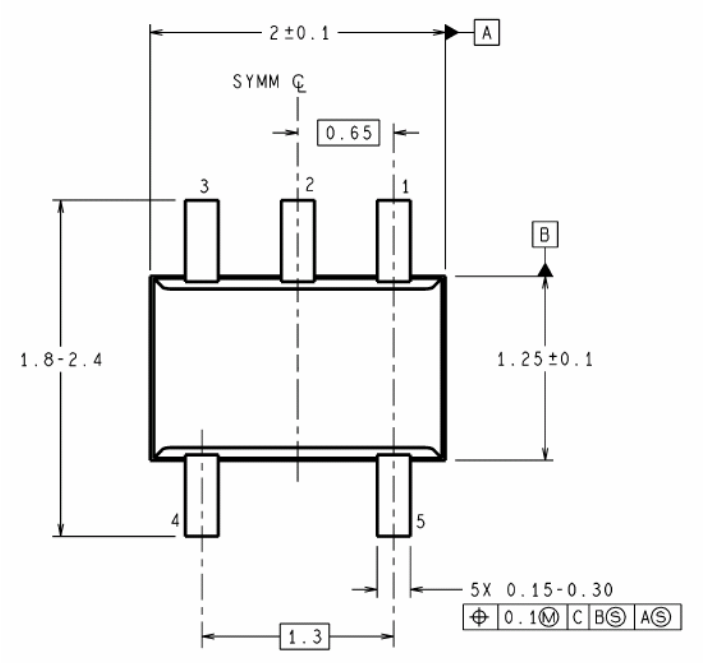


Figure 10-2 : PCM and wires are removed

10.1.3 Box Integration

The first step is soldering the AWG 28 Kapton wires on the terminals of the batteries and soldering the thermal sensor LM94022 on the two flexible PCB strips.



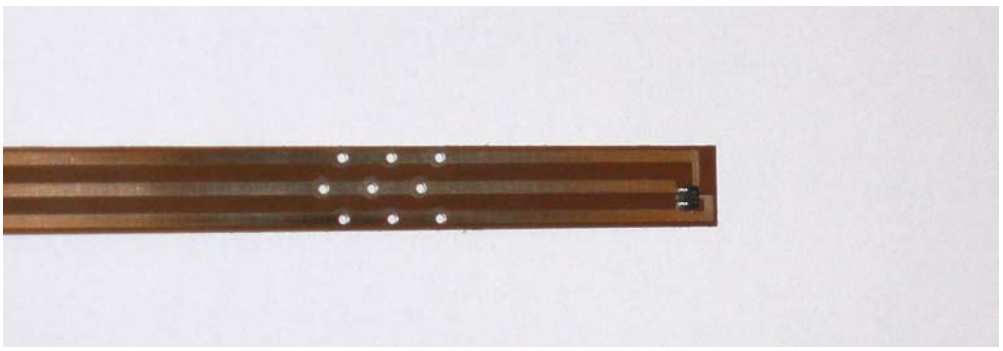


Figure 10-3 : One flexible PCB strip (substrate: Kapton) with the thermal sensor

The second step is soldering the heating resistor on the copper plate.

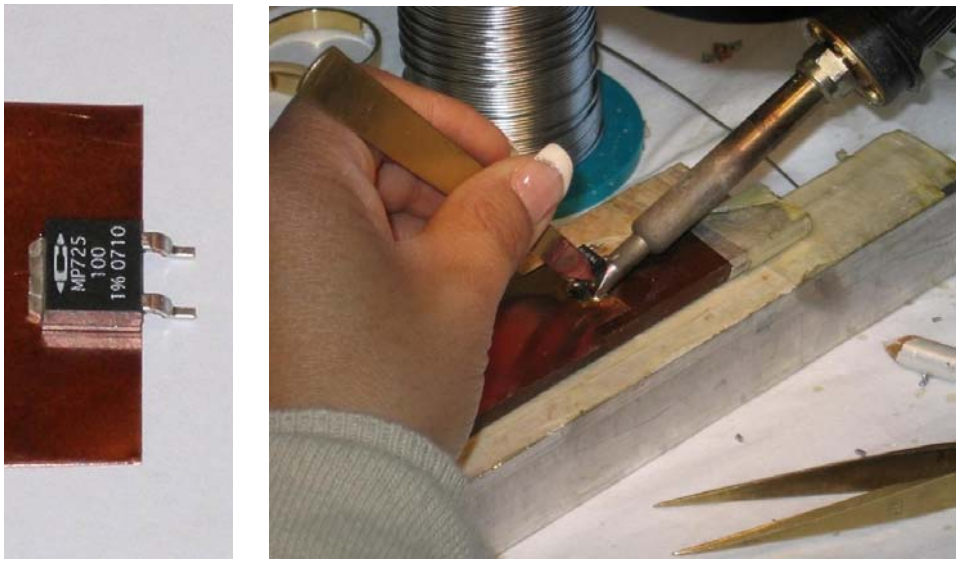


Figure 10-4 : Heating resistor of 100 Ohm

Then the two batteries are attached together with Kapton adhesive tape (with the copper plate between). And then they are introduced inside the aluminium box.

