Influence of PCB plating on reliability of CIN::APSE assemblies

P. Monfraix, C. Drevon

CTB Working Group on Hybrids, MCM, interco & micropackaging
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outline

- objective of the contract
- solutions designed for LGA packages
- trade-off analysis
- new plating for Printed Circuit Board
- test vehicles
- environmental tests

objective

advantages of solder less connectors (i.e.without brazing)

- very compact solutions
- various possibilities of design
- some solutions allow RF design
- easy rework ability of the connection

CIN::APSE® connector

- excellent example of solder less connection
- many electrical (from DC to 20GHz) and reliability results
- however :
  - reliability linked to the quality of interface between the button/plunger connection and the pad of the Printed Circuit Board
  - choice of the plating for the PCB to avoid particles or sticking is staying a key point which is not yet under evaluation.

objective of this study: evaluate the quality of the connection - including a button CIN::APSE with a plunger, the plating and the printed circuit board

organization of the contract

related to DAD 5.03.02

work statement divided in three main parts :

- comparative paper study on the available concepts from the different manufacturers
- design and manufacturing of test vehicles (based on CIN::APSE® solution)
- reliability tests
  - thermal files with thermal cycles up to 1000 cycles with visual inspection and measurements at 0, 10, 100, 200, 500 and 1000 cycles (through 10 monitored cycles) and high temperature storage
  - mechanical file with vibrations, shocks and damp heat

solutions from LGA

4 four main families

- **bent metal:** relatively fine pieces of metal formed into a curvilinear shape in order to provide a cantilever effect
  - InterCon Systems cLGA® system (Amphenol), Elasticon connector (IBM)
- **conductive elastomer:** composite of conductive metal partially embedded in a matrix of elastomer
  - MPI (TYCO), PARIPOSER (PARICON), Zebra® solutions (FUJIPOLY, SHIN ETSU)
- **pogo pin**: two small tubular sections joined together with an internal spring and with a contactor (or plunger) formed on the end of the smaller tube
  - RFF contacts (HYPERTAC), spring contacts (SYNERGETIX)
- **fuzz button**: small column of kinked molybdenum wire as a miniature steel wool pad, typically contained in a cylindrically shaped housing included into a polymer
  - CIN::APSE® (CINCH), fuzz button technology (TECKNIT)

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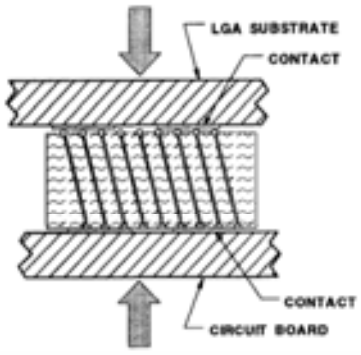
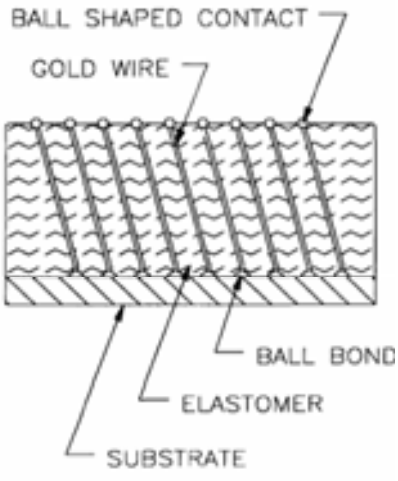
bent metal solutions

Elasticon from IBM



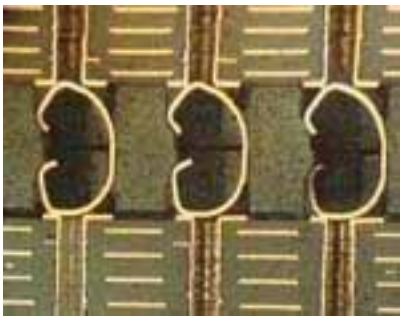


- Many reliability tests done cycling (some up to 180°C)

bent metal solutions

InterCon cLGA system from Amphenol

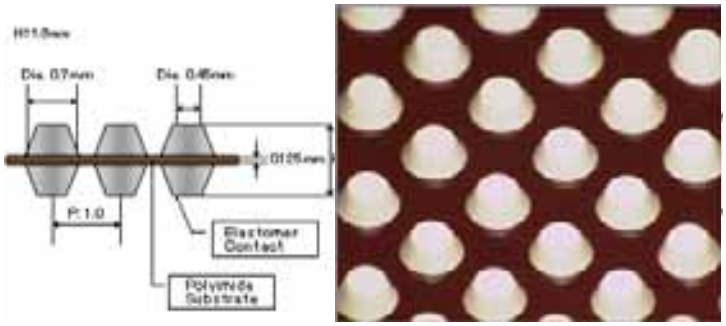
- 1.27mm and 1mm pitch
- 1dB insertion loss and –10dB return loss @7.3GHz
- large sockets achieved with 4000 contacts (5000 contacts in design)

