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TAKING THE PULSE
OF OUR PLANET FROM SPACE



Advanced Receiver for Future L-Band Radiometer development results

Roger Vilaseca, Albert Catalán, José Montero, Montserrat Puertolas, Bianca Santano, Dani Giménez, Ignasi Corbella

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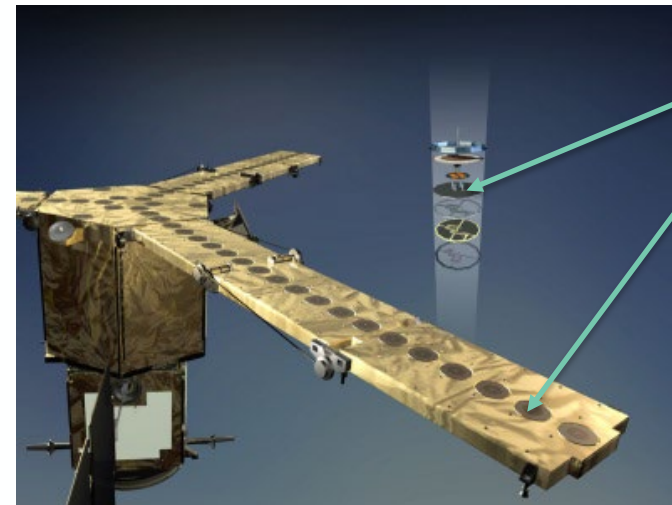
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I – SMOS follow-on: targeted performance improvements

- SMOS was launched in 2009
- Provides L-band valuable scientific global measurements:
 - Soil Moisture + Ocean Salinity
 - Secondary products: thin sea ice, frost/thaw soils, high winds, ocean surface wind and Sun brightness temperature
- SMOS L-band receivers (LICEF) provided by SENER Aeroespacial



LICEF receivers
(L-band)

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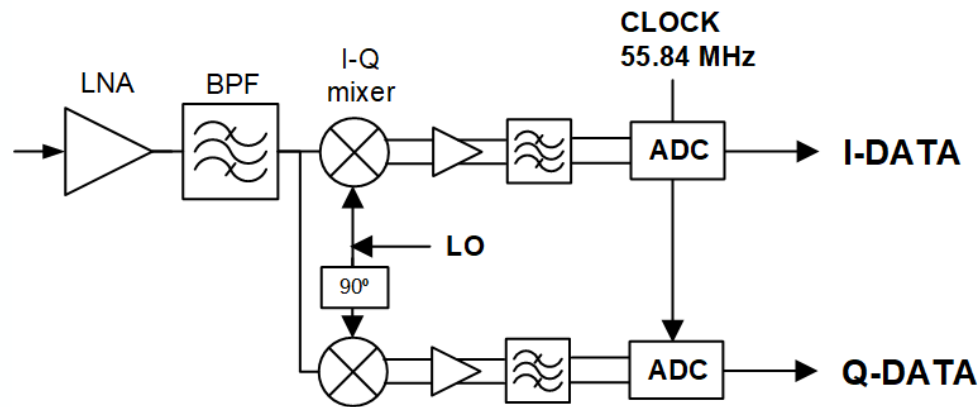
I – SMOS follow-on: targeted performance improvements

- ALR (Advanced L-band Receiver) is a development under ESA contract of a new receiver to improve system level performance from SMOS:
 - Increase spatial resolution => Larger instrument (envelope, power, mass)
 - Increase Alias free FOV => Reduce antennas spacing (smaller receiver)
 - Full-polarimetric mode => Two RF chains (H and V polarisations) instead of 1 RF chain + input switch
 - Improve instrument sensitivity => Improve NF