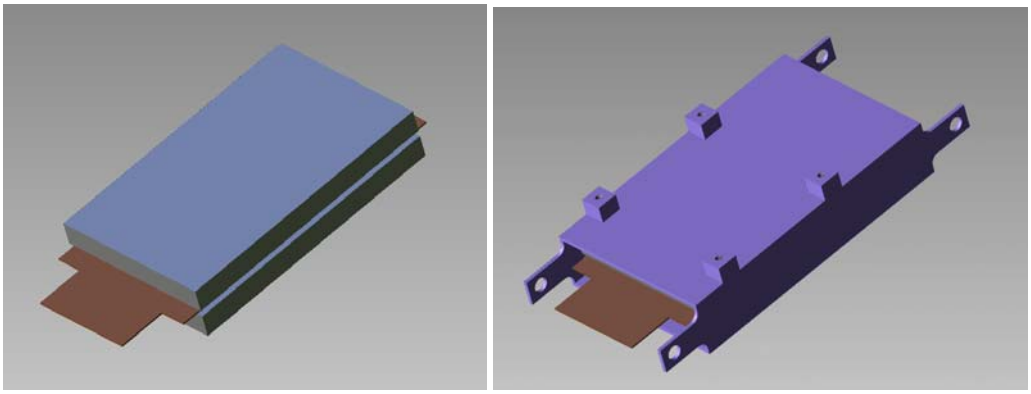


Figure 10-5 : Batteries introduced inside the box

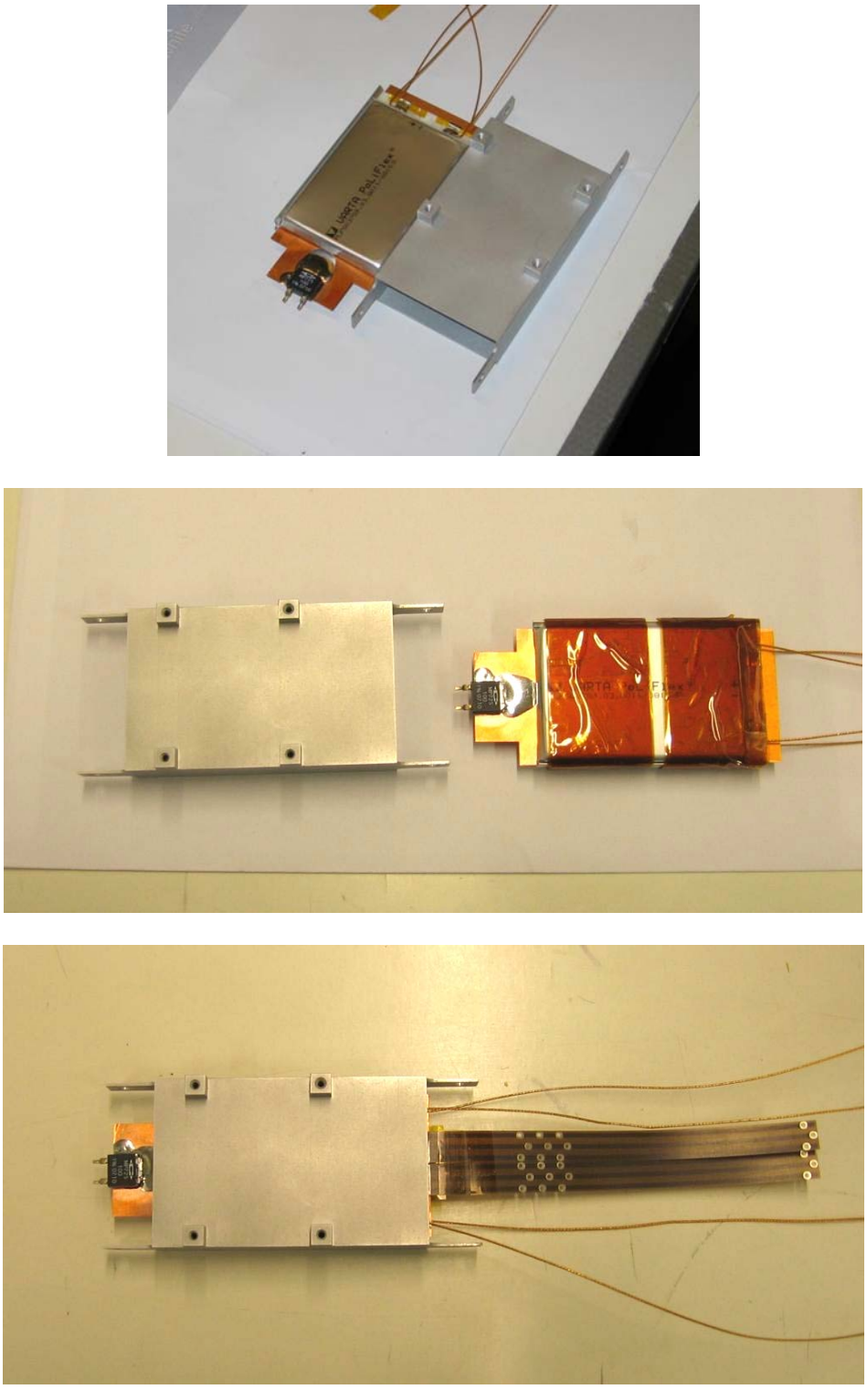


Figure 10-6 : Battery Box Integration

After that, the box is sealed on both sides with epoxy resin EC 2216. The thermal sensors are also attached on the copper plate with this epoxy seal. The thermal sensors are located at the opposite side of the heating resistor.

Then the battery board will be screwed on the aluminium box.

