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High power SMA connectors

(PSM Connectors)
Presenter: K. Wettstein

Project ”High Power SMA Connectors” (ESTEC/Contract No. C20967/07/NL/GLC)
ARTES-5 activity

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Outline

- Overview Project
- Goals
- Results
- Connector design
- Thermal Analysis
- Multipaction
- Corona
- PIM
- Compliance
- Conclusion

Overview of project

- Design and fabrication of a connector with
  - Size and mass like an SMA connector
  - Frequency range like an SMA connector
  - Power performance like a TNC connector
  - PIM performance like a TNC connector
  - Multipaction performance like a TNC connector
  - Space application capability (pressure between 0 and 1 bar)
- Work was carried out within the Project
  - “High Power SMA-Connector“, (ESTEC/Contract No. C20967/07/NL/GLC)
  - ARTES-5 activity, funding 300 + 60 k€, Technical Officer: David Raboso
  - Start: November 2007 - End: December 2011
- Co-operation of
  - EPF Lausanne: E. Sorolla, M. Mattes,
  - TU Darmstadt: D. Schönherr, H.-L. Hartnagel,
  - ESA/ESTEC: D. Raboso,
  - HUBER+SUHNER: J. Fuchs, K. Wettstein, H. Karstensen

Goals

- Design and fabrication of a connector with
  - High power capability in space
    - Multipaction
    - Corona
    - Thermal radiation
    - Venting issue

type	band	f / GHz	operating power	test power	test	time
Corona	L-band	1	40 W	80 W		cw, 10 min
	C-band	4	30 W	60 W		cw, 10 min
	Ku-band	11.6	30 W	60 W		cw, 10 min
High Power CW	L-band	1	50 W	100 W		cw, 10 min
	C-band	4	50 W	100 W		cw, 10 min
	Ku-band	11.6	50 W	100 W		cw, 10 min
High Power Pulsed, Multipactor	L-band	1	200 W	800 W		T=1ms, 2% dc
	C-band	4	180 W	720 W		T=1ms, 2% dc
	Ku-band	11.6	150 W	600 W		T=1ms, 2% dc

band	carrier frequencies	carrier power	acceptance criteria	test
PIM L-band	1.65 GHz	50 W	3rd order power <-140 dBm	7^{th} order

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Results summary

type	band	f / GHz	operating power	test power	test	time
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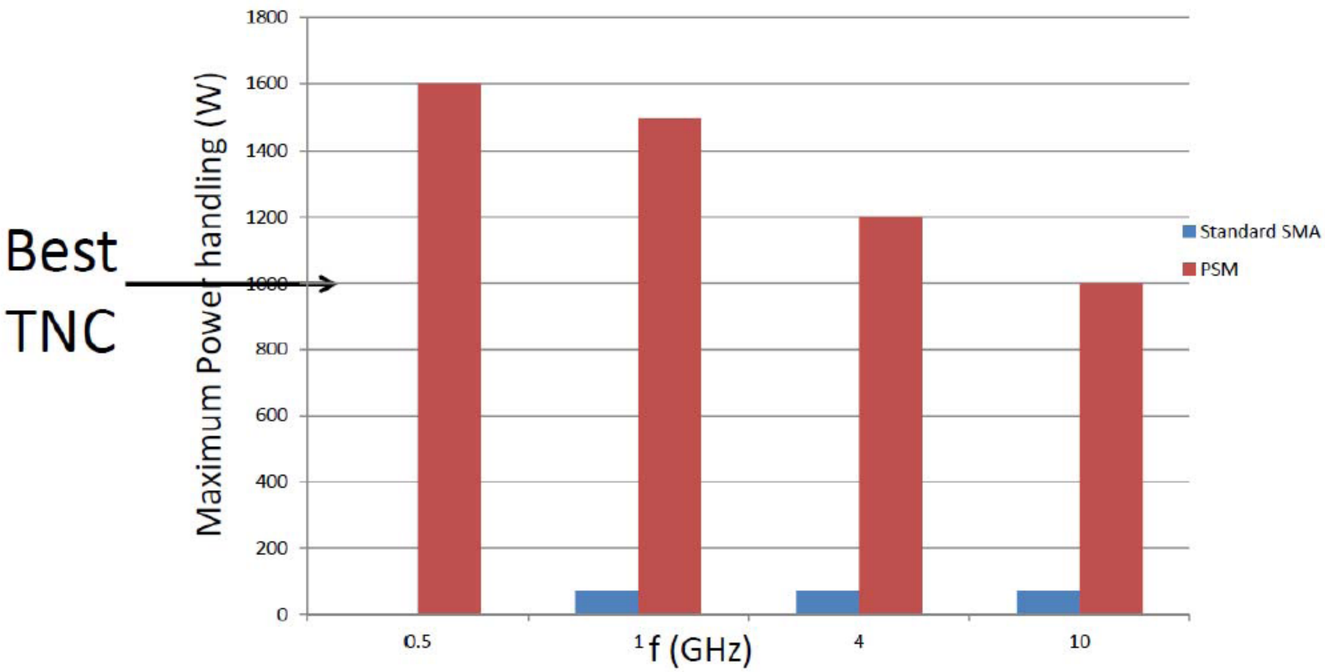
Multipactor thresholds in P- (435 MHz) and L-band (1.155GHz):
SMA-Connector: < 10 W
N-Connector: < 100 W
TNC-Connector: 600 – 1000 W
PSM-Connector: > 1500 W

