SPCD Seminar 2022

Low profile and solderless solutions for flat space interconnect

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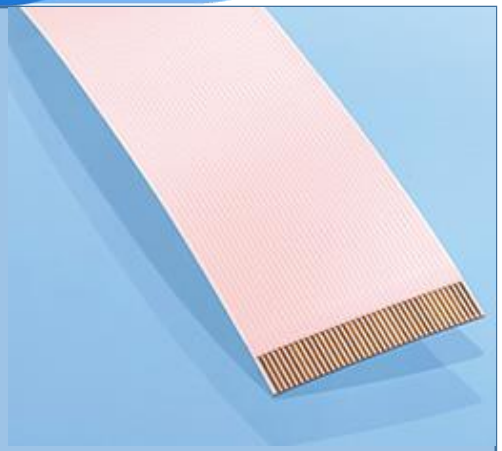
FFC / FCC – what is it?

- **FFC = Flat Flexible Cable**
  - Flat section conductors in a laminated insulation “sandwich”
- **FCC = Flat Conductor Cable**
  - Terminology starting to be used in space, slightly more precise in description …
  - … but essentially the same thing



- Different from a **flat or ribbon cable**, where the conductors remain single or multi-stranded **round** conductors, but in an overall flat construction

- And different also from **FPC (Flexible Printed Circuit)**, which nevertheless exhibits many of the same properties as a FFC/FPC

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VOLUME AND THERMAL COMPARISON BETWEEN ROUND AND FLAT CABLES

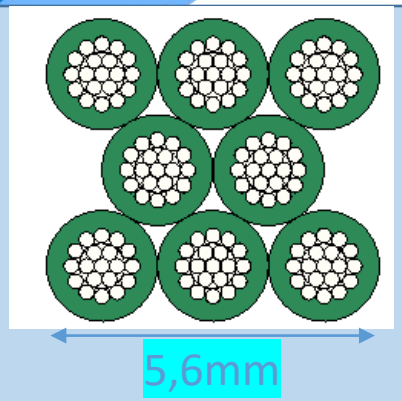
Comparison: 8 x AWG18 FFC and 8 x AWG18 wires round or flat

- FFC is more compact than round cable assemblies
- FFC has a better heat dissipation efficiency:
  - more surface contact with structure => better in conduction when applied in spacecraft structure
  - more radiation surface

Bundle with round wires and conductors

Footprint area: ~19mm²

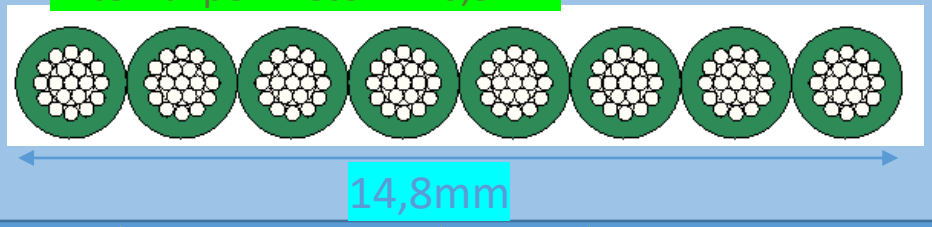
External perimeter: ~31mm



Flat cable with round wires and conductors

Footprint area : ~18,4mm²

External perimeter: ~46,5mm



Flat cable with flat conductors (FFC / FCC)

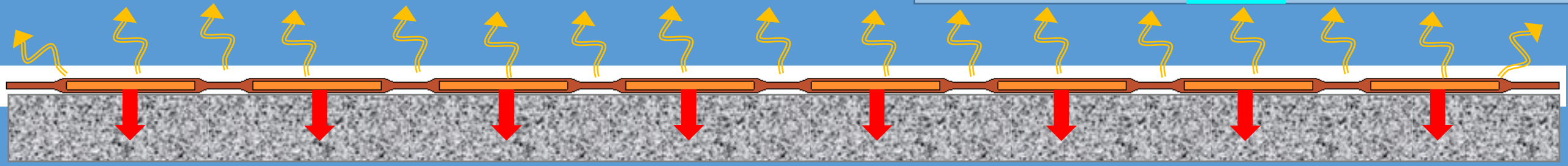
Footprint area : ~14,6mm²

External perimeter: >80mm

Picture below shows radiative and conduction thermal dissipation of a flat cable

~40mm on radiative emission

~40mm on conductive dissipation



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PARTS AND MATERIALS OF A SPACE-GRADE FFC

Space grade insulation materials

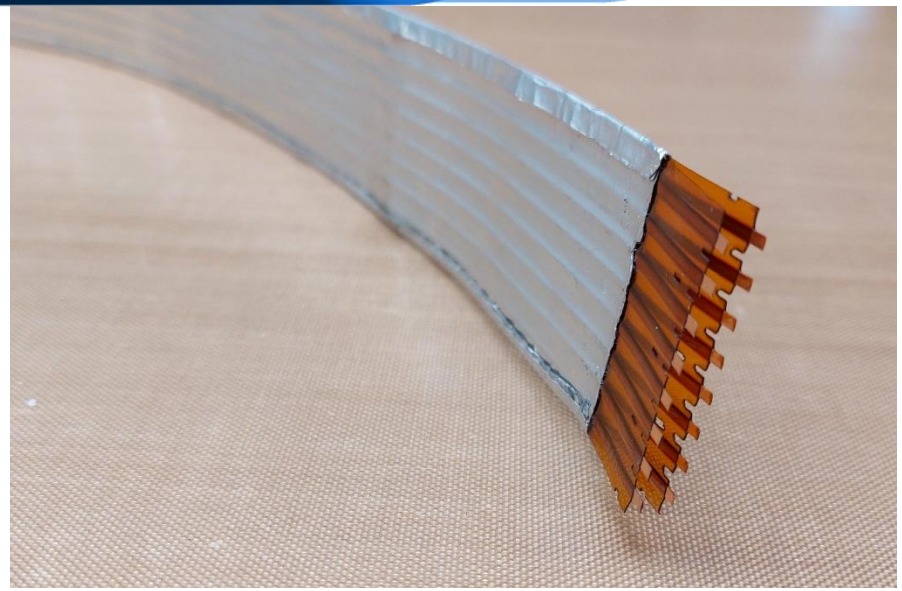
- Laminated polyimide tape + acrylic glue (for power and signal application)
- Possibility to use PTFE tape + adhesive