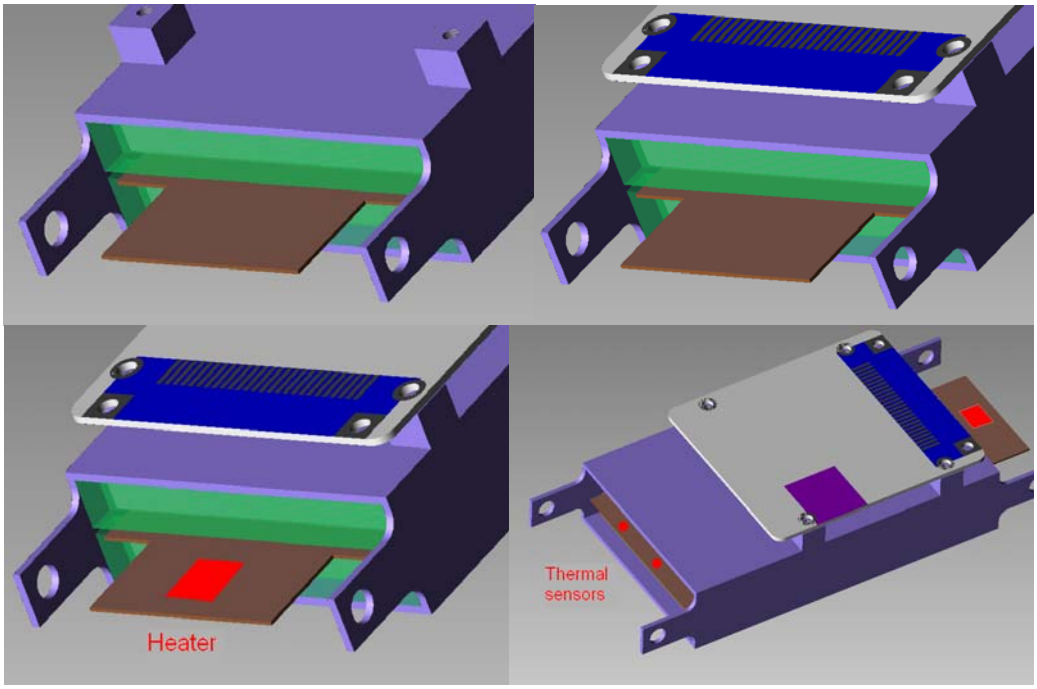


Figure 10-7 : Epoxy seal (in green) and battery board

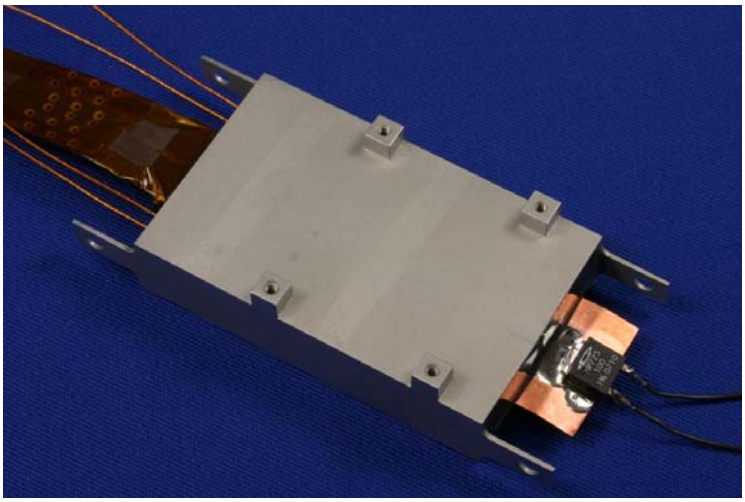


Figure 10-8 : Battery Box Integrated

Appendix A FRA-4 Specifications

Matsushita Electric Works Electronic Materials (Europe)
Specification Sheet

Specification sheet #:	IPC-4101A/92	
Reinforcement:	**1:** Woven E-Glass	**2:** N/A
Resin System:	**Primary:** Epoxy	
	Secondary 1: Multifunktional Epoxy	**Secondary2: N/A**
Flame retardant mechanism:	Phosphorous	**Minimum UL94 Requirerment:** V-1
Fillers:	N/A	
ID Reverence:	**UL/ANSI:** FR-4	**Mil-S-13949: N/A**
	ANSI: FR-4/92	
Glass transition (TG):	110 °C - 150 °C	

Product Name: UL-Designation	**Laminate:** R-1566 / R-1566W R-1566	**Prepreg:** R-1551 / R-1551W R-1551

1.Laminate		IPC Specification < 0,5 mm	IPC Specification > 0,5 mm	Units	Typical values < 0,50 mm	Typical values ≥0,5 mm	Test methode IPC-TM-650 (or as noted)
Physical property							
Peel strength, minimum A. Low profile and very low profile copper foil-all copper foil	18µm	0,7	0,7	N/mm	-	-	2.4.8
B. Standard profile copper foil	35µm	-	-		-	-	2.4.8.2
1. after thermal stress		0,8	1,05		1,5	1,6	2.4.8.3
2. at 125 °C		0,7	0,7		1,4	1,5	
3. after process solutions		0,55	0,8		1,5	1,6	
Moisture Absorptions, maximum		-	0,8	%	-	0,11	2.6.2.1
Flexural strength, minimum	A. Length direction	-	415	N/mm²	-	595	2.4.4
	B. Cross direction	-	345			412	
Flammability (laminate and prepreg as laminated)		V1 min.	V1 min.	rating	V0	V0	UL 94
CTE (pre/post Tg)		-	-	ppm/°C	-	-	2.4.24
Z		-	-		-	40/180	
X		-	-		-	13	
Y		-	-		-	15	
Young´s modulus X / Y		-	-	GPa	-	N/A	2.4.18.3
Poisson´s ratio X / Y		-	-	-	-	N/A	ASTM
Density		-	-	g/cm³	2,0	2,0	
Decomposition Temperature		-	-	°C	-	330	TGA
Electrical property							
Volume resistivity, minimum	A. 96/35/90	10^8	-	MΩ-cm	$5*10^7$	-	2.5.17.1
	B. after moisture resistance	-	10^6		-	N/A	
	C. at elevated temp. E-24/125	10^3	10^3		N/A	N/A	
Surface resistivity, minimum	A. 96/35/90	10^4	-	MΩ	$5*10^8$	-	2.5.17.1
	B. after moisture resistance	-	10^4		-	N/A	
	C. at elevated temp. E-24/125	10^3	10^3		N/A	N/A	
Dielectric breakdown, minimum		-	40	kV	-	> 50	2.5.6
Permitivity, maximum (laminate and prepreg as laminated)	at 1 MHz	5,4	5,4	-	N/A	4,95	2.5.5.2/3/9
	at 1 GHz	-	-	-	N/A	4,7	
Loss tangent, maximum (laminate and prepreg as laminated)	at 1 MHz	0,035	0,035	-	0,014	0,014	2.5.5.2/3/9
	at 1 GHz	-	-	-	0,011	0,011	
Arc resistance, minimum		60	60	sec	NI	NI	2.5.1
Electrical strength, minimum (laminate and prepreg as laminated)		30	-	kV/mm	49	-	2.5.6.2
CTI (comparative tracking index)		-	-	V	-	500	IEC 112
Thermal Property							
Thermal stress 10 sec at 288 °C, minimum	A. unetched	Pass	Pass	Rating	Pass	Pass	2.4.13.1
	B. etched	Pass	Pass		Pass	Pass	
Tg by DSC (TMA / DMA)		110 min	110 min	°C	152,7	153(145/180)	2.4.25
Thermal conductivity		-	-	W/mK	-	0,62	Laser flash
Specific heat		-	-	J/kgK	-	950	DSC