For the PSM connector a patent has been filed.

Multipactor Threshold

Comparison of multipactor threshold of PSM and SMA connectors



(Measurements done at ESA-VSC laboratories, VAL Space, Valencia)

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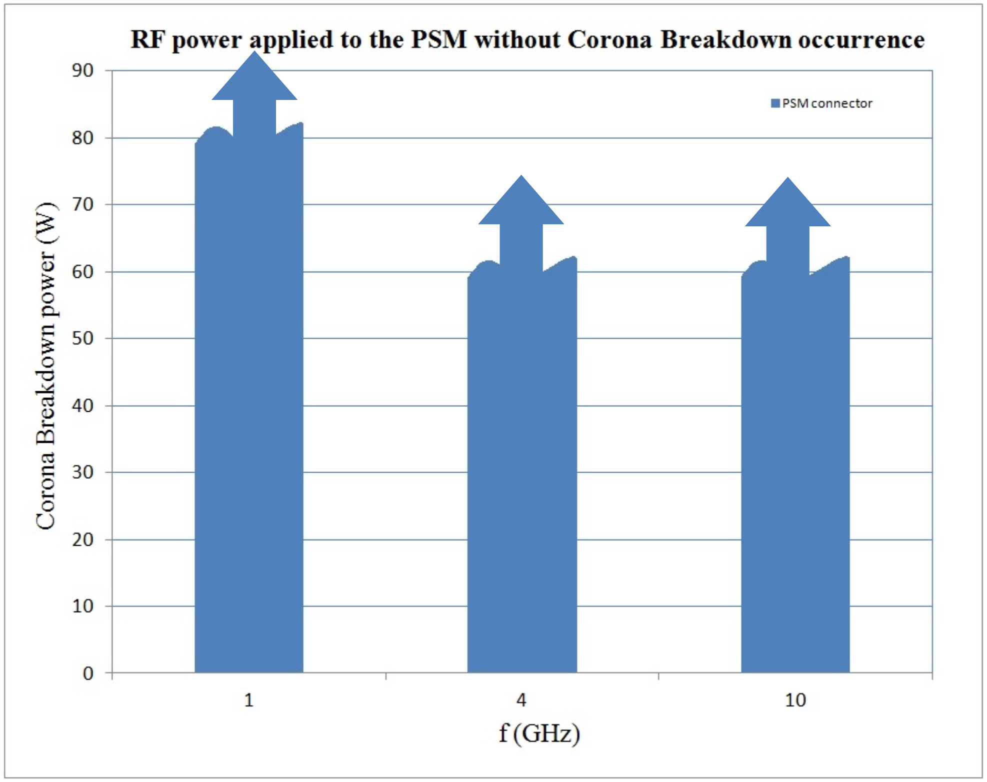
Corona thresholds

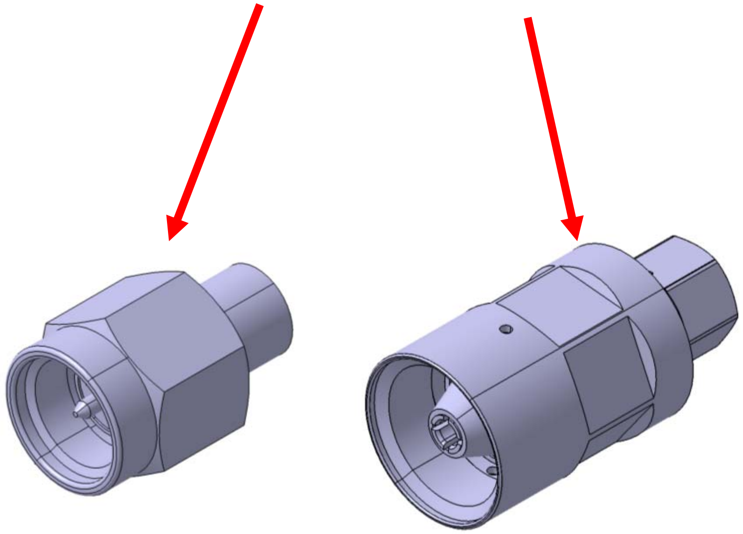


Corona withstanding capabilities of the PSM connector

(Measurements done at ESA-VSC laboratories, VAL Space, Valencia)

Fabricated components (engineering samples)

View of the SMA and the PSM connector.