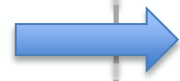
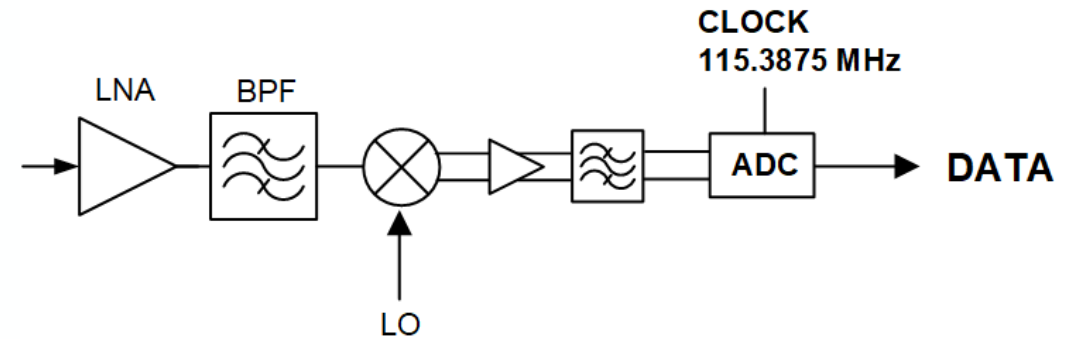
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II – ALR trade-off's: Digital vs Analog I-Q

Analog I-Q (SMOS)



Digital I-Q (ALR)



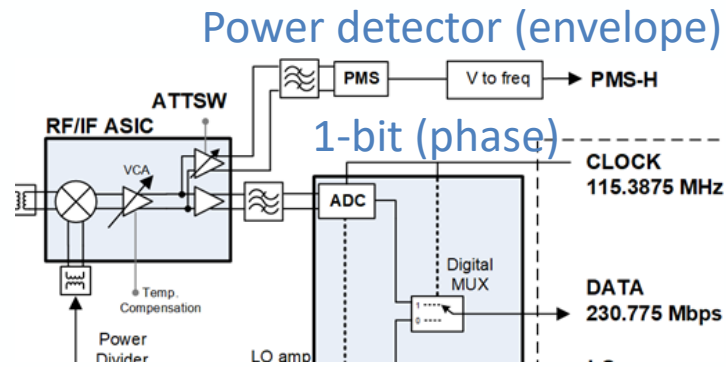
- ! • Two mixers and IF chains
- ! • Higher mass, power and envelope
- I-Q quadrature unbalance phase error
- I and Q IF chains frequency response must be matched

- Only one IF chain
- Lower mass, power and envelope
- IF centre frequency (CLK / 4) error becomes relevant, but it can be corrected by data post-processing

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II – ALR trade-off's: 1-bit ADC vs fully digital

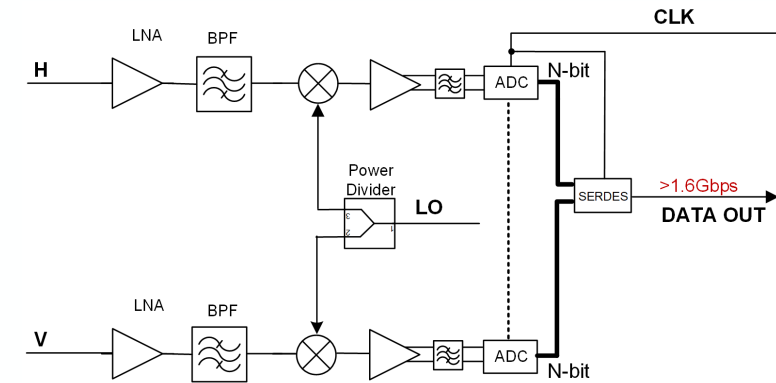
PMS + 1-bit ADC (SMOS, ALR)



- RFI mitigation at correlator level
- Instrument performance and equations are known from SMOS
- Digital correlations are simple, require minimum FPGA/ASIC resources (XOR+Add/Accumulator)
- 230Mbps of digital data / unit
- Lower consumption (<1.5W per unit)



N-bit ADC + Digital processing

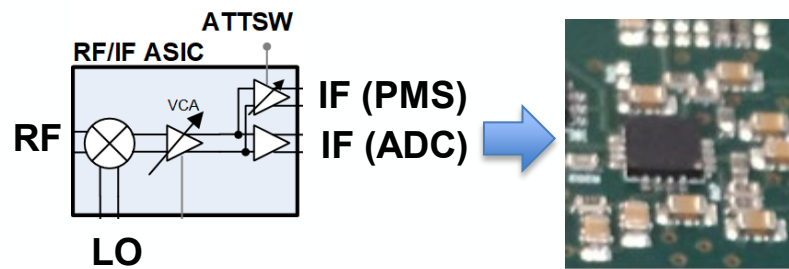


- Additional techniques could be applied for RFI mitigation (sub-bands, etc)
- Complex digital processing (correlation requires Multiplier + Add/Accumulator)
- ! • >1600Mbps of digital data / unit
- ! • Higher consumption (>2W per unit) (plus digital processor)