2. Prepreg Property		IPC-Specifikation		Units	Typical values		
Shelf life, minimum (from date of delivery)	A. condition <20 °C and <50 % rel. H.	90		Days	60		AABUS
	B. condition < 5 °C	180			180		
Volatile content, maximum		0,75		%	meets requirements		2.3.19
Prepreg parameters		-	-	-	AABUS		AABUS

AABUS = As Agreed Between User and Suppier

Note:

Test data contained in this data sheet represents typical values and does not constitute any warrenty or guarantee. For review of critical specification tolerances, please contact a Matsushita Electric Works representative. Matsushita Electric Works reserve the right to change these typical values as a natural process of refering our test equipment and technics.

Appendix B Solder Mask Specifications

TAIYO TECHNO RESEARCH COMPANY **PSR-4000 GEC50 / CA-40 G50**

Technical Datasheet

MS00158800
MS00159000
2000/12

Taiyo Ink Mfg. Co., Ltd.
2-7-1, Hazawa, Nerima-ku, Tokyo
176-8508 JAPAN
Phone: +81-3-5999-1411
FAX : +81-3-5999-1422

Photoimageable Solder Mask Ink

PSR-4000 GEC50/CA-40 G50

UL Suffix: PSR-4000CB2/CA-40DE

Halogen Free

1. Features

PSR-4000 GEC50/CA-40 G50 is a two-component, alkaline developable photoimageable solder mask ink for screen printing application with the following features:

*Halogen free and low mist emission in post-cure process.

*High photospeed

*Excellent resistance to gold plating and water soluble flux.

2. General specifications

Color	*	Green
Mixing ratio	*	Main agent: 70 % / Hardener: 30 % (by weight)
Viscosity	*	165 dPa-s (cone/plate viscometer, 5 min^{-1}/25°C)
Non volatile content	*	78 wt %
Specific gravity	*	1.4
Tack dry window	*	80 °C, 60 minutes maximum
Standard exposure energy	*	200 to 400 mJ/cm^2 (Under Mylar film) 140 to 280 mJ/cm^2 (on ink)
Pot life	*	24 hours, stored in dark place with the temperature less than 25 °C.
Shelf life		6 months after production date, stored in dark place with the temperature less than 20 °C.

Note: The asterisk (*) denotes the characteristics after the mixture of the hardener

Technical Datasheet

MS00158800
MS00159000
PSR-4000 GEC50
/CA-40 G50

3. Process

			Control Range
Board:	FR-4, 1.6 mm thick		
Pretreatment:	Acid cleaning – Buff scrubbing		
Printing:	100 mesh polyester screen		100 to 125 mesh
Hold time:	10 minutes		10 to 20 minutes
Tack dry (pre-cure):	Hot air convection oven.		
	For printing on both sides:		
	Side 1: 80 °C, 15 minutes		80 °C, 10 to 25 minutes
	Side 2: 80 °C, 25 minutes		80 °C, 20 to 35 minutes
	For single side printing:		
	80 °C, 30 minutes		80 °C, 20 to 60 minutes
Exposure:	7 kW metal halide lamp (HMW-680, ORC Manufacturing Co., Ltd.)		
	300 mJ/cm^2 under Mylar film (210 mJ/cm^2 on resist ink)		200 to 400 mJ/cm^2
			140 to 280 mJ/cm^2
Hold Time:	10 minutes		10 to 20 minutes
Development:	Developer:	1 wt % Na_2CO_3	
	Temperature:	30 °C	
	Spray pressure:	0.2 MPa	0.2 to 0.25 MPa
	Time:	60 seconds	60 to 100 seconds
Water rinse:	Temperature:	25 °C	30 °C maximum
	Spray pressure:	0.1 MPa	0.1 to 0.15 MPa
	Time:	45 seconds	45 to 60 seconds
Thermal cure (Post-cure):	Hot air convection oven 150 °C, 60 minutes		

Remark:

- If the nomenclature printing is to be conducted, the solder mask should be cured for 30 minutes at 150 °C, and then the nomenclature ink should be cured at 140 °C, 20 minutes, 2 cycles.
- If the nomenclature printing is not conducted, the solder mask should be cured for 60 minutes at 150 °C.

