International Centre for Radio Astronomy Research

RFI Assessment of Photovoltaic Modules for Radio Astronomy Applications

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Curtin University

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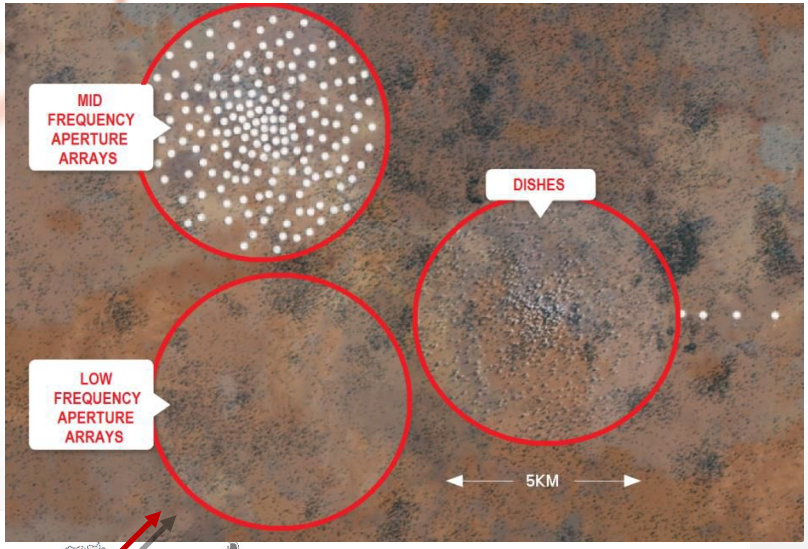
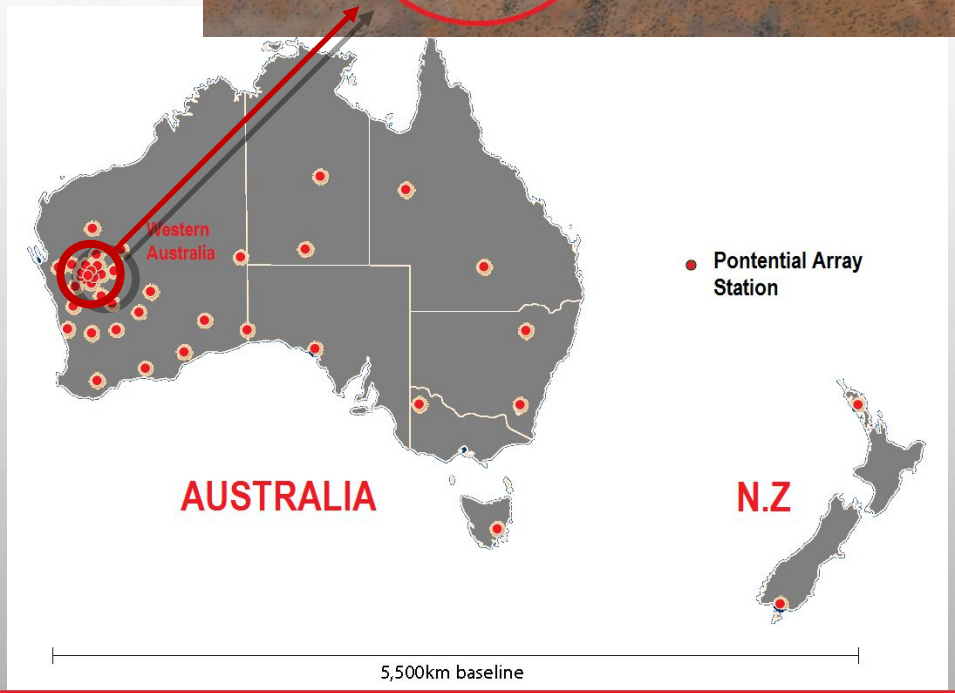
Overview

- Introduction
- Interference model
- Preliminary measurements
- Conclusion

Introduction





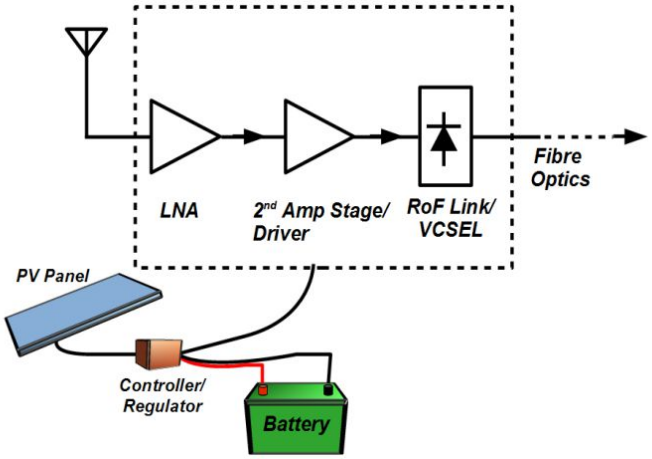
Square Kilometre Array (SKA)