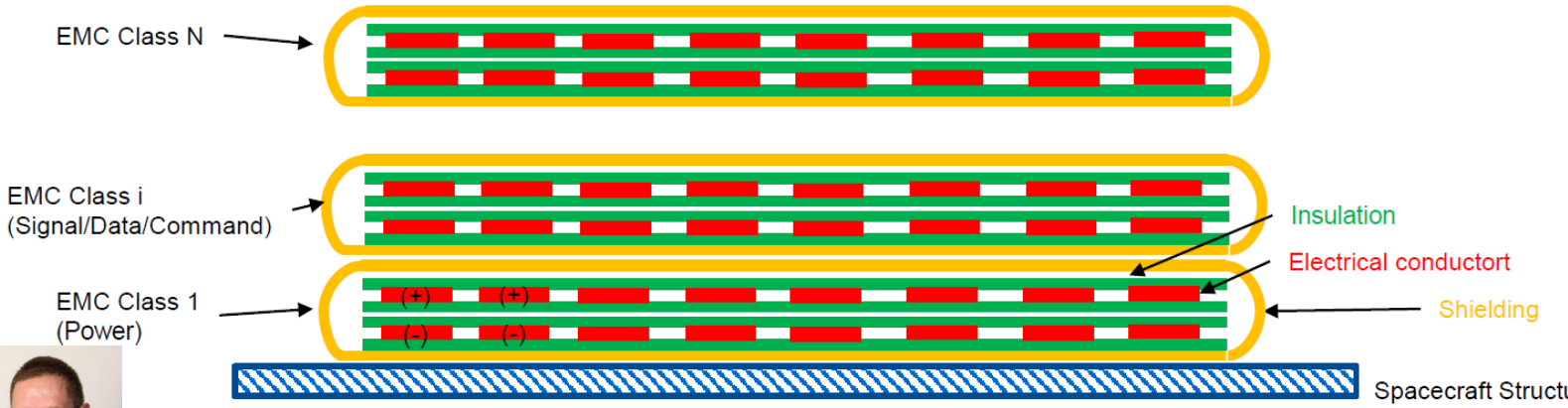
Conductors

- Rolled flat copper conductors
- Selective of full gold/silver surface treatment can be applied

Assembly

- FFC can be easily stacked for compact assemblies
- Shielding tape can be used for EMI protection/segregation





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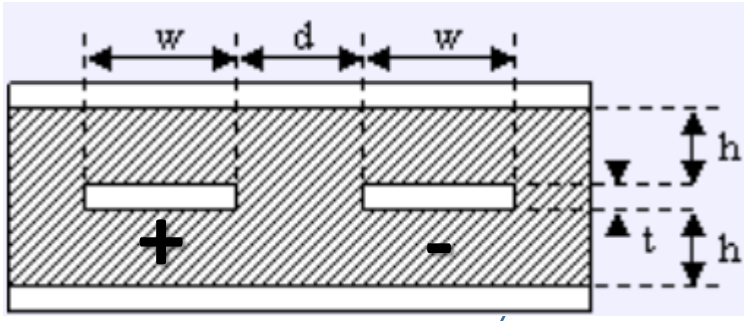
INTRODUCTION
CONSTRUCTION OF A SPACE-GRADE HIGH DATA RATE FFC

Adapted links FFC

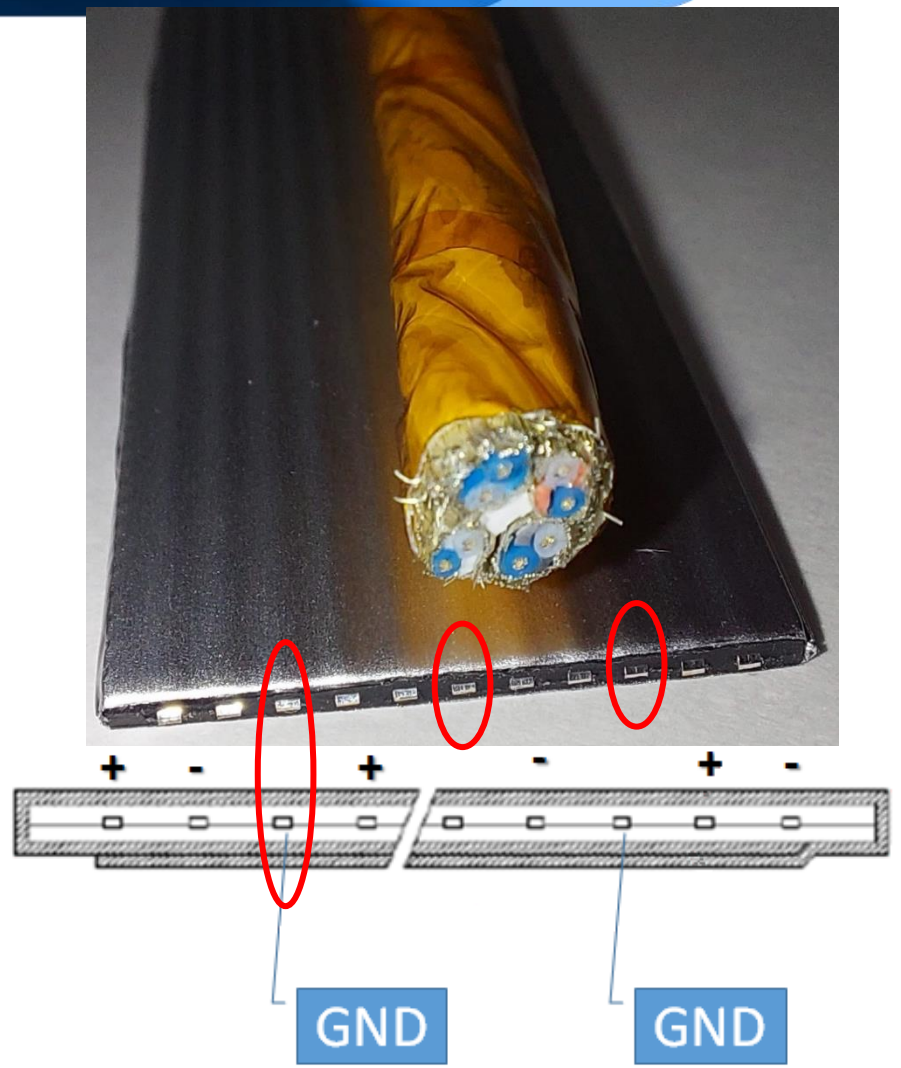
- An adapted link FFC can be used as an effective **SpaceWire** cable
- Some conductors can be used as shielding walls