Same HEX-Nut size of 8mm and the same coupling torque of 100Ncm.

Engineering samples of straight cable plugs (male) for (from left) EZ 250, EZ 141, SUCOFLEX 304, SUCOFLEX 106 cables, plus two flange connectors.

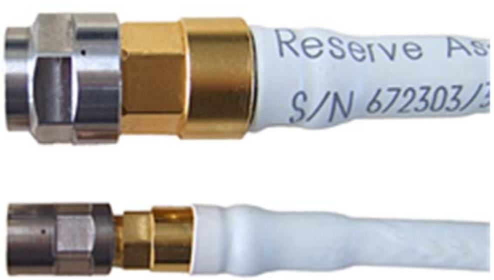
Fabricated components.

SMA receptacles can directly be replaced by PSM because of identical flange size

Size comparison

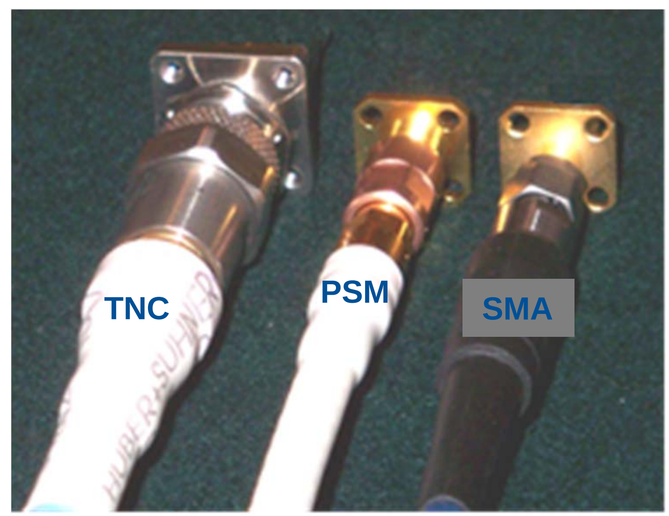
TNC (top) and an engineering sample of a PSM (bottom) cable assembly