TAIYO TECHNO RESEARCH COMPANY **PSR-4000 GEC50 / CA-40 G50**

Technical Datasheet

MS00158800
MS00159000
PSR-4000 GEC50
/CA-40 G50

(3) End Properties

Test Item	Test Condition	Results
Adhesion	Crosscut test by JIS D0202	100/100
Pencil hardness	By JIS K5400 (No scratch on the copper surface)	7H
Solder resistance	Rosin flux, 260°C, 30 seconds, 1 cycle, solder float test	Pass
	Water soluble flux (Solbond K183), 260°C, 30 seconds, 1 cycle, solder float test	Pass
Solvent resistance	Tape peel test after immersion in PGM-AC, 20 °C, 20 minutes	Pass
Chemical resistance (Acid)	Tape peel test after immersion in 10 vol % H_2SO_4, 20 °C, 20 minutes	Pass
Chemical resistance (Alkaline)	Tape peel test after immersion in 10 wt % NaOH, 20 °C, 20 minutes	Pass
Insulation resistance	Pattern B of IPC comb pattern. Measured a value of 1 minute under DC 500 V, at room temperature, after the humidity cycling of 25 to 65 °C cycles, 90 %RH, DC 100 V bias, 7 days	Initial: $2.0 \times 10^{13}\ \Omega$ After humidity cycles: $4.7 \times 10^{11}\ \Omega$
Dielectric constant	By JIS C6481, measured at 1 MHz, at room temperature, after the humidity cycling of 25 to 65 °C cycles, 90 %RH, 7 days	Initial: 4.2 After humidity cycles: 4.8
Dissipation factor	By JIS C6481, measured at 1 MHz, at room temperature, after the humidity cycling of 25 to 65 °C cycles, 90 %RH, 7 days	Initial: 0.025 After humidity cycles: 0.032
Electrolytic Gold plating	Internal test Ni 5 µm, Au 1 µm	Pass
Immersion Gold	Internal test Ni 3 µm, Au 0.03 µm	Pass
Total Halogen amount	Measured value. Based on the values submitted from the manufacturer of raw material	Less than 300ppm

Remarks:

- The above values of ink characteristic are typical data when tested according to the process conditions stated above and the each test condition stated in the above table. The contents of this technical datasheet are based on the results of our extensive experiments. However, we do not guarantee that its contents are correct or reproducible. We recommend the users to verify the required characteristics before the usage.

Appendix C Solder Pots specifications

Plato Precision Solder Pots
SP-500T, SP-150T, SP-600T & SP-750T

EXCEEDS ANSI (J-STD-001B)
PRECISION TEMPERATURE CONTROLLED ± 5ºF (±2.75ºC)

Plato's Solder Pots exceed the requirements of military specifications ANSI (J-STD-001B) and Navy WS-6536E. The pots control temperatures to ± 5°F (± 2.75°C) of a preselected setting from ambient to 925°F (496°C) and have an LCD temperature display.

Standard features include:
- A new solid state controller that limits transient voltage spiking to 2mV peak-to-peak, or less, for voltage sensitive components.
- A temperature preset switch to select the desired temperature.
- AN LCD that displays present temperature and operating temperature.
- Internal circuitry to compensate for incoming power fluctuations, power line circuit breaker.
  All metal construction for ESD protection.
- Safety heat shield.
- Removable dross tray for easy cleaning.
- Three-wire, grounded UL listed cord.

SP-500T and SP-150T Additional Features:
- 2.5" (64mm) diameter by 1.5" (38mm) deep crucible.
- Adjustable leveling feet.
- Capacity: 2.0 lbs. (1 kg).
- Shipping Weight: 12 lbs. (5.4 kg).

SP-600T and SP-750T Additional Features:
- Large capacity crucible, 4" (102mm) by 6" (152mm) by 4" (102mm) deep.
- Adjustable leveling feet.
- Safety warm-up crucible cover.
- An output jack for external temperature

SP-500T & SP-150T

SP-600T & SP-750T

Appendix D Conformal Coating Specification

CV-1152

Controlled Volatility RTV Silicone Conformal Coating

Product Profile

NuSil SILICONE TECHNOLOGY
Creative Partners in a Material World

NuSil Technology
1050 Cindy Lane • Carpinteria, CA 93013
805/684-8780 • 805/566-9905 Fax
www.nusil.com

An ISO 9001 Certified Company

Description

- One-Part, flowable, solvent free silicone
- Based on a dimethyl diphenyl silicone polymer with a broad temperature range

Applications

- For industrial or space applications requiring low outgassing and minimal volatile condensables under extreme operating conditions
- As a conformal coating on rigid and flexible circuit boards
- For encapsulating sensitive electronic components such as connectors and switches
- To provide protection against harsh environments while maintaining good dielectric properties

Typical Properties	Result	Metric Conv.	ASTM	NT-TM
Uncured:				
Chemical Classification	PMQ	-	-	-
Color	Clear	-	-	-
Viscosity	7,300 cP	7,300 mPas	D-1084, D-2196	001
Cure Time, 50% R.H. @ 25°C				
Tack Free	1 hour	-	C-679	005
Set Up	24 hours	-	-	-
Cure System	Oxime	-	-	-
Full Cure	7 days	-	-	075
Cured: 7 days @ 25°C (77°F), 50% R.H.				
Appearance	Clear, elastomer	-	D-2090	002
Specific Gravity @ 25°C (77°F)	1.01	-	D-792	003
Refractive Index	1.43	-	D-1747, D-1218	018
Dielectric Strength	500 volts/mil	19.7 kV/mm	D-149	-
Volume Resistivity	1×10^{15}	-	D-257	040
Collected Volatile Condensable Material (CVCM)	0.03%	-	E 595	072
Total Mass Loss (TML)	0.27%	-	E 595	072
Operating Temperature Range	-178°F to 500°F	-115°C to 260°C	-	-

Instructions for Use

Thoroughly mix for 5 minutes prior to every use, as the product separates. Apply by spraying, dipping or brushing. Thin with VM&P Naphtha to the appropriate viscosity for spray equipment. Mix with a moisture free solvent in a closed container, preferably with a commercial paint shaker.

Substrate Considerations
Although generally considered to be non-corrosive to most substrates, the oxime cure system may cause discoloration in the presence of copper or copper alloys.

Note: Some bonding applications may require the use of a primer. NuSil Technology SP-120 silicone primer is recommended.

