QUARTZ-S: SMT Electromechanical Relay ESA Qualification

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ABSTRACT

The constant challenge for space manufacturers is to save both weight and volume. Every gram matters, every cubic centimeter counts. Systems must become more compact and lighter while meeting the uncompromising reliability standards required for space missions. At the same time, cost efficiency remains a key driver in an increasingly competitive industry.

Electromechanical RF switches are widely used in payloads, particularly for redundancy architectures where reliability is absolutely critical. Designers are therefore constantly seeking solutions that maintain the highest levels of performance while reducing cost, weight, and integration complexity.

In response to this challenge, Radiall developed five years ago an innovative SMT electromechanical RF switch, designed to integrate the switching function directly onto the PCB. By eliminating traditional coaxial RF ports, this solution enables a new level of compactness and system integration. The device weighs less than 10 grams, compared to approximately 60 grams for conventional solutions. Even more significant are the system-level savings achieved by replacing RF cable assemblies with direct PCB track interconnections.

The first qualification campaign was successfully completed in 2022. Following this milestone, the focus shifted toward industrialization in order to prepare the product for repeatable and reliable series production. Several batches of flight models have since been manufactured. As is often the case in such programs, this phase allowed us to refine manufacturing processes, improve tooling performance, and strengthen overall process robustness.

Today, the product has reached a new maturity level and we are ready to freeze the design and manufacturing baseline in preparation for ESA QPL qualification.

This presentation will first revisit the operating principles of these SMT electromechanical switches, and then detail the development, industrialization, and qualification journey that has brought us to this key milestone.

As of March 10th, the qualification test campaign has just begun. The schedule is secured, and completion is expected within the planned timeframe. We are therefore confident that this work will soon stand as a compelling success story to be presented at the 2026 SPCD conference.

INTRODUCTION

In 2020, Radiall was included in SELECTOR consortium, “Smt compatible ELECTroMechanical relay for cOmpact redundancy Ring”

SELECTOR value chain includes a supplier of space passive component “Radiall”, a space integrator “Thales Alenia Space”, a leader into electromagnetic design the “Universitat polytecnica of Valencia” and a center of excellence for space reliability of high complexity miniature component the “CSEM”.

SELECTOR initial objective was to reinforce European technological autonomy by developing innovative passive components for the space sector. The project focuses on high miniaturization through SMT-compatible electromechanical relays (MEMR), with the objective to add them to ESA’s European Preferred Part List (EPPL) for unrestricted industry-wide access.

Strategic Goal: Reduce EU’s technology dependence and strengthen European space industry competitiveness.

Developments:

- To have Space-qualified, SMT-compatible Miniature Electromechanical Relays (MEMR), already validated in terrestrial microwave applications.
- To include it in the ESA EPPL to ensure availability to all European manufacturers with no export restrictions.
- To demonstration of a new concept for self-redundant microwave “Metaequipment,” using SMT board-level integration with MEMRs to lower cost and maximize miniaturization.

Target Applications: Very High Throughput Satellites (VHTS), where massive RF chain integration via digital technologies requires cost-driven, miniaturized, highly integrated solutions.

Project ended successfully with the Quartz-S final prototypes qualification and design validation.

OPERATING PRINCIPLE OF THE SMT ELECTROMECHANICAL SWITCH QUARTZ-S

Quartz-S is the commercial name for a latching, SMT, SPDT switch that can work with 6V; 12V or 24V. The only change required to go from one nominal voltage to another is to update the coil wiring.



Fig. 1 Photo of the QUARTZ-S SMT electromechanical switch

The RADIALL electromechanical switches use an arrangement of rectangular coaxial transmission lines either in «transmission line» position or in «isolated line» position to realize the required switching function.

The RF signal is supplied on the input port through the RF connector soldered on a PCB: circular coaxial transmission line; then from the input to the output RF connector antennas, the RF signal is transmitted through the RF cavity via the RF blade in “transmission position”: rectangular coaxial transmission line.

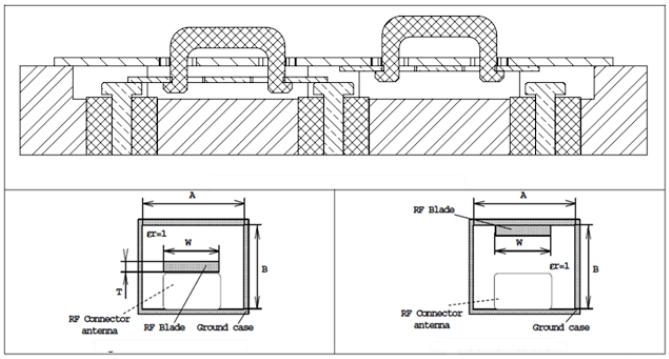


Fig. 2 - RF transmission and isolated lines (simplified view)

The Quartz-S is designed to transmit signal up to 32 GHz. For Qualification testing, the Quartz-S is soldered on a Test fixture with stripline technology and soldered SMA2.9 connector for RF measurement (See “Fig. 3”). Due to this large wideband, there is some difficulty to have test fixture compliant up to 32 GHz. Measurement start to deteriorate after 28 GHz, with TDR analysis, it is confirmed that the performance degradation comes from the test fixture.