TNC

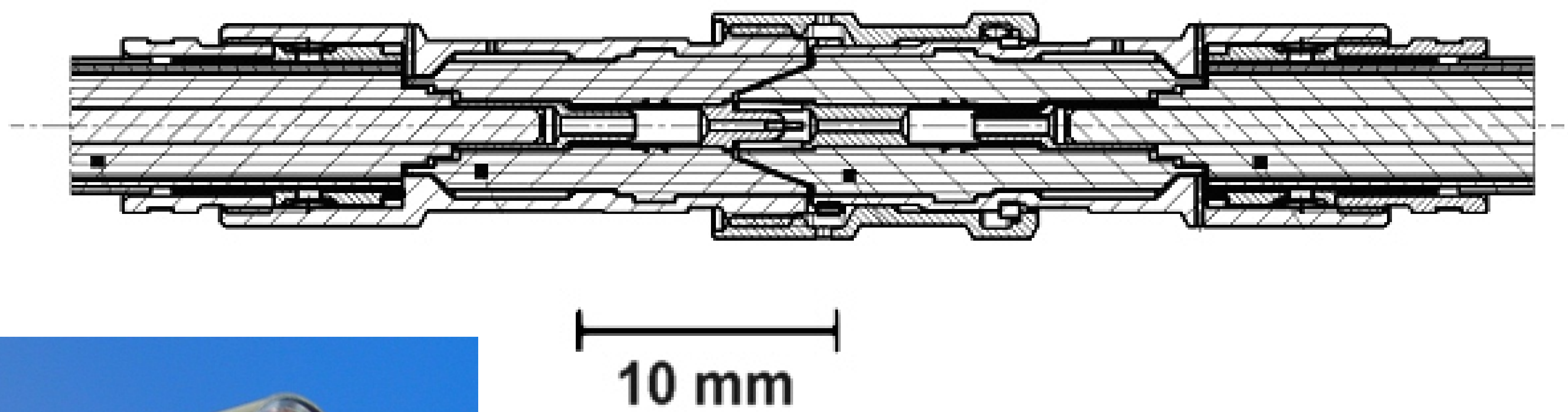


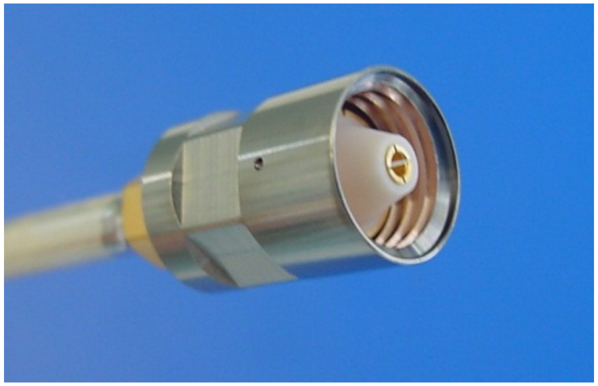
PSM

Cable assemblies connected to flange connectors



Design: Cross-Section of a PSM Connector Pair





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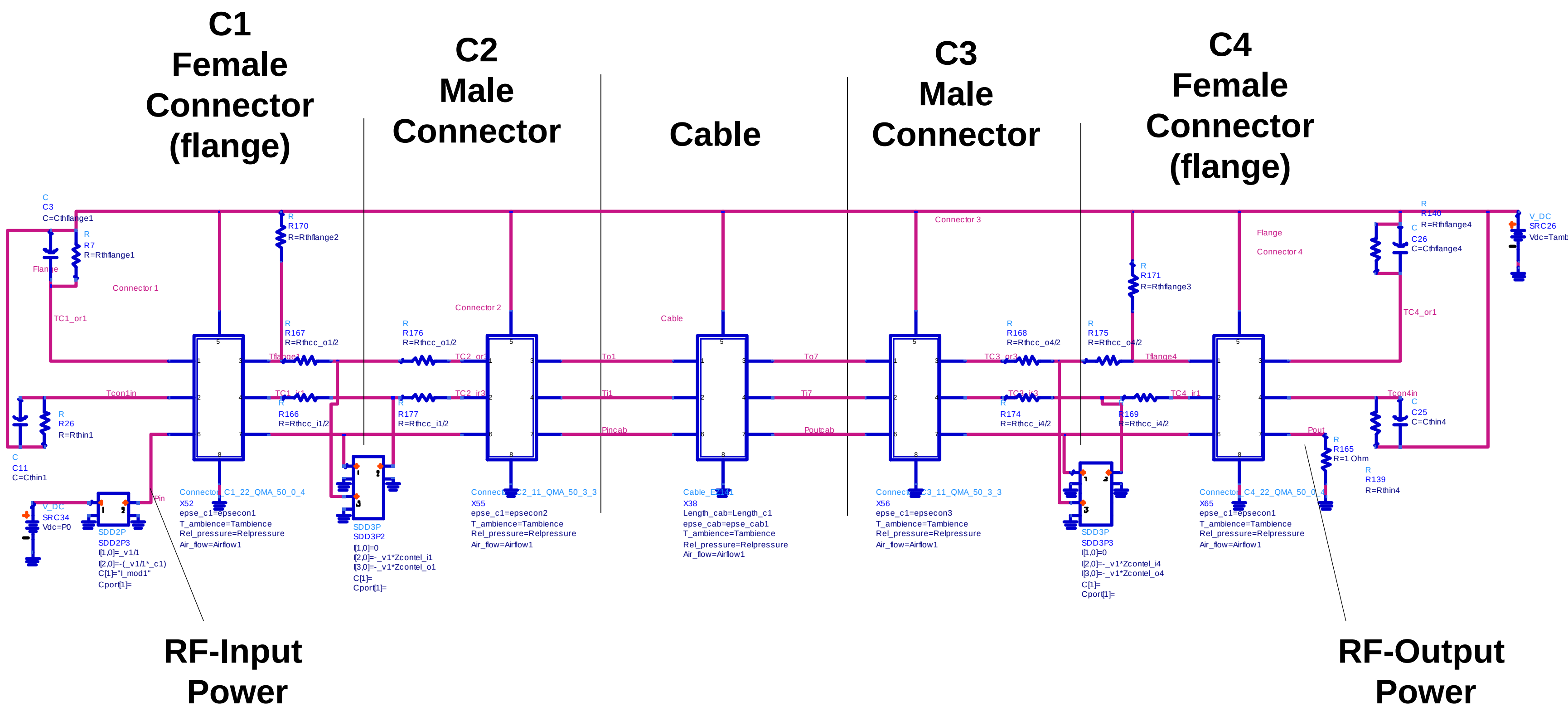
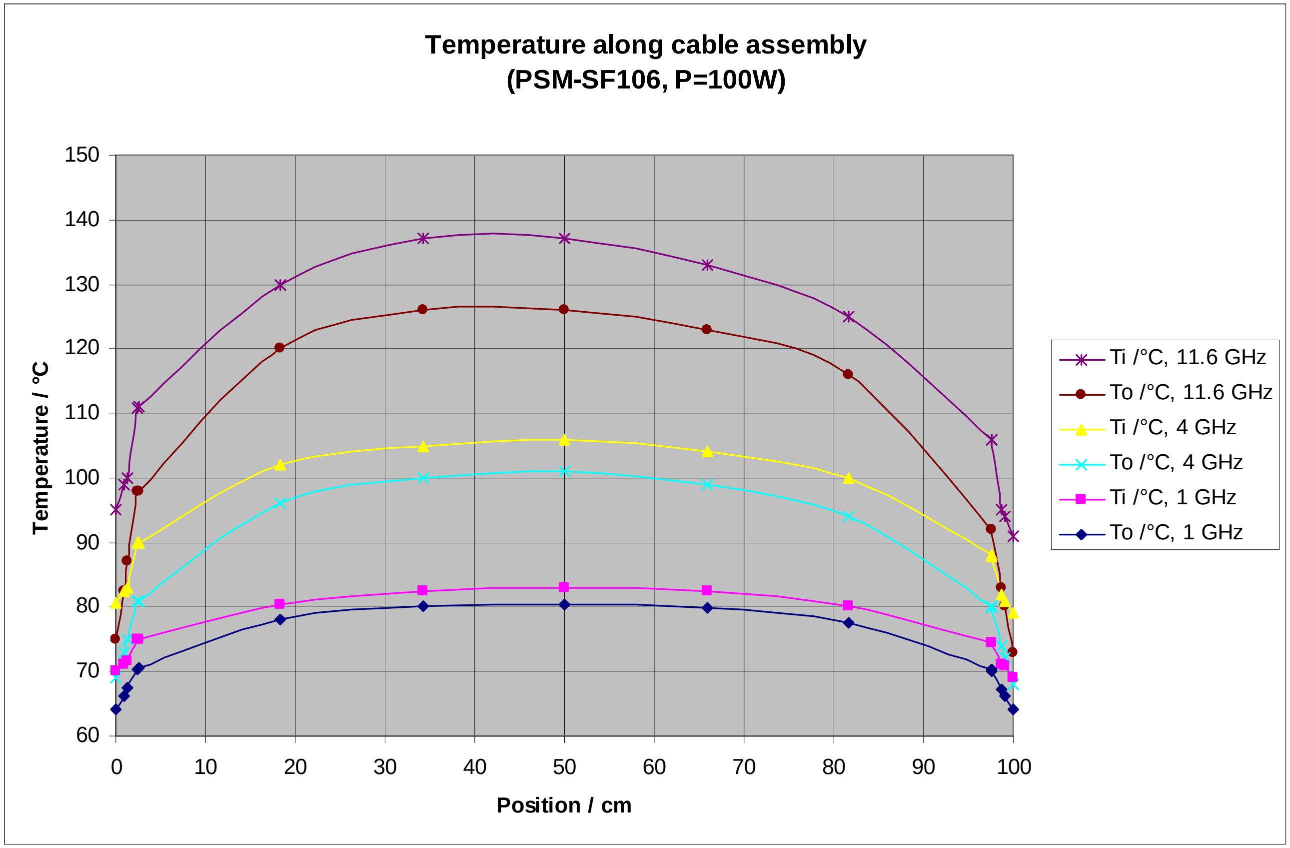
Equivalent Circuit Diagram of a Cable Assembly