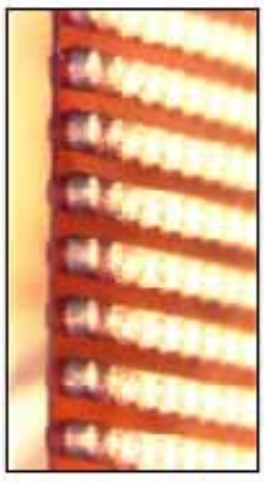


conductive elastomer

Metallized Particle Interconnect: HXC125 by TYCO and RP type by SHIN ETSU

- compression required to compress a column : around 45g
- contact resistance 0.05 Ohms at 60g compression
- 4 amps per column
- durability : 20 mating cycles

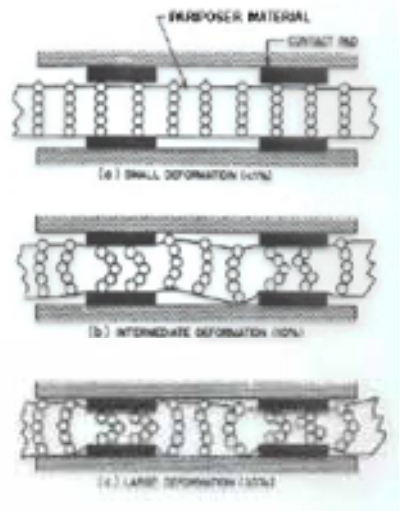


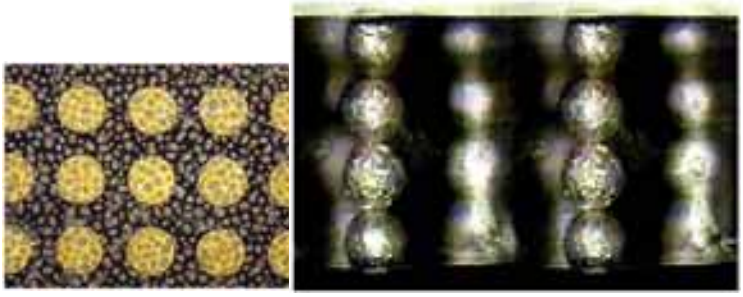


conductive elastomer

PARIPOSER® from PARICON

- minimum pitch is 1mm
- thickness of the interconnection system: 0.15mm and 0.508mm
- high cycle life and short term overloading
- experience at microwave frequency: 1dB loss @ 40GHz (55 Ohms)

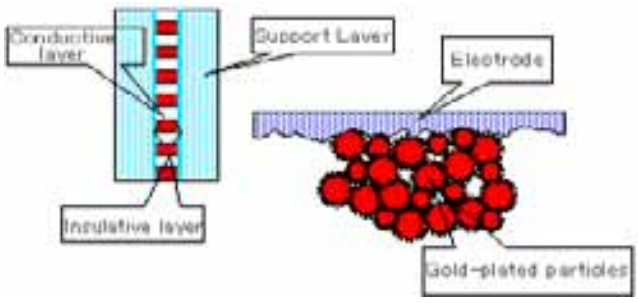


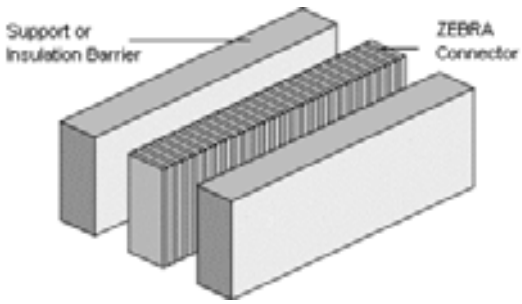


conductive elastomer

Zebra® from FUJIPOLY and SHIN ETSU

- some characteristics:
  - different fillers solutions depending on the main drivers (resistivity, high current, cost)
  - from 140 to 500 contacts per inch fro alternating layers solutions and from 300 to 2000 for fine metal wire solutions
- some reliability results on the "Gold 8000" reference (salt spray, temperature cycling, humidity test, corrosive test)