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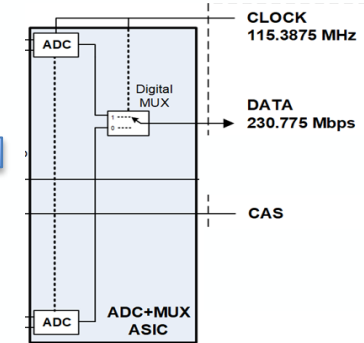
III – ALR improvements: ASIC

- SiGe mixed signal ASIC's developed to minituarize RF section and reduce power consumption:



RF/IF ASIC

- Mixer
- IF amplifiers
- Variable attenuator
- Slope corrector
- PMS switchable attenuator



ADC+MUX ASIC

- Dual 1-bit ADC's
- 2:1 Digital Multiplexer
- Transmission over single fiber

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III – ALR improvements: BPF mass reduction

- Two BPF required => Mass, envelope driver!
- Added transfer zeros to reduce order from 8 to 6 (mass reduction of 25%)
- Direct interface with RF substrates instead of SMA cables
- Meet same mask as SMOS with 25% mass reduction

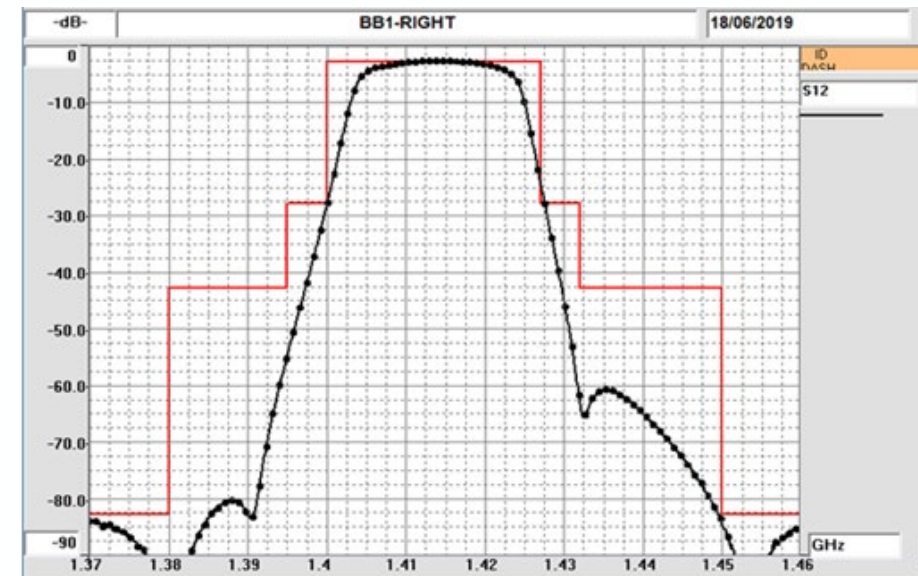
SMOS BPF



ALR BPF



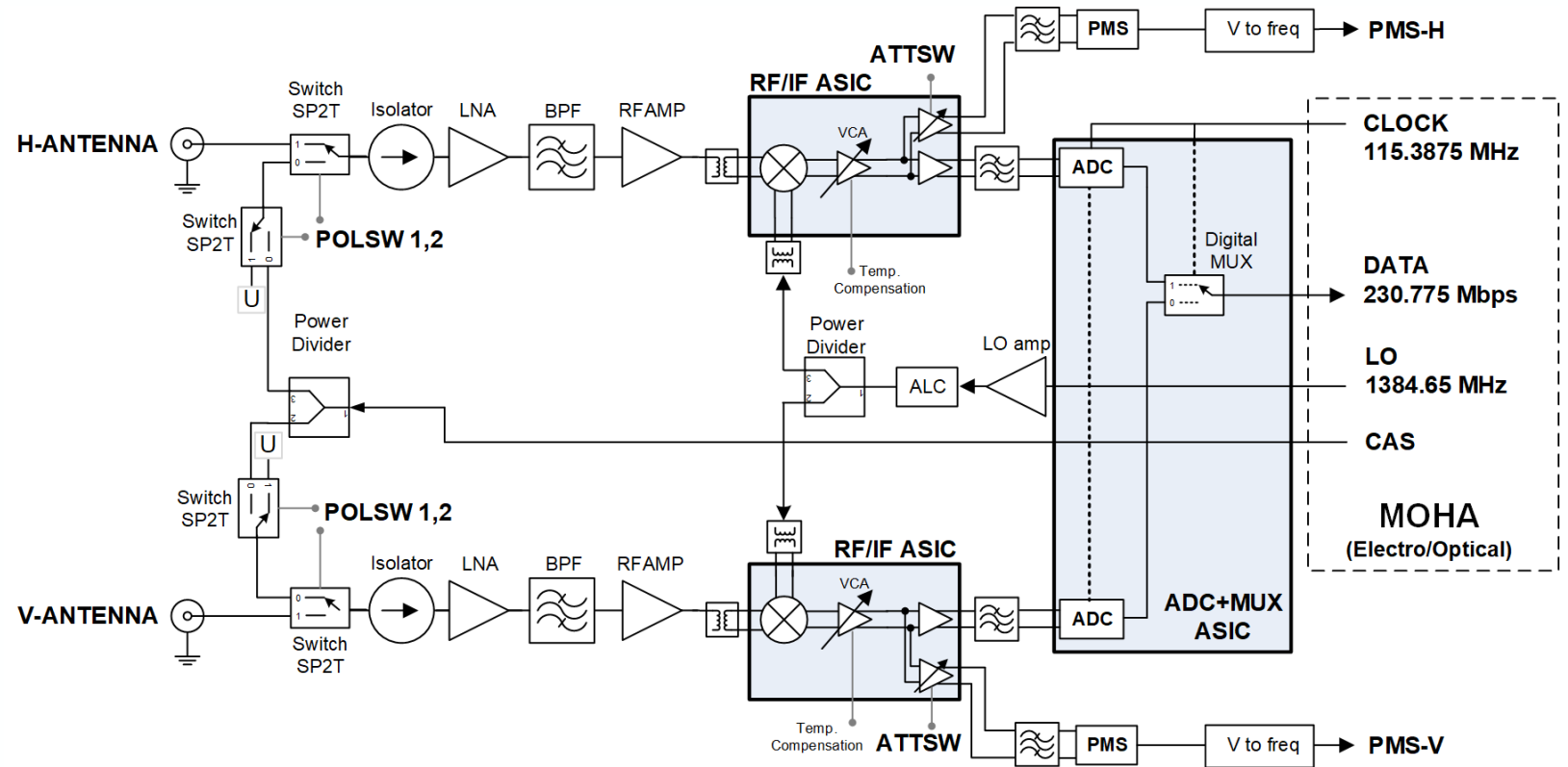
ALR BPF test result



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IV – ALR Design Description

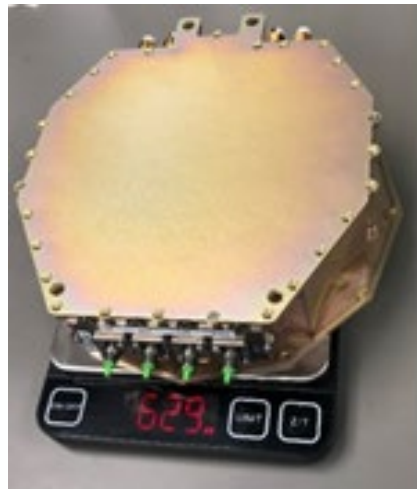
- Radiometer calibration switch (U and CAS)
- H & V parallel receiver chains
- LNA with minimum NF
- BPF
- PMS (power monitor) with V to freq converter
- RF/IF and ADC based on ASIC's
- Optical signal distribution