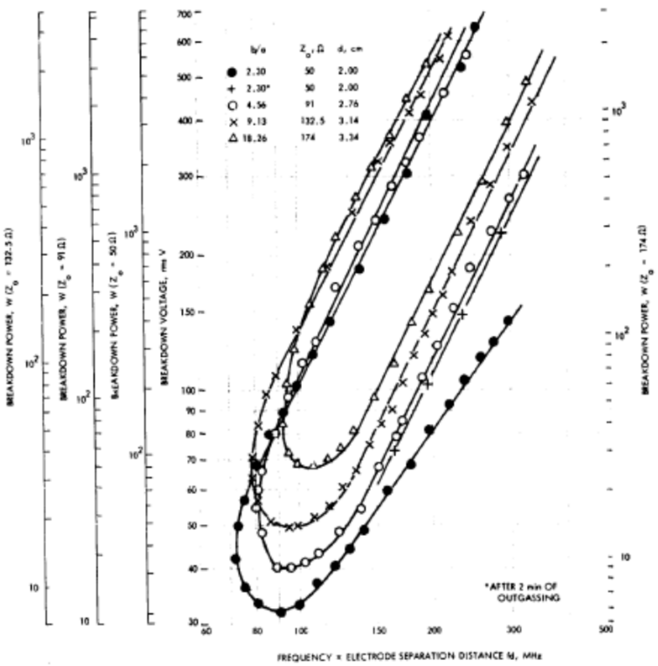
- **(Metal) attenuation is temperature dependent**
- **Radiation is temperature dependent**
- **Convection is temperature dependent**