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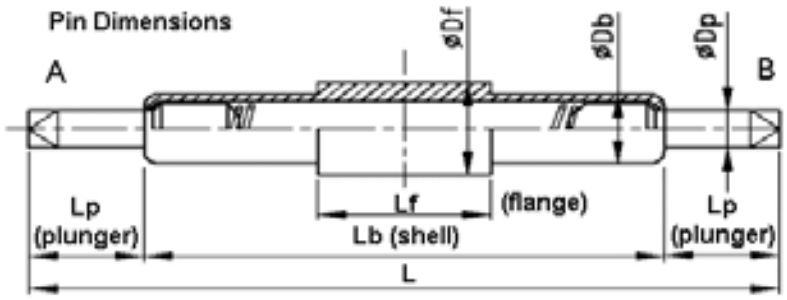
RFF contact from HYPERTAC and Spring contact from SYNERGETIX

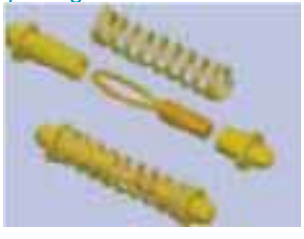
- consist of two small tubular sections joined together with an internal spring and with a contactor (or plunger) formed on the end of the smaller tube

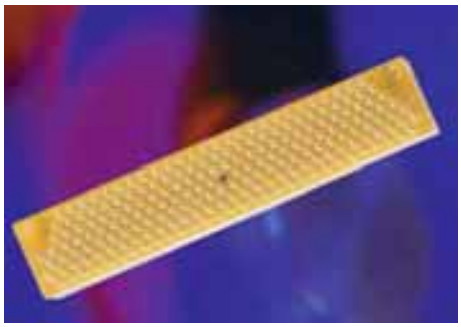


pogo pin

RFF contact from HYPERTAC

- multipoint connection design based upon a sliding 2 loop wire pin, held within a passive socket to allow for a solderless compression contact, applicable to multi chip modules
- mechanical deflection of 1mm of the compressed spring
  - button contact : brass, gold over nickel plating
  - wire : copper beryllium, gold over nickel plating
  - insulator : thermoplastic (very low outgassing characteristics)
  - PCB pad diameters should be 0.8 mm with an electrolytic gold (1.27 µm min.) over Nickel plating





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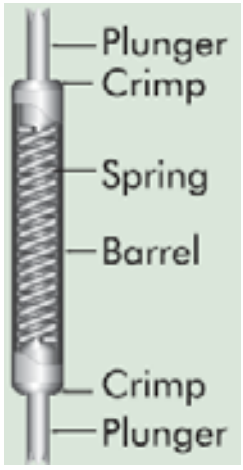
RFF contact from HYPERTAC

- Some reliability tests done
  - sinusoidal vibrations : 10 Hz/2000 Hz – 1.5 mm – 20 g
  - random vibrations: 90.2 m/s2 during 10 s per axis, 20 to 2500 Hz
  - shocks : 600 g/0.4 ms
  - electrical discontinuity : <20 ns
  - environmental category : -55°C, +125°C, 56 days
  - dry heat : 1000 h at 125°C
  - salt spray : 96 hours following
  - humidity : 56 days
  - rapid variation of temperature : –55°C, +125°C

pogo pin

Spring contact from SYNERGETIX



- telescopic electromechanical interconnects
- consist of
  - a plunger (retained within the barrel by a crimp)
  - an helical coil spring
  - both housed within a conductive barrel
- spring contacts embedded in different moulded materials
  - Torlon® (poly(amide-imide)
    - low creep, flame resistance,
    - outstanding electrical properties,
    - exceptional integrity in severe environments even at temperatures in excess of 232°C),
  - ULTEM 2300 (30% glass reinforced PEI resin)
    - better rigidity and dimensional stability with excellent processability
  - Ryton® R-4XT (a 40% fiber-glass reinforced polyphenylene sulphide)
    - for ductility and impact strength

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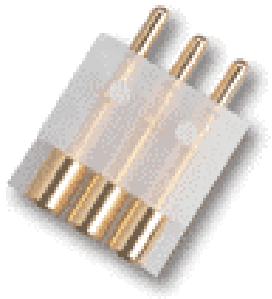
pogo pin