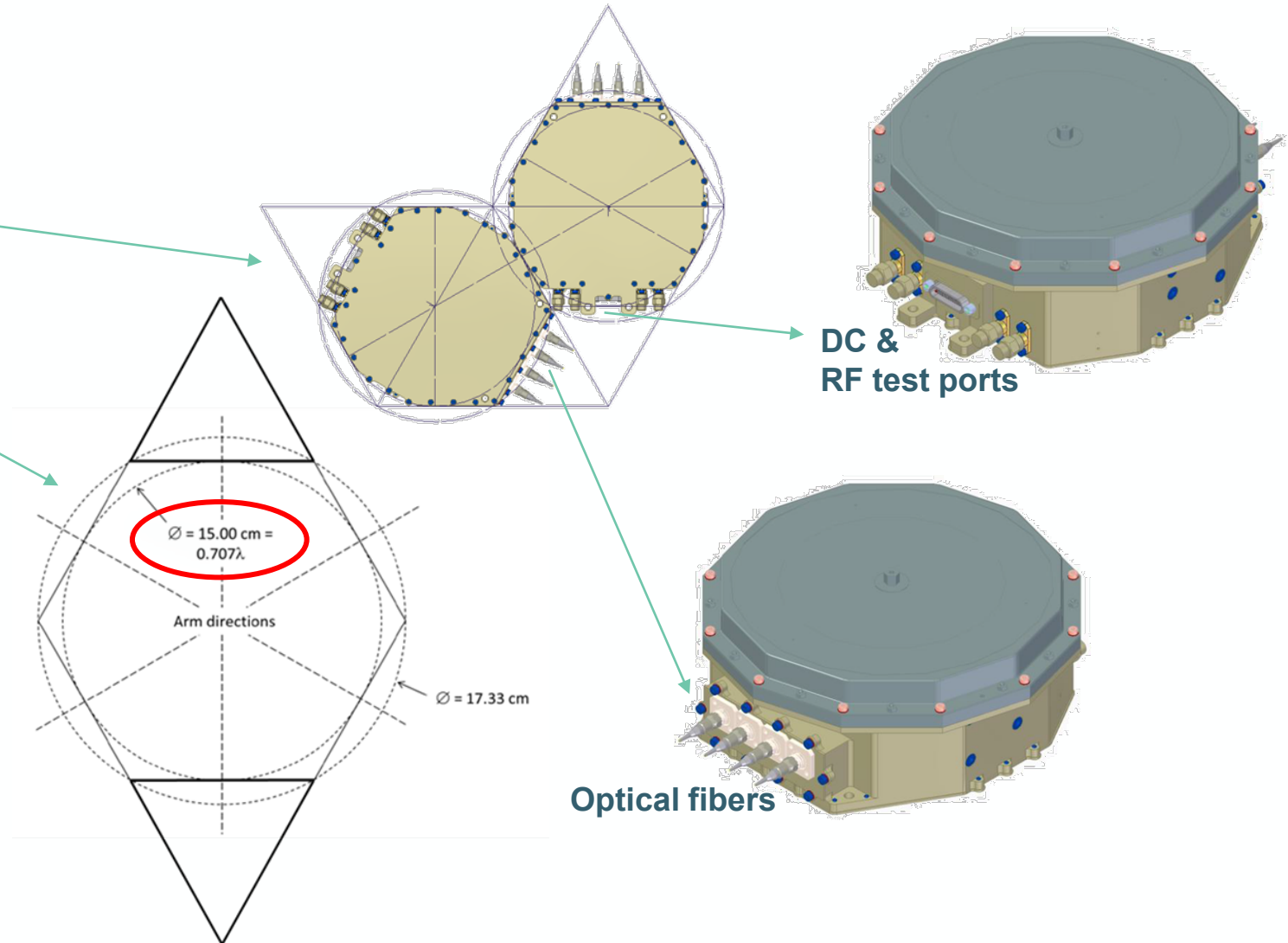
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IV – ALR Design Description

- Connectors location to avoid mechanical interference
- Envelope: Fit into smaller hexagon
- Mass reduction