Example: Temperature distribution in a cable assembly



Temperature distribution along a PSM-SF106 cable assembly for 3 different frequencies with input powers of 100W. (Ti = temperature of inner conductor, To = temperature of cable jacket)

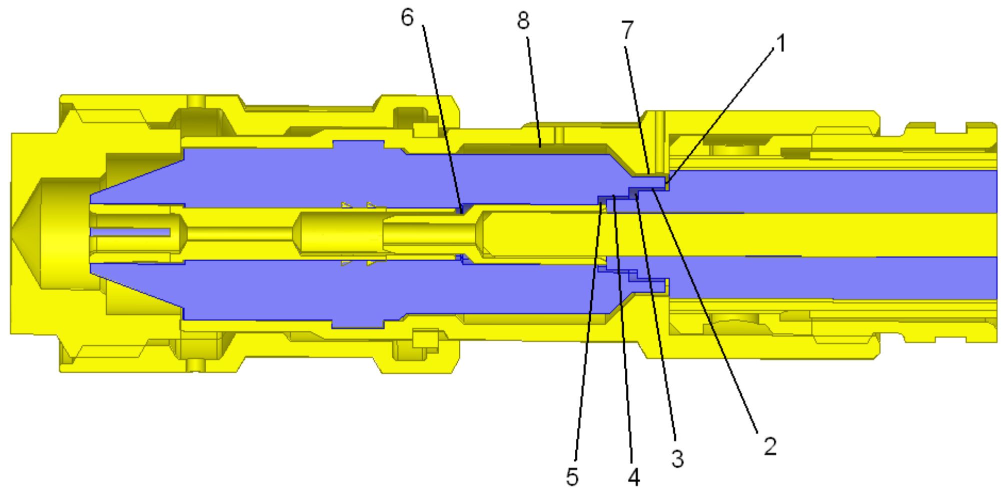
Multipaction



Coaxial multipactor susceptibility chart

(Richard Woo, *Multipacting Discharges between Coaxial Electrodes)*

Gaps in the connector cable interface area



Multipaction: Approach

Analysis of Multipaction:

- **Some Gaps can be analysed by Parallel Plate Approximation**
- **For Others the Measurements of Woo are used, and/or with the Multipactor Tool of ESA**
- **Further ESA Software (MEST and CEST) for non-standard Gaps**

Models for Corona (and Multipaction) Simulations

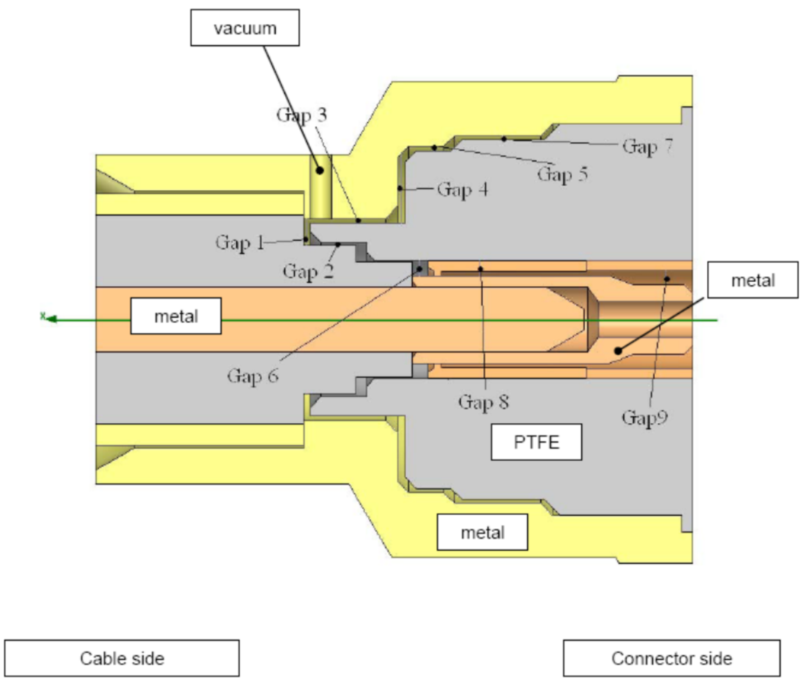


Fig. 31: Cable-Connector Interface. HFSS model.