Spring contact from SYNERGETIX: some examples



fuzz button

CIN::APSE® from CINCH (and Fuzz buttons from TECKNIT)

- solderless z-axis interconnect technology with exceptional mechanical and electrical performance
- multipoint contact
  - as small as 0.8mm in height
  - minimum pitch 1mm with a ø 0.5 mm contact (standard pitch is 1.27mm)
  - up to 20 GHz
- many button/plunger/spacer assembly configurations
- insulator design in ULTEM or LCP
- buttons with a high modulus of elasticity can be compressed thousands of times without taking a compression set

CIN::APSE® from CINCH

- Many reliability data existing on this connector (including FAFR DOMINO2 ESA contract)
  - mechanical tests : sine vibrations + random vibrations + 500 thermal cycles [-55°C, +125°C]
  - life-test for 1000 hours at 125°C
  - humidity test for 6 days at 60°C/95%HR
  - the isolation resistance is better than $25x10^3$Mohms
  - the contact resistance evolution is better than 2% after the mechanical test, 1.5% after the life-test and 3.7% after the humidity test
  - no electrical breakdown with a very precise monitoring continuity after 10 thermal cycles [-55°C, +125°C] (slope of 2°C/mn)

fuzz button

Fuzz buttons from TECKNIT (and CIN::APSE® from CINCH)

- same principle as the CIN::APSE solution
- mains differences to CINCH solution are
  - buttons in combination with multiple hardhat contact pins : concave, flat, crown, …
  - Be-Cu wire or Ni-Cr for the button (instead of Mo or W for CINCH)
  - lower diameter for the button (0.381mm vs 0.508mm for CINCH)
  - lower pitch (0.65mm vs 1mm for CINCH)
- ALCATEL, through a DGA contract (French MoD), has designed and characterized a connection using the TECKNIT reference up to 20GHz between two multilayer PCBs

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some trade-off analysis (1/2)

integration :

- Zebra® solution (cf. mobile phone): small, very fine pitch, die-cut to shape...
- adapted thickness of fuzz buttons solutions: with different plunger/buttons

reliability :

- elastomers solutions are subjected to problems on low/high temperature ratings and on required compression force (can be >x10 spring solutions)
- bent metal contacts have contact resistance increasing gradually with assembly cycles
- many successful reliability results on the pogo pins & fuzz button technologies, well suited for harsh environment conditions

cost analysis :

- bent metal connectors: very cheap for high volume needs
- fuzz button and spring contact technologies: custom design, prototypes and low volume

some trade-off analysis (2/2)

microwave applications :

- bent metal connectors are limited to low frequency (<1GHz)
- PARIPOSER solution also restricted to low frequency (<1GHz)
- Zebra® solution (MG-type contacts) have shown some results up to 10-15GHz but strong risk of electrical crosstalk
- solutions such as MPI/RP-based system, RFF contacts, spring contacts from SYNERGETIX, fuzz button, based on a coaxial design, can show good electrical characteristics up to 20GHz, and even higher frequency in some configurations

plating solutions

plating solutions from the technical proposal:

- hard gold
- electroless Ni/flash gold
- thick gold compatible wire bonding

from experience on FaFR, new plating solutions are proposed:

- thick electrolytic Ni/Au with improvement on Ni in via holes
- ENIG (Electroless Nickel Immersion Gold): technical solution preferred for solder reflow of CSP and BGA packaging approaches
- fused SnPb: standard technique for solder reflow