Differential stripline structure

- Shielding tape can be used as ground plane
- It is possible to adapt spacing, conductor width and thickness
- Insulation type and thickness can be adapted as a function of the dielectric constant (similar to a PCB structure)



Differential Stripline structure



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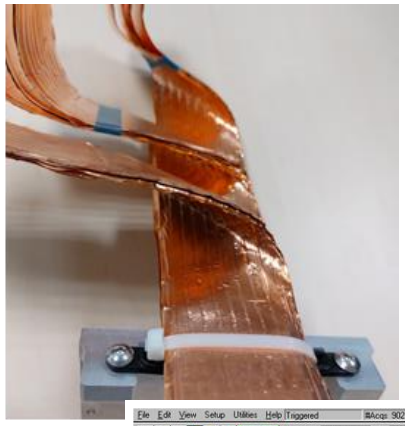
INTRODUCTION
FFC ROBUSTNESS

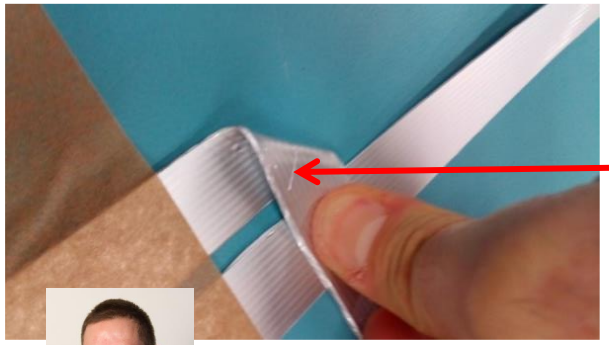
Common FFC

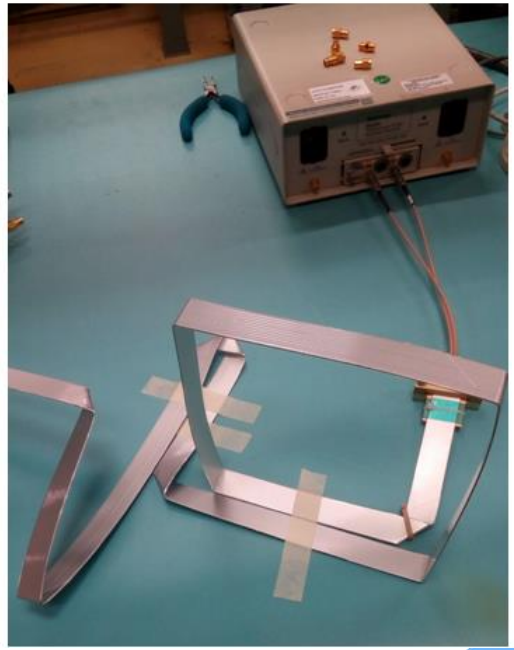
- Ultra small bend radius – even a fold is possible - for FFC alone
- Good routing anticipation is necessary. Unlike wires and cables, FFC conductors and FFC themselves cannot be crossed
- A FFC or FFC assembly cannot be routed in every direction
- Shielded and very populated assemblies can be very stiff, bend radius can be affected

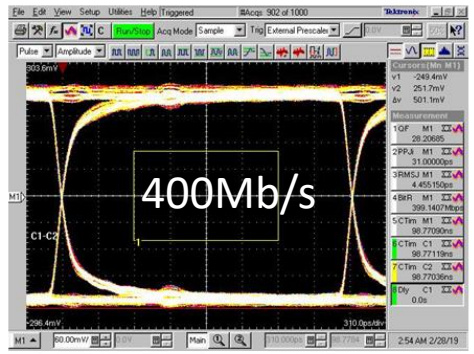


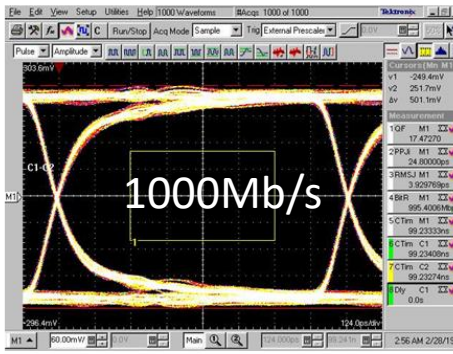
High data rate FFC

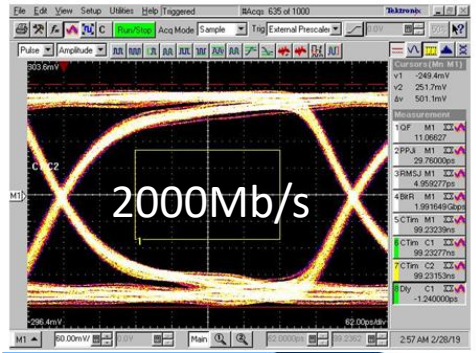
- 1 fold creates <2Ω of impedance variation

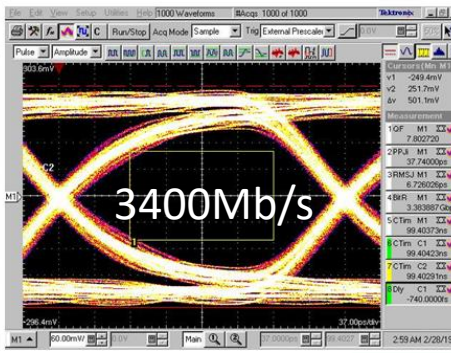












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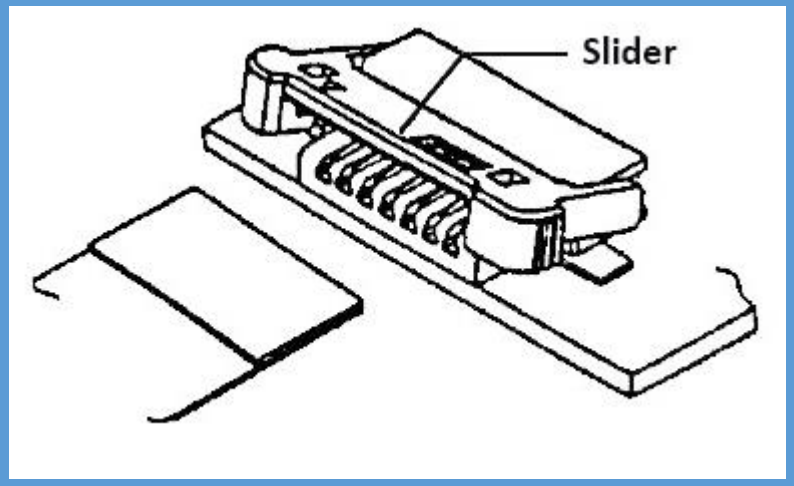
FFC/FCC Connectors