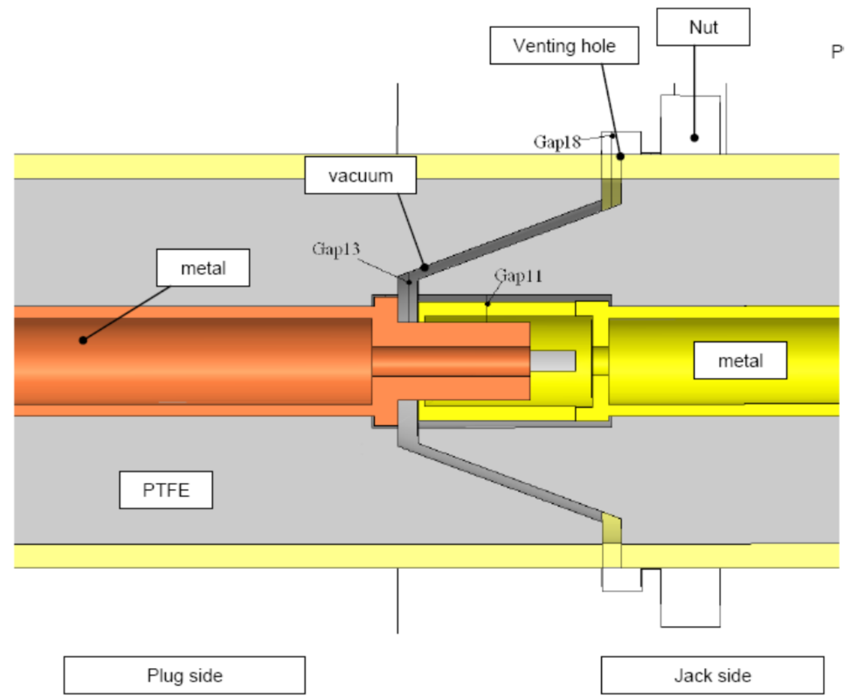


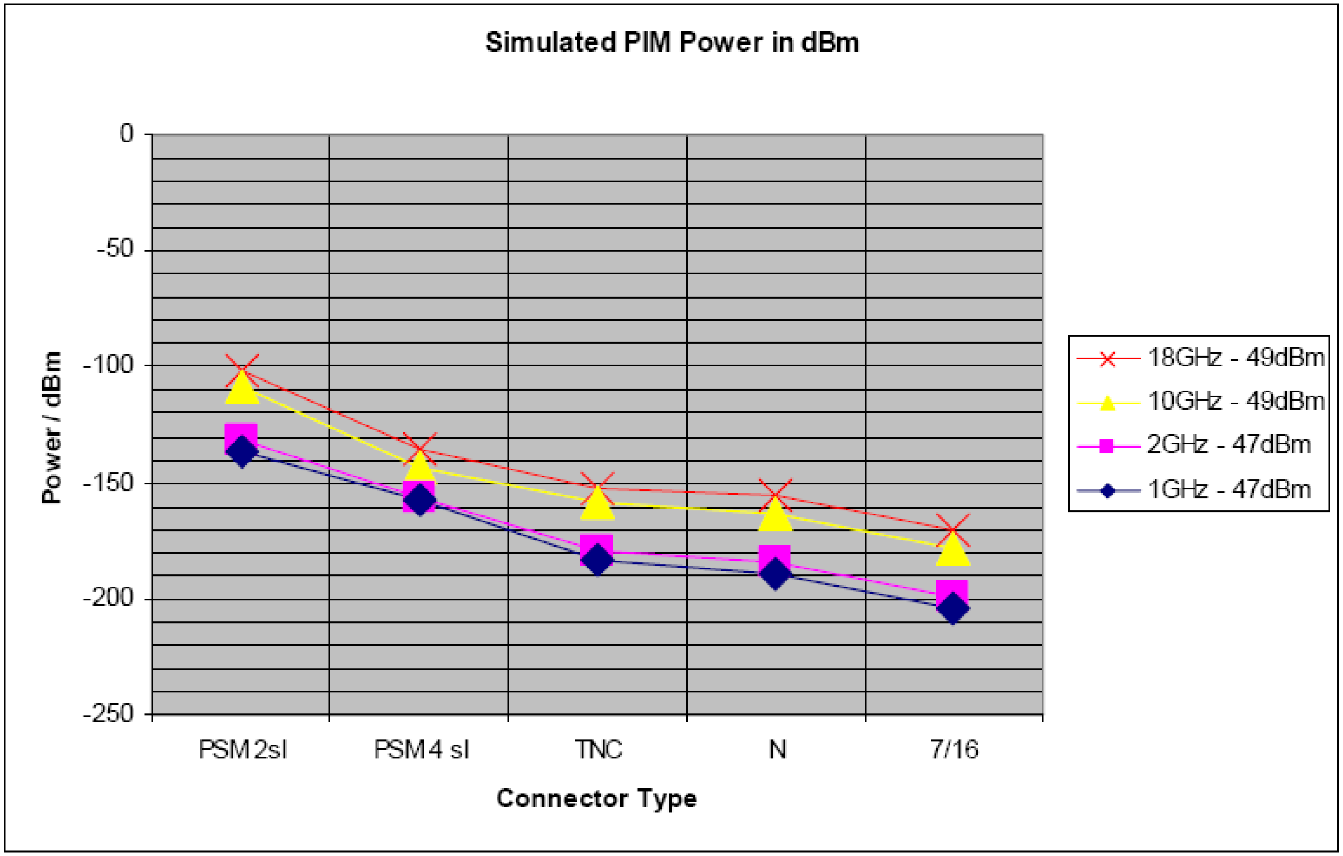
Fig. 35: Jack-Plug Interface (Half-view). HFSS model.