Mass without antenna



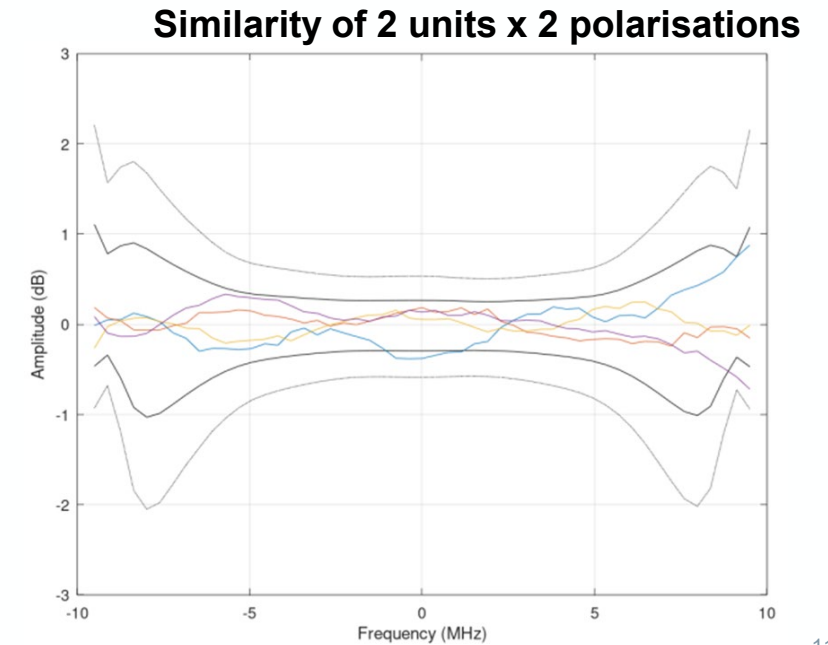
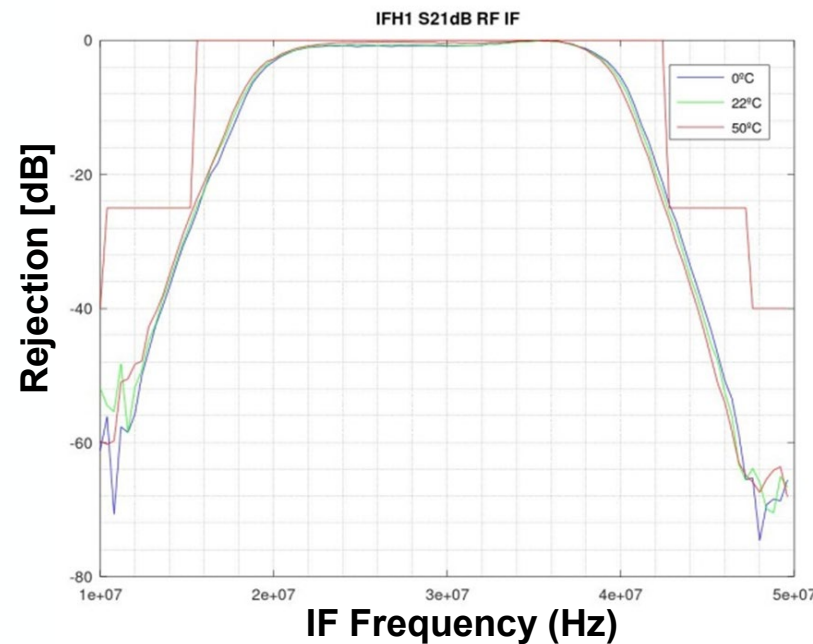
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V – ALR test results

- NF @T=22°C reduced from 1.86dB (SMOS) to 1.35dB (ALR)

	0°C	16°C	22°C	28°C	50°C
EM01-V	1.126	1.241	1.296	1.335	1.487
EM01-H	1.157	1.252	1.352	1.394	1.548

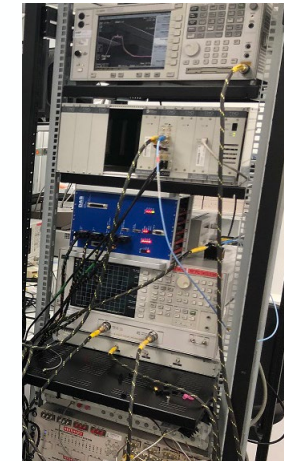
- RF/IF performance
(Rejection + similarity mask):