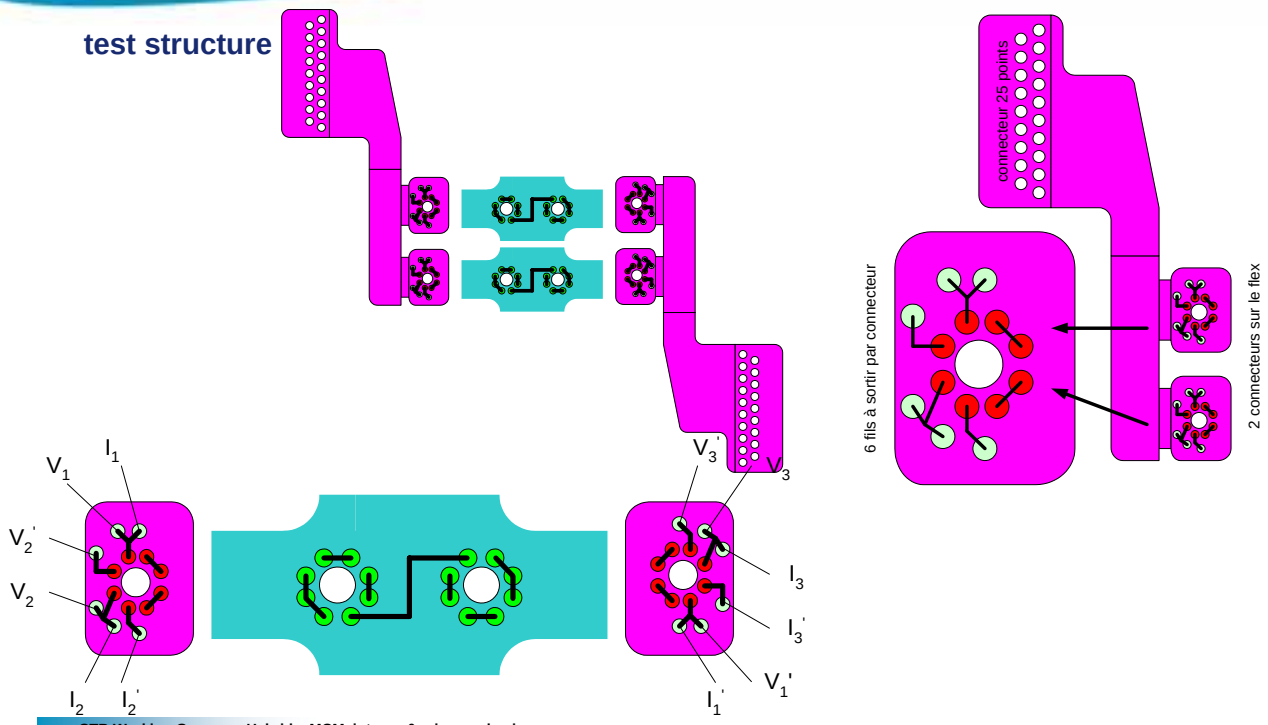
test vehicle

CIN::APSE connector

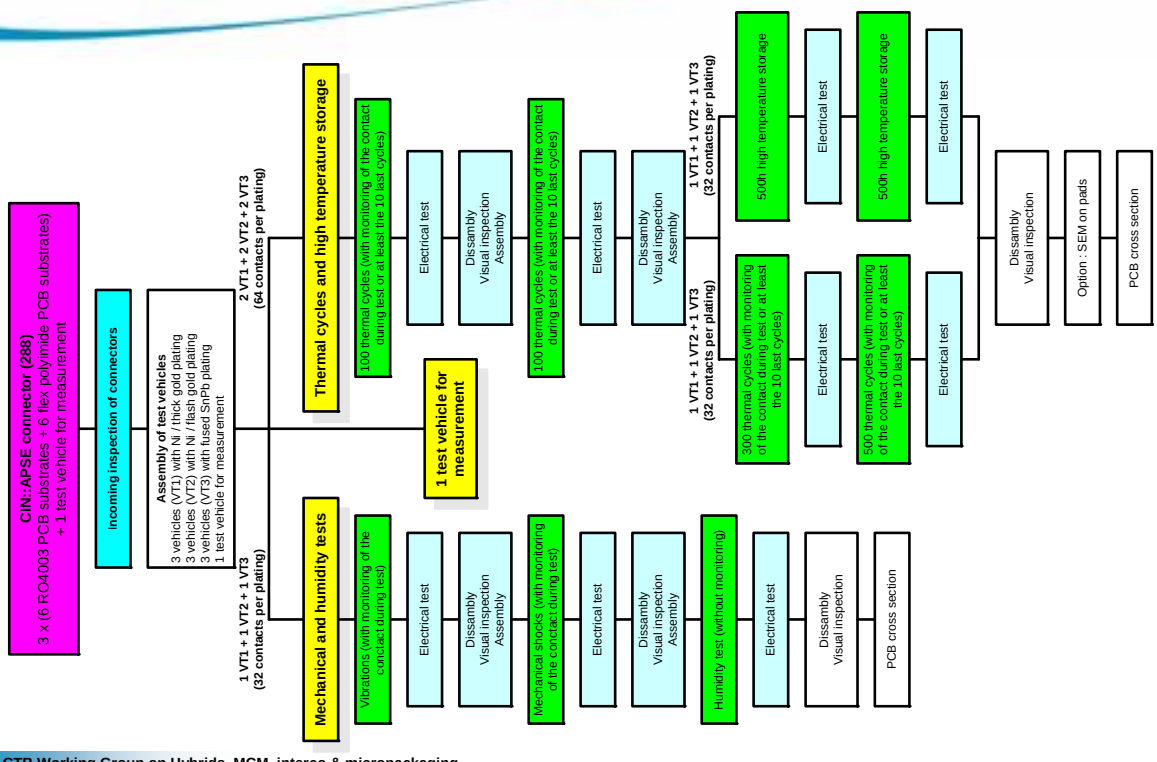
- 2 ½ shells ULTEM 1000
- button: ball of molybdenum
- plonger: brass
- outgassing: TML = 0.519% CVCM = 0.008% RML 0.241% WVR = 0.278%