Packaging

100 Gram
200 Gram
1 Pint

Warranty

6 months

CV-1152 06 February 2004

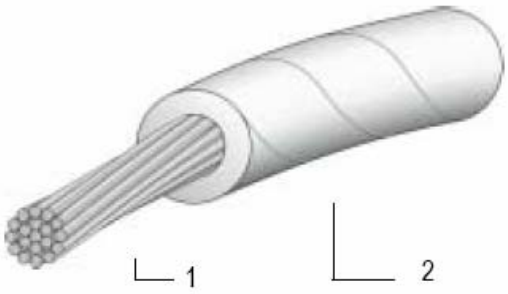
Appendix E Kapton wire

axon' CABLE & INTERCONNECTIQUE

Fils simples

TYPE FHT xxxx TF Ag ou Cu Ag

-50°C / +200°C
POLYIMIDE RUBANE
CABLES SANS HALOGENE / FDN
250 Volts AC.



COMPOSITION

Fil primaire

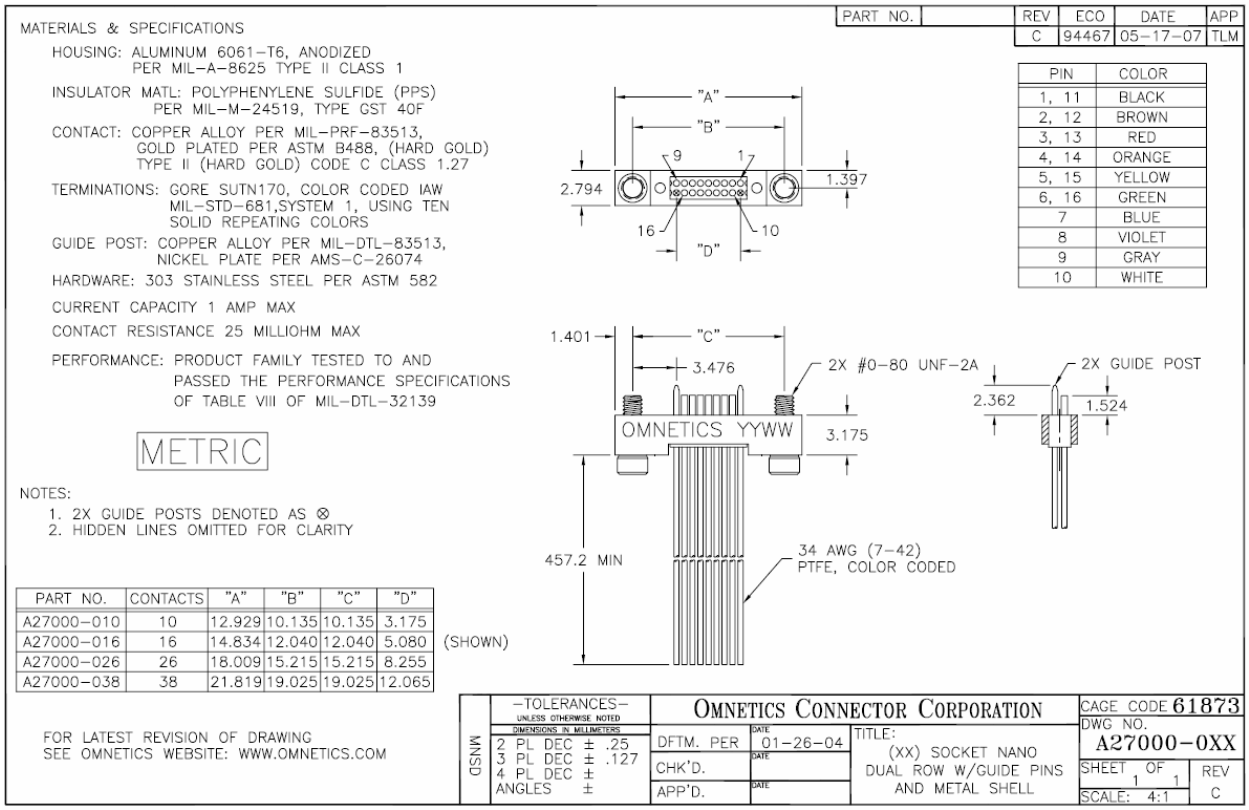
1 - Ame : cuivre électrolytique argenté recuit ou alliage de cuivre argenté.
2 - Isolant : polyimide rubané et soudé.

CARACTERISTIQUES PRINCIPALES

- Gamme de température : - 50°C à + 200°C.
- Tension de service : 250 V AC / 350 V DC.
- Couleur naturelle de la matière. Autres couleurs sur demande.

REFERENCE AXON'	AWG	COMPOSITION	∅ NOMINAL AME (mm)	SECTION NOMINALE AME (mm²)	RESISTANCE NOMINALE FIL ISOLE (Ω / 100m)	∅ NOMINAL FIL ISOLE (mm)	MASSE APPROX. (g/m)
FHT 3007TF	30	7 x 0,102	0,304	0,057	37	0,53	0,76
FHT 3001TF	30	1 x 0,254	0,254	0,051	39	0,48	0,69
FHT 2807TF	28	7 x 0,127	0,381	0,089	23	0,61	1,11
FHT 2801TF	28	1 x 0,320	0,320	0,080	26	0,55	1,00
FHT 2619	26	19 x 0,102	0,504	0,16	12	0,74	1,79
FHT 2601	26	1 x 0,404	0,404	0,13	13	0,63	1,49
FHT 2419	24	19 x 0,127	0,634	0,24	7,6	0,86	2,65
FHT 2401	24	1 x 0,511	0,511	0,20	8,4	0,74	2,26
FHT 2219	22	19 x 0,160	0,800	0,38	4,7	1,03	4,73
FHT 2201	22	1 x 0,643	0,643	0,32	5,3	0,87	3,41
FHT 2019	20	19 x 0,203	1,009	0,616	3,2	1,24	6,26
FHT 2001	20	1 x 0,812	0,812	0,52	3,3	1,04	5,30
FHT 1819	18	19 x 0,254	1,269	0,96	2,1	1,50	9,63
FHT 1619	16	19 x 0,300	1,500	1,34	1,4	1,73	12,30