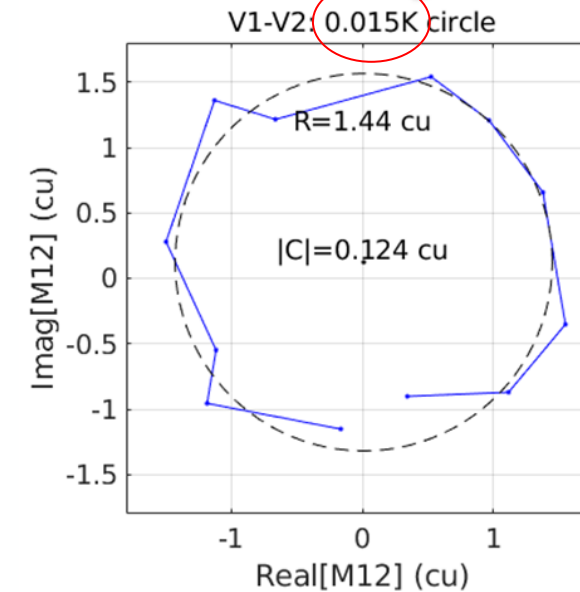
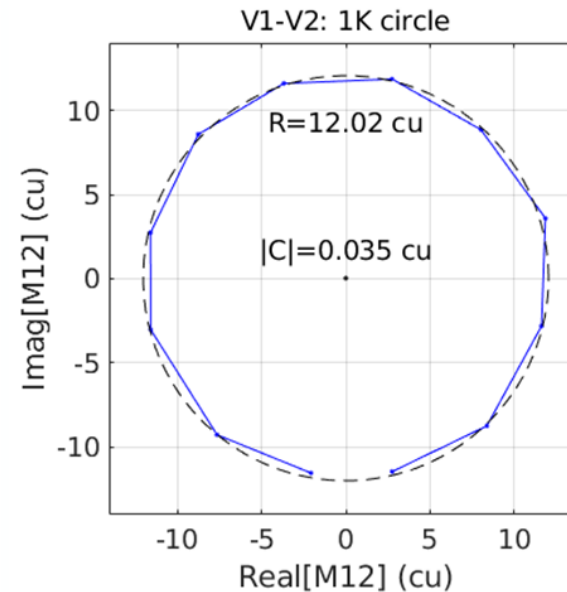
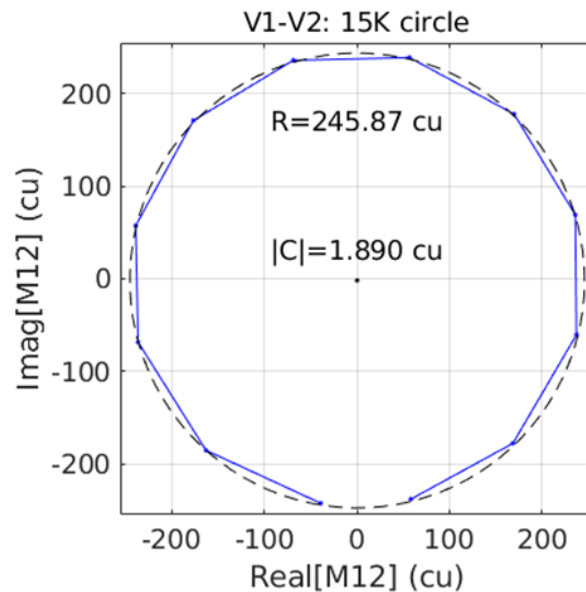
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V – ALR test results

- Correlation measured with our custom EGSE correlator
- >100 cross-correlation products calculated in real time
- Results processed by UPC



0.015K of correlated noise measured



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VI – Conclusions

Two ALR receivers have been built and tested achieving (compared with SMOS):

- Lower NF (higher instrument sensitivity)
- Full polarimetric (simultaneous measurement of H and V polarisations)
- Smaller envelope (reduced distance between receiver antennas to increase instrument alias-free field of view)
- Lower mass (more receivers can be included for higher spatial resolution)

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THANK YOU

 www.aerospace.sener

 www.linkedin.com/company/sener

 www.youtube.com/user/senerengineering