test vehicle

test structure

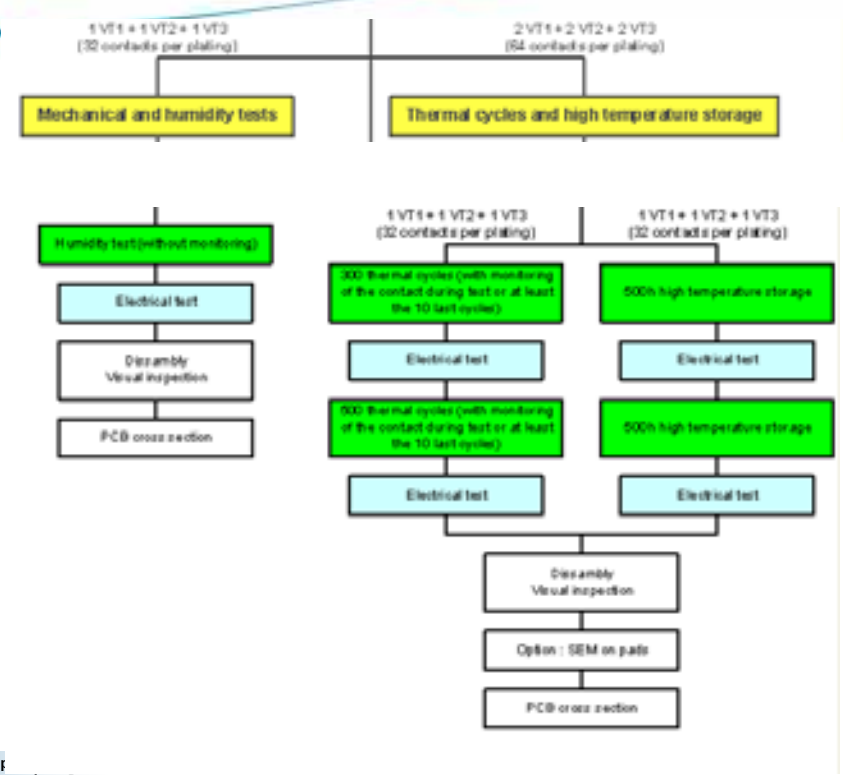


environmental test-plan



environmental test-plan

environmental test-plan



test conditions (1/2)

Sine vibrations

- sweep frequencies : 10 Hz - 2000 Hz - 10 Hz
- amplitude : 15 g
- duration : 30 mn per axis to traverse the entire frequency range (10Hz to 2000Hz and return to 10 Hz)
- monitoring of the daisy chain during test

Random vibrations

- frequency range: 20Hz - 2000Hz
- amplitude level : 0.2 g^2/Hz
- duration : 10 minutes per axis
- monitoring of the daisy chain during test

High temperature storage

- duration : 1000 hours
- temperature : 125°C

test conditions (2/2)

Shocks

- number of shocks : 3 per axis
- envelope : half sine, 50 g peak, 11 ms
- monitoring of the daisy chain during test

Damp heat (according to IEC 68-2-30, test "Db", severity b, var. 2)

- number of cycles : 6
- cycle duration : 24 h
- 95% RH
- recovery: 2h ambient temperature and 75%RH

Thermal cycles

- low temperature : -55°C / high temperature : +125°C
- slope : 10°C per minute
- 15 to 20 minutes rest at -55 and + 125°C
- monitoring of the daisy chain each 10 last cycles

status

new plating definition done

printed circuit boards available

CIN::APSE available

all assembly done

under test plan

and now, any question ?

thanks for your attention

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