Appendix F A27000-026 Connector with PTFE wires



Appendix G RF coaxial wire and connector

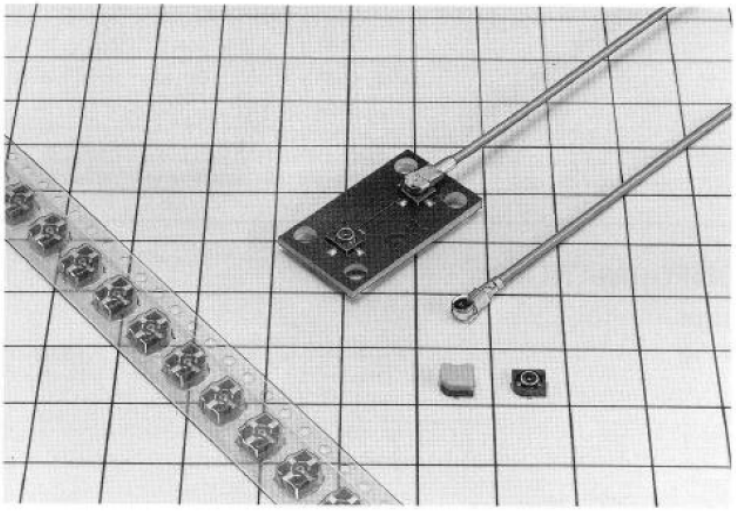
HRS H.FL Series

The world's smallest low-profile coaxial connectors
H.FL Coaxial Connectors

■ OUTLINE

The H.FL series of coaxial connectors consists of the world's smallest surface-mount low profile coaxial connectors.

The H.FL connectors have a lower profile, with a mounted height of approximately 30% that of our S.FL2 connectors. They occupy 20% less board space, allowing higher density internal wiring.



■ FEATURES

(1) Height off printed circuit board of 3mm when connected (lowest in the world).
(2) High frequency response of V.S.W.R 1.3 or less from D.C. to 3000 MHz.
(3) Compressed wire system used on the cable side connector for both the center and exterior, providing stable connection quality. For the external conductor compression part, the shielded wire is compressed between metal, providing stability with respect to fluctuations in heat.
(4) The ultra-fine Teflon cable can be used for wiring connections and this enables high-density wiring inside of the unit.
1.48 mm diameter (single shield) cable :
CO-6F/FH-SB manufactured by Hitachi Cable Ltd. DFS111-UL1979 manufactured by Junkosha Co., Ltd. and 0.8DS-PBE manufactured by Sumitomo Electric Industry Co., Ltd.
1.32 mm diameter (double shield) cable :
A12B0733 manufactured by Junkosha Co., Ltd.
1.47 mm diameter (single shield) cable :
CXN2571 manufactured by W.L. Gore+Associates, Inc.
(5) The connector can be easily removed with an extraction jig.
(6) Emboss taping makes automatic mounting possible.
In addition, connectors with caps are available for use with all types of mounters.
(7) Connection can be easily verified.
Despite the ultra small size, a locking feeling is provided making it possible to check that the connector is securely connected.
(8) The connectors are designed to protect against mis-insertion.
(9) A cut is provided on the circuit board side connector, making it simple to check the direction after mounting.
(10) A plug connector (H.FL-LP 1.25C) for use with 75Ω cable has been added to the Series.
The board-side connector is used jointly with H.FL-R-SMT.
The high frequency characteristics show a V.S.W.R. of 1.2 or less from DC to 500 MHz.
Suitable cable is 1.25C-6FFH manufactured by Hitachi Cable Ltd.

■ APPLICATIONS

Portable telephones, cellular telephones, wireless communications devices, electronic measuring equipment, GPS, etc.

1

■ MATERIALS and TREATMENT

Part name	Material	Treatment
Shell	Phosphor bronze	Silver plating
Insulator	PBT plastic (plug side) Liquid crystal polymer (receptacle side)	Black Black
Male center contact	Bronze	Gold plating
Female center contact	Phosphor bronze	Gold plating

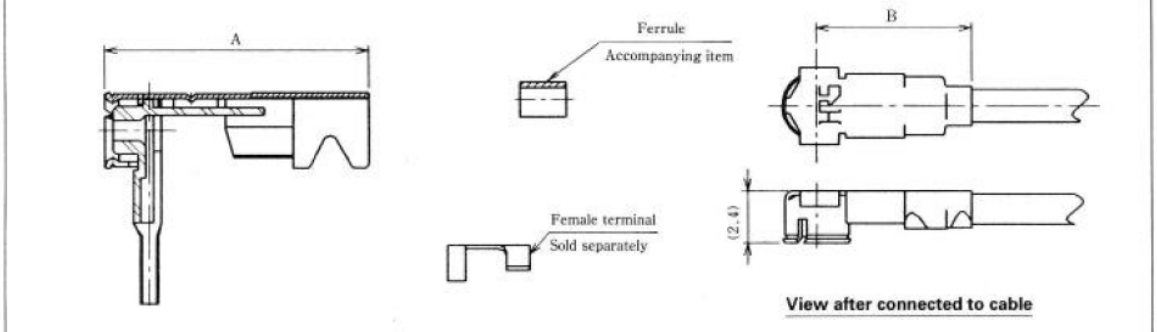
■ PERFORMANCE

Item	Rated value
Characteristic impedance	50Ω
Insulation resistance	500MΩ or greater at DC 250V
Contact resistance	20mΩ (center), 10mΩ (exterior) at DC 10mA
Dielectric strength	AC 300V (r.m.s), 1 minute
Contact service life	50 times
Voltage standing wave ratio	1.3 or less, DC to 3,000MHz (target value)