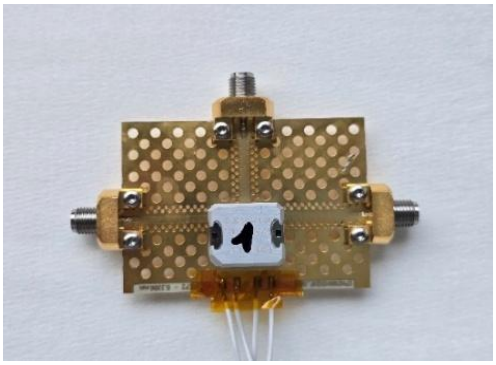


Fig. 3 Photo of the QUARTZ-S Soldered on a test fixture

Insertion Loss and VSWR data measured on qualification unit are given in “Fig. 4” below:

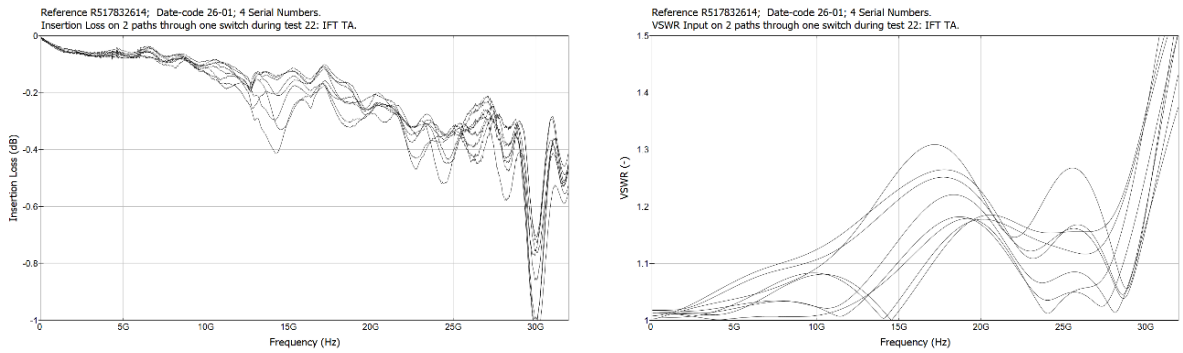


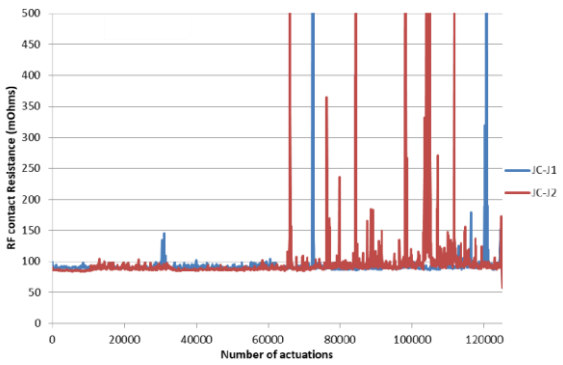
Fig. 4 Qualification initial IL & VSWR performance DC-32 GHz (4 units)

DEVELOPMENT AND INDUSTRIALIZATION

- **Life test improvement**

As stated in the abstract, Quartz-S design was validated in 2022 during SELECTOR project.

Biggest challenge from this experience was the life testing as the product started to show some poor RF contact resistance measurement after 50 000 actuations shown in “Fig. 5”



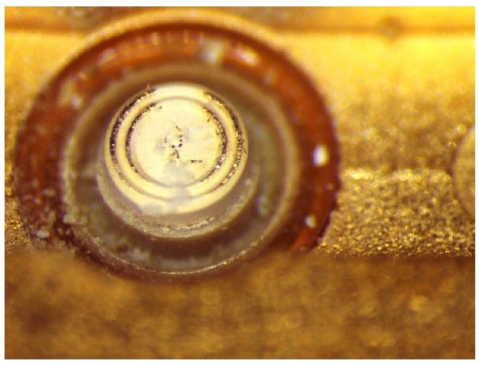


Fig. 5 Life test result and contact photograph after 1 000 000 actuations

After a lot of investigation and delta-testing, Radiall found a way to remove this white “residue” shown on the photo above and to have a unit compliant up to 300 000 actuations cycles.