- Many advantages to FFC routing
  - Lightweight, foldable, can be embedded in structure, can be suitable for high power, can be suitable for high data rates …

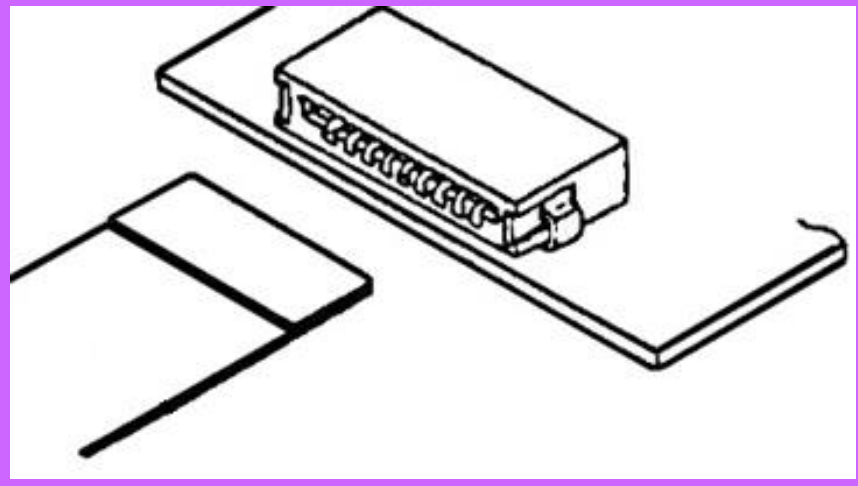
- ***But what about the termination?***
  - do we have suitable space grade ***connectors***?

CONNECTORS
SMT CONNECTOR WITH FAST LOCKING MECHANISM



ZIF (Zero Insertion Force)

- The FFC is placed without force
- Mechanical slider as locking system and applies pressure between the cable and the contacts
- Highest possible number of mating cycles



LIF (Low Insertion Force)

- The FFC is inserted with a degree of force
- Cable and connector are retained by the existing sprung pressue
- More compact size

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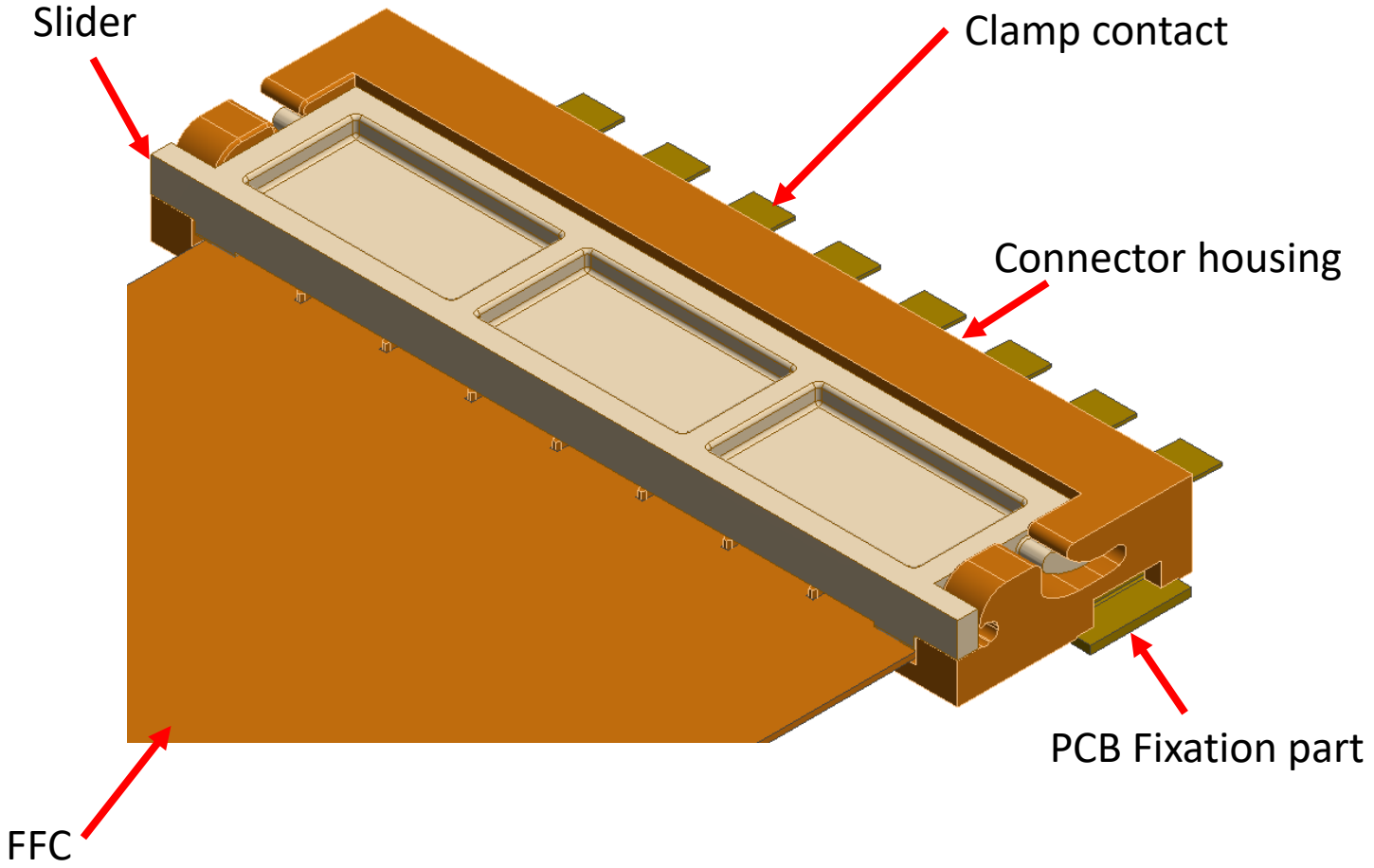
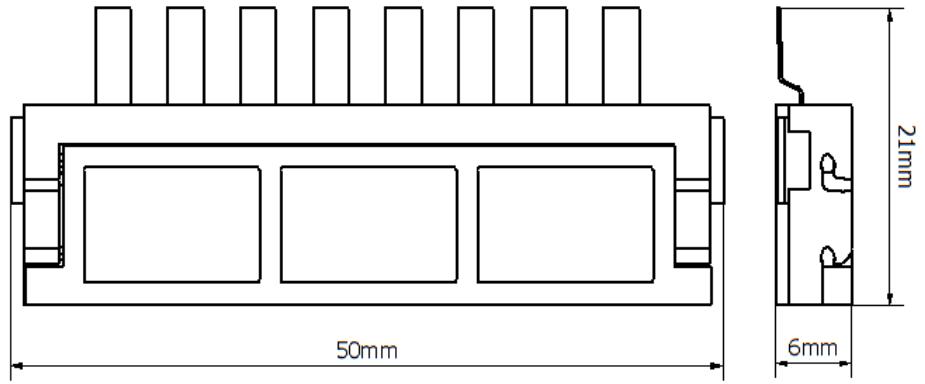
CONNECTORS
ZIF CONNECTOR: ASSEMBLY