■ PRODUCT INFORMATION

▲ L-shaped plugs

Item	HRS No.	Model No.	Sales Quantities	Applicable cable	A length	B length
Right-angle plug shell	CL331-0503-4-01	H.FL-LP-DFS111 (01)	Sold by the package (100 pieces per pack)	Hitachi CO-6F and FH-SB Junkosha DFS111-UL1979 Sumitomo 0.8DS-PBE	10.4	(6.95)
	CL331-0504-7-01	H.FL-LP-A32 (01)	Sold by the package (100 pieces per pack)	Junkosha A12B0733	10.8	(7.35)
	CL331-0506	H.FL-LP-1.25C (01)	Sold by the package (100 pieces per pack)	Hitachi 1.25C-6FFH	10.4	(6.95)
Female contacts	CL331-0511-2	H.FL-LP Female contacts	Sold by the reel (10,000 contacts per reel)	The same as above		

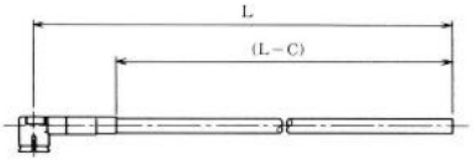


NOTE 1 : Sales quantities of the H.FL-LP-DFS111 (01), H.FL-LP-A32 (01) are in units of 1 package (containing 100 pieces).
Also note that the H.FL-LP female contacts are sold in units of 1 reel (containing 10,000 pieces).
NOTE 2 : The female contacts are sold as separate items.

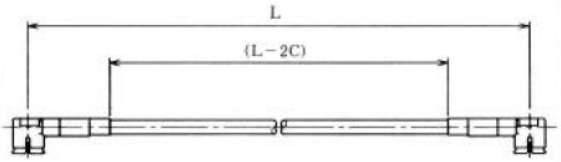
Harness Items

The dimension specifications of the harness items of the H.FL Series should be made as indicated below.

Single-end harness



Double-end harness



Please specify the dimensions from the connector center for both the double-end and single-end types.
The standard tolerances are as follows :

Total length	Tolerance (mm)
35 ~ 200	±4
201 ~ 500	±8
501 ~ 1000	±12
1001 ~	±1.5%

NOTE : The shortest length is 35 mm.

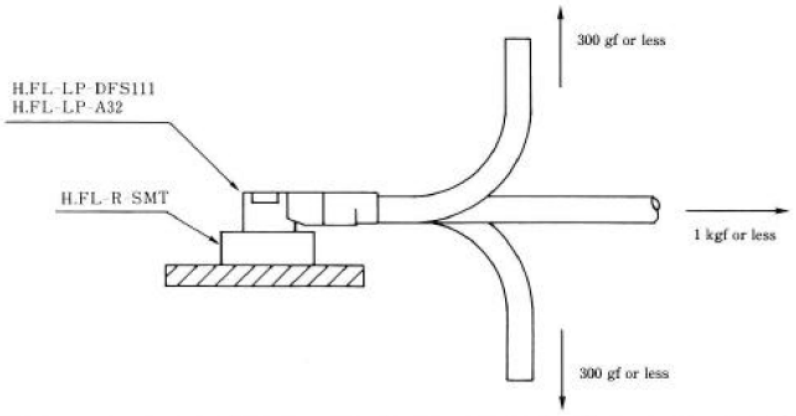
C Dimension

H.FL-LP-DFS111 : 6.95
H.FL-LP-A32 : 7.35

Usage Precautions

Plugs

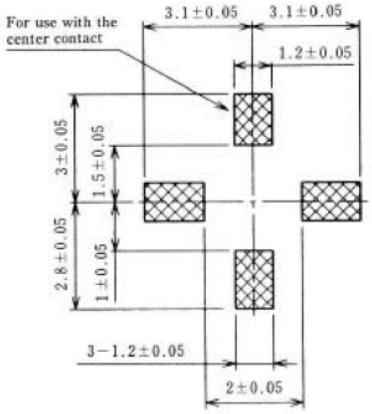
- **Disconnection and Connection of Connectors**
  a. The disconnection and connection of the connectors is accomplished by hooking the end portion of the S.FL-LP-N or H.FL-LP-N onto the connector hook portion, aligning with the connector coupling axis, and pulling it off perpendicularly, or, holding the connector body, aligning with the connector coupling axis and pulling it off.
  Holding the cable to pull off the connector should never be attempted since doing so will damage the connector.
  b. To join connectors, the coupling axes of both connectors are aligned and inserted as perpendicular as possible.
  Do not attempt an insertion on an extreme angle.
- **Permissible Load On the Cable After Connector Coupling**
  The permissible load on the cable after connector coupling is indicated in the diagram below.
  A load in excess of this value should not be applied to the cable.



5

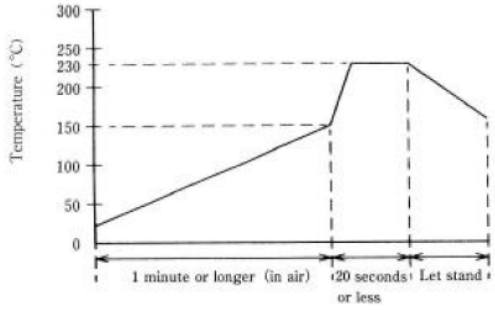
▲ Receptacles

• **Board Pattern Dimensions**



- The pattern dimensions listed to the left should be strictly observed.
  Pattern dimensions other than those specified could lead to short circuits or a drop in the binding force of the board.
- A screen thickness of 0.15 to 0.25 mm is recommended for cream solder printing.

• **Mounting Temperature Profile (Reference)**



NOTE : Reflow soldering should be conducted with a printed circuit board surface peak temperature of 240 ℃ for 5 seconds or less.
The mounting temperature profile will change depending on such factors as the size of the board, solder used, and the solder thickness.

◆ View of mounted connector