- **Process improvement**

Radiall implemented and qualified a new equipment to deposit the correct quantity of glue on the RF contact and RF insulator. This process was previously made manually and highly dependent on the dexterity of the operator. “Fig. 6” shows a Ø 0.4 mm in diameter RF contact glued in its insulator.





Fig. 6 RF pin glue photograph and Automatic glue equipment

- **Screening RF measurement tools**

During SELECTOR, Radiall designed and improved a specific tool for a solderless RF measurement on screening unit. The unit is placed on a rigid plate and RF connection is made by solderless contact (Gold/Gold). The contact pressure is applied by a blade that act as a spring and keep the 50 Ohms impedance through the cavity.

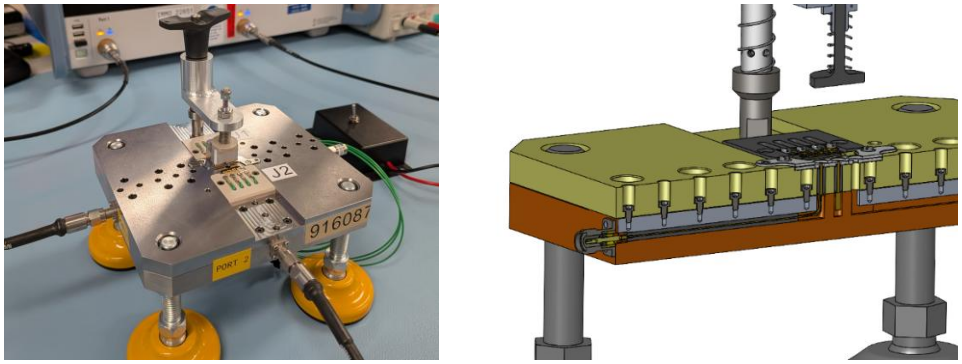


Fig. 7 RF measurement tool

ESA QPL QUALIFICATION CAMPAIGN

After all those changes were validated, Radiall was audited by ESA ESCC team in October 2025 (Report Radiall-AUD-2025). Findings are taking cared of and will be closed before end of 2026.

ESA qualification was launched in march 2026 as per ESCC3603[1]

Test	**Description**
Initial functional test	All RF and Electrical performance checked at Min and max temperature
Sine vibration test	30g up to 2000 Hz
Random vibration test	50 grms
Mechanical shock test	1500g Half sine 0.3ms
Thermal Vacuum test	25 cycles Non-Operating -55° to 95°C 10 cycles Operating -40 to 85°C
Operating life test	300 000 actuation cycles (-40°C to 85°C)
Final functional test	All RF and Electrical performance checked at Min and max temperature

Table 1. ESA QPL Test plan summary

For vibrations, the relays are fixed on a metallic plate that will vibrate at the specific ESA requirement. Radiall check first resonant frequency on each unit before and after each vibration test. No electrical or RF measurement are performed during test.

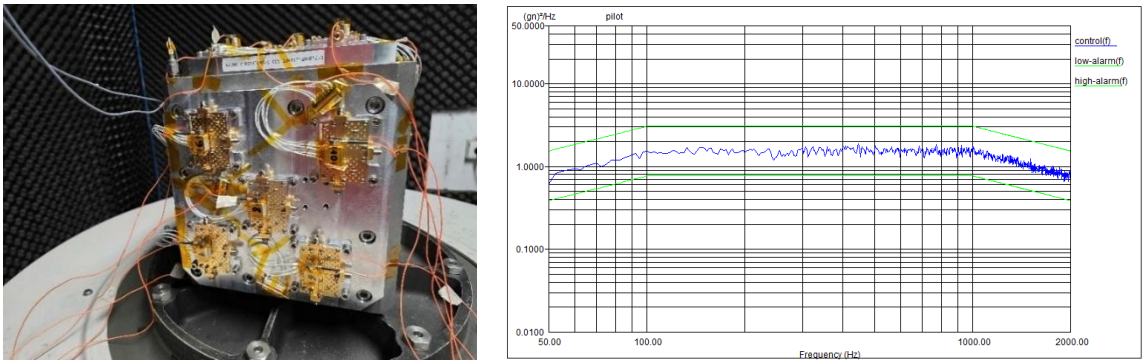


Fig. 8 Vibration test set-up & Random spectrum

Same principle for the shock testing with following shock applied:

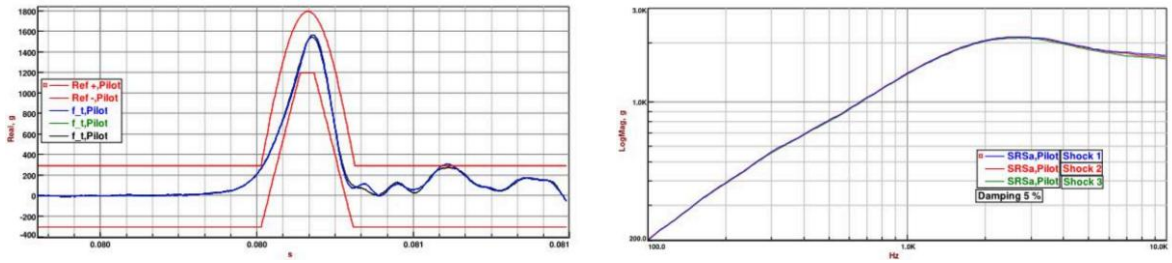


Fig. 9 Temporal Shock & SRS

Thermal Vacuum test is performed with a Thermal vacuum chamber (See "Fig. 10") that can reduce the pressure down to 1 x 10^{-6} mBar. The relays are placed inside the chamber, screwed on a Rigid plate for convection heat transfer and then placed under vacuum. The relays are also wired to an automatic bench to perform electrical measurement at each temperature plateau (Pick-up Voltage, switching time, RF path resistance, etc…). "Fig. 11" shows RF contact resistance measurement during TVT, 30 measurement at cold and hot temperature.

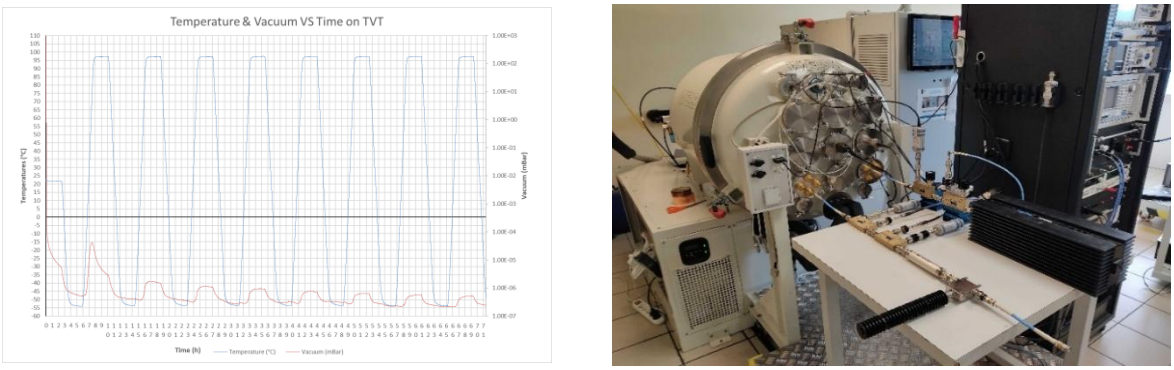


Fig. 10 Thermal Vacuum Chamber

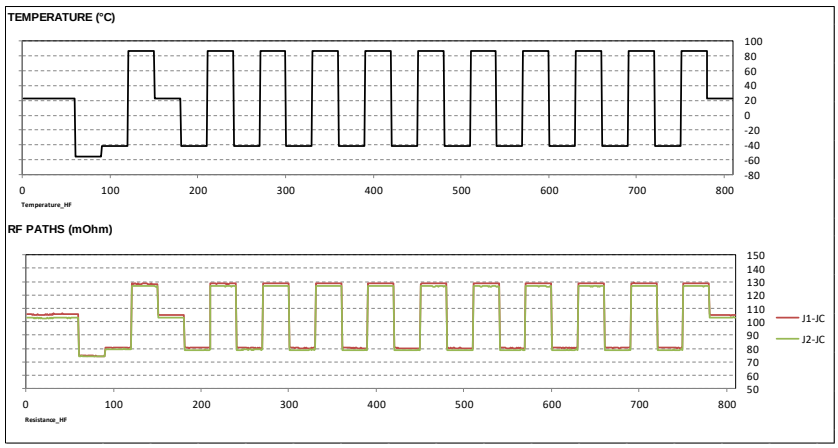


Fig. 11 Example of RF contact resistance measurement during TVT

CONCLUSION

Quartz-S ESCC QPL validation is planned for end of 2026.

With SELECTOR, TAS had the idea to implement the Quartz-S in their new Software-defined satellite soon to be launched with approximately 200 unit per satellite. This will be the first flight heritage for the Quartz-S.

Quartz-S was also proposed for other customer (with first EM and FM delivered) without any real hook yet due to major PCB design requirement to implement SMT relays to replace current electromechanical switches.

ACKNOWLEDGEMENT

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REFERENCES

[1] [ESCC 3603 Issue 2]

[2] [ESCC 3603007 Issue 2]