- 8 way ZIF connector compatible with AWG18 and 22 FFC
  - Pitch 5,08mm
  - Conductor thickness: 0,2mm
  - Conductor width:
    - AWG18 : 1,75mm
    - AWG22 : 3,5mm
- Walls in connector housing for double insulation
- Studs and ears for cable retention



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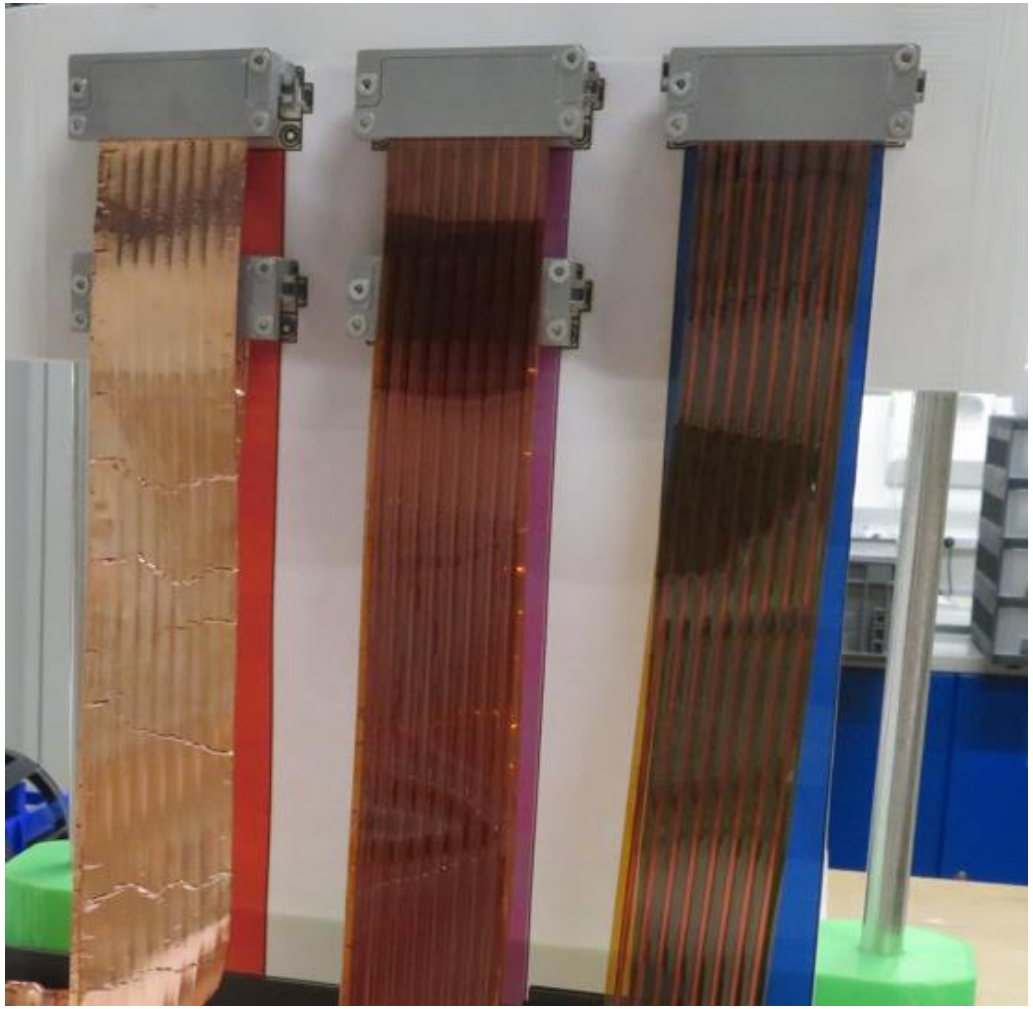
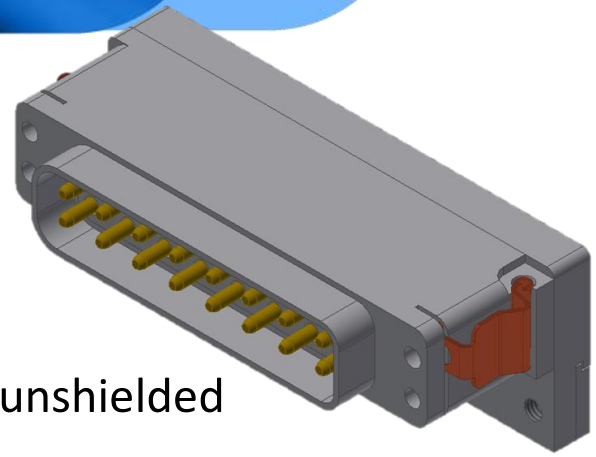
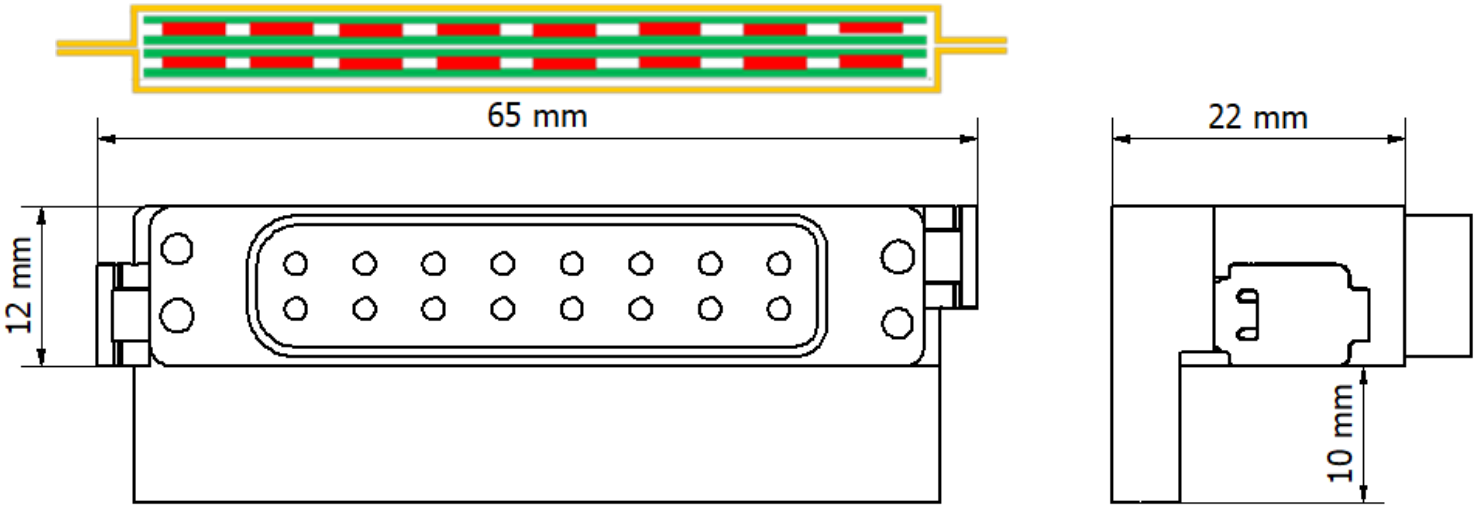
CONNECTORS
POWER CONNECTOR COMPATIBLE WITH FLAT CABLE