PIM

- **Assumptions**

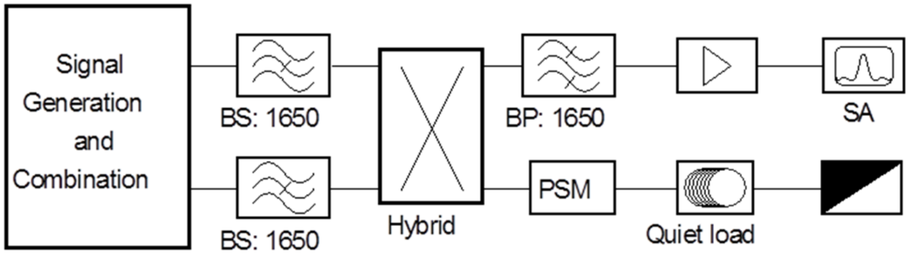
- **PIM is dependent on current density of metal surfaces, especially at metal-metal contact points**
- **Current density depends on input power, frequency, size of conductors, area of contact point**
- **PIM is dependent on contact pressure**
- **PIM is dependent on surface topology**
- **No magnetic effects**

Absolute PIM Power in different Connectors

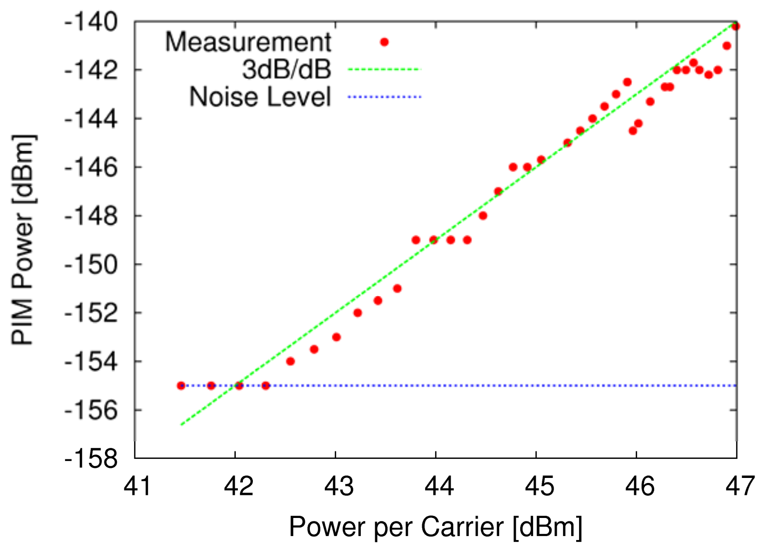


PIM Measurements

PIM measurement setup. The connections from hybrid to band stop (BS), band pass (BP) filter and PSM are done with contact less connectors



Measured PIM level as a function of the power per carrier (7th order)



(Measurements done at ESA-VSC laboratories, VAL Space, Valencia)

Conclusions

- Models and Simulations of
  - Thermal properties
  - PIM
  - Corona, Multipaction
  - Mechanical Design
- A set of engineering sample connectors fabricated and characterised
- The PSM connector is a fully optimized connector for high power applications in space with low mass
- Easy replacement of SMA connectors with power levels of TNC
- Easy one by one replacement of TNC (soon)
- For the PSM connector a patent has been filed.

Next Steps

- **Start of product development project with the goal of ESA-qualification**
- **Fabrication and measurement of new cable assemblies**

Many thanks

(in the name of the whole team)

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