- Fast locking hardware
- Right angled backshell
- Compatible with shielded and unshielded assemblies
- Same construction than standard VERSATYS AWG16, in two rows configuration 2x8 points



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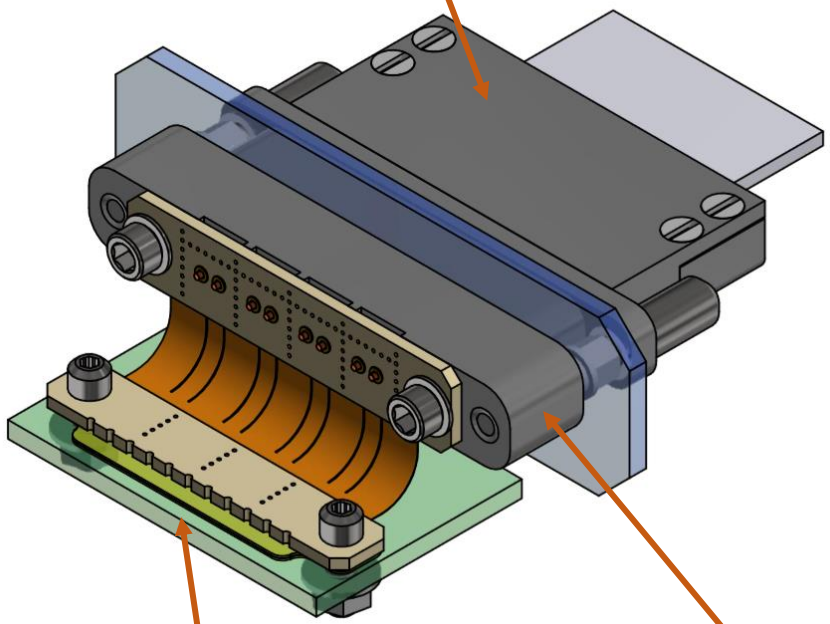
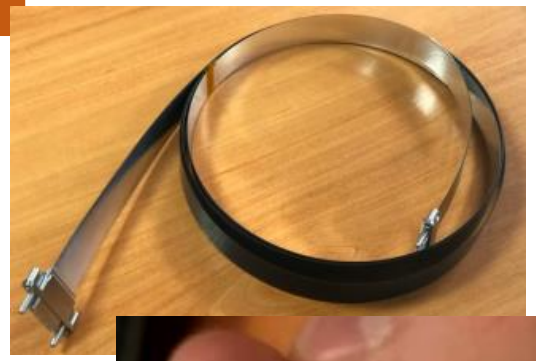
CONNECTORS
HIGH DATA RATE CONNECTOR COMPATIBLE WITH FLAT CABLE

Male MicroMach® FFC Connector



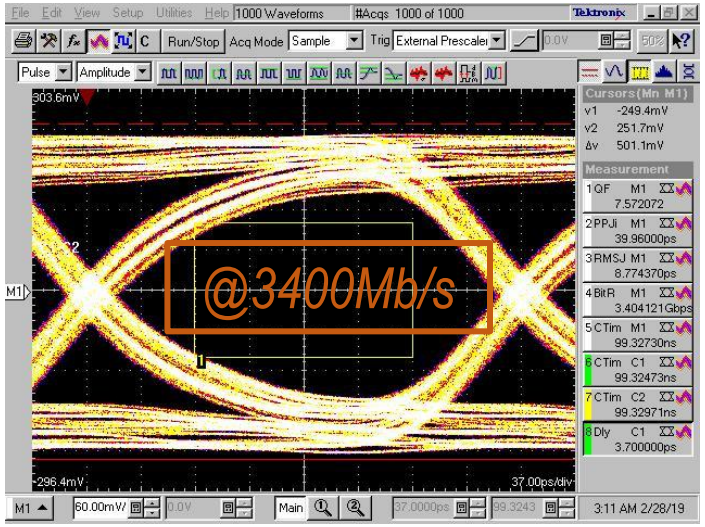
Interposer termination



Female MicroMach® Flex PCB Connector

Signal integrity on 2m length harness connected to a flex PCB panel mount connector:

- Skew <5ps
- >3Gb/s baseband (e.g. SpaceFibre)



- CAT6A 10Gb/s (“TT” Ethernet)
- **SpaceWire** and **SpaceFibre**

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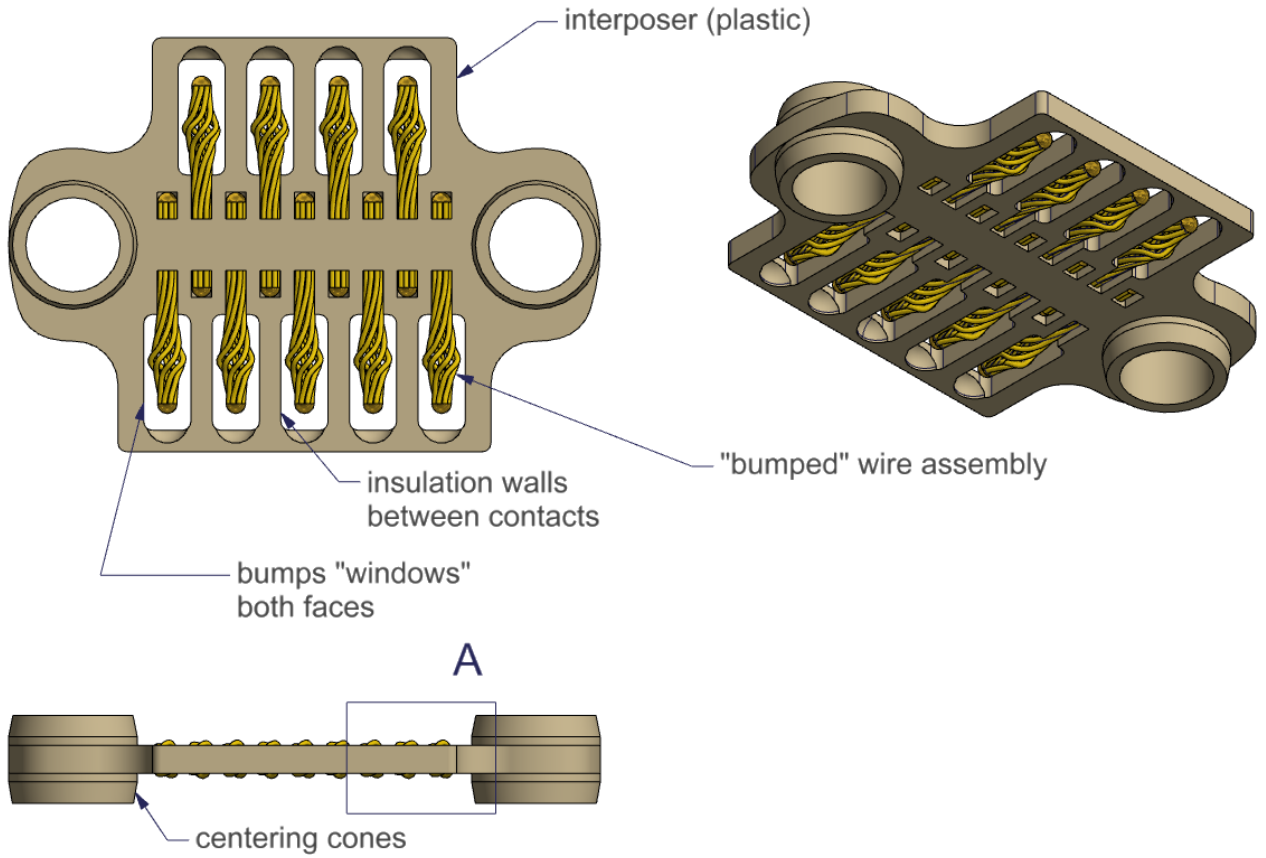
CONNECTORS
SOLDERLESS INTERPOSER COMPATIBLE WITH FLAT CABLE AND PCB

Product's performances to consider

- **Electrical**:
  - Low contact resistance
  - Good insulation
  - Controlled characteristic impedance (HDR)
- **Environmental:**
  - Resistant to Vibration & shock levels
  - Operational temperature behavior (dilatation)
- Good Density of points = Space saving
- ***Ultra low-profile: <1.0 mm high***



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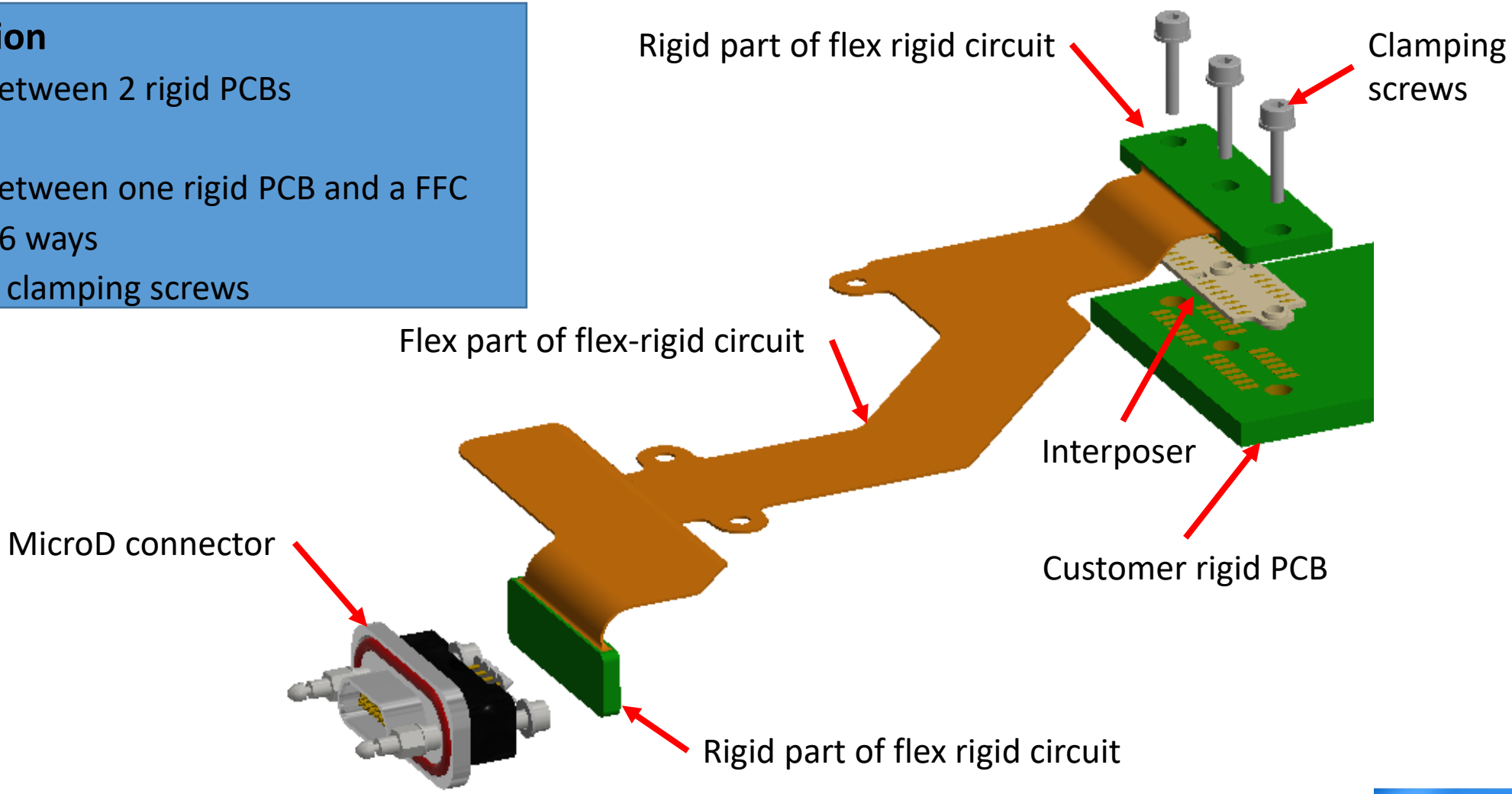
INTERPOSER TERMINATION: EXAMPLE OF APPLICATION USING FLEX RIGID PCB

Product application

- Sandwich between 2 rigid PCBs

or

- Sandwich between one rigid PCB and a FFC
- From 9 to 26 ways
- From 2 to 3 clamping screws



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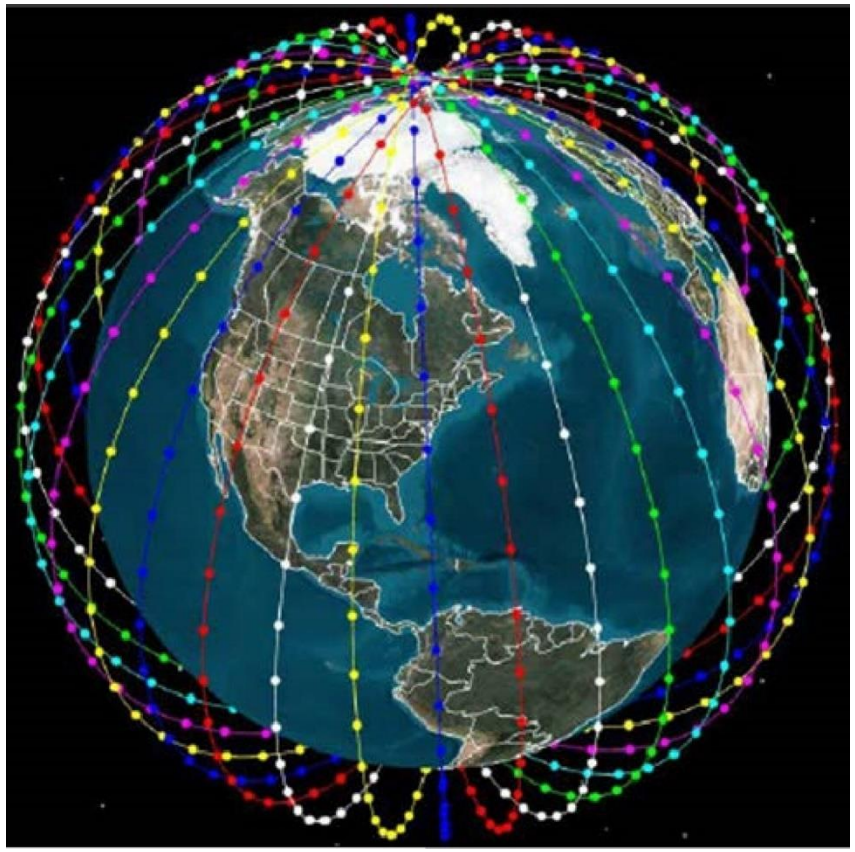
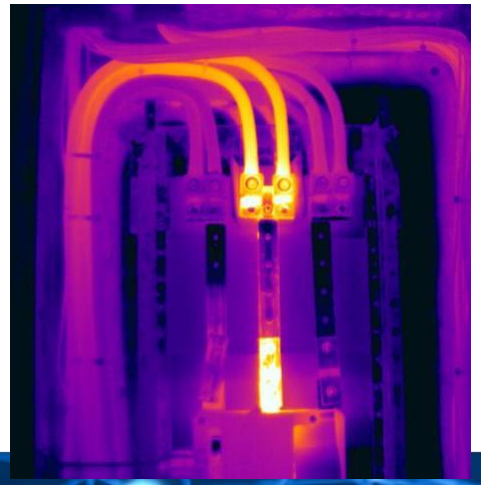
CONCLUSION AND OUTLOOK

Trends

- Satellites are getting smaller, and more numerous
- New Space approach is driving cost down
- Data rates are increasing, as is signal density
- Power handling is increasing, but less space to do it in

=> greater **heat density** generated by cabling





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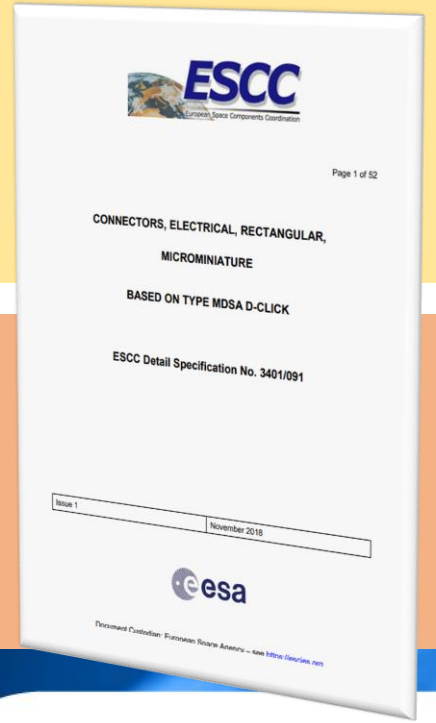
CONCLUSION AND OUTLOOK

- **Can FFC (FCC) be part of the answer?**
  - FFC (***non-space***) heritage is low cost, high volume manufacture
    - Axon' produces in excess of **50 million pieces per year**
      - for automotive and office equipment applications

- FFC and its connectors need to be re-engineered for space ("**FCC**"?)
  - Radiation tolerance, thermal stability, double insulation
  - This work is already ***well advanced***



- Then followed up with **EEE component specifications**, why not …
  - ESCC**3903** – **Flat Conductor Cables**
  - ESCC**3401/xxx** – **FCC connectors**
  - ESCC**3410** – **Flat Conductor Cable Assemblies**

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THANKS FOR YOUR ATTENTION

ANY QUESTIONS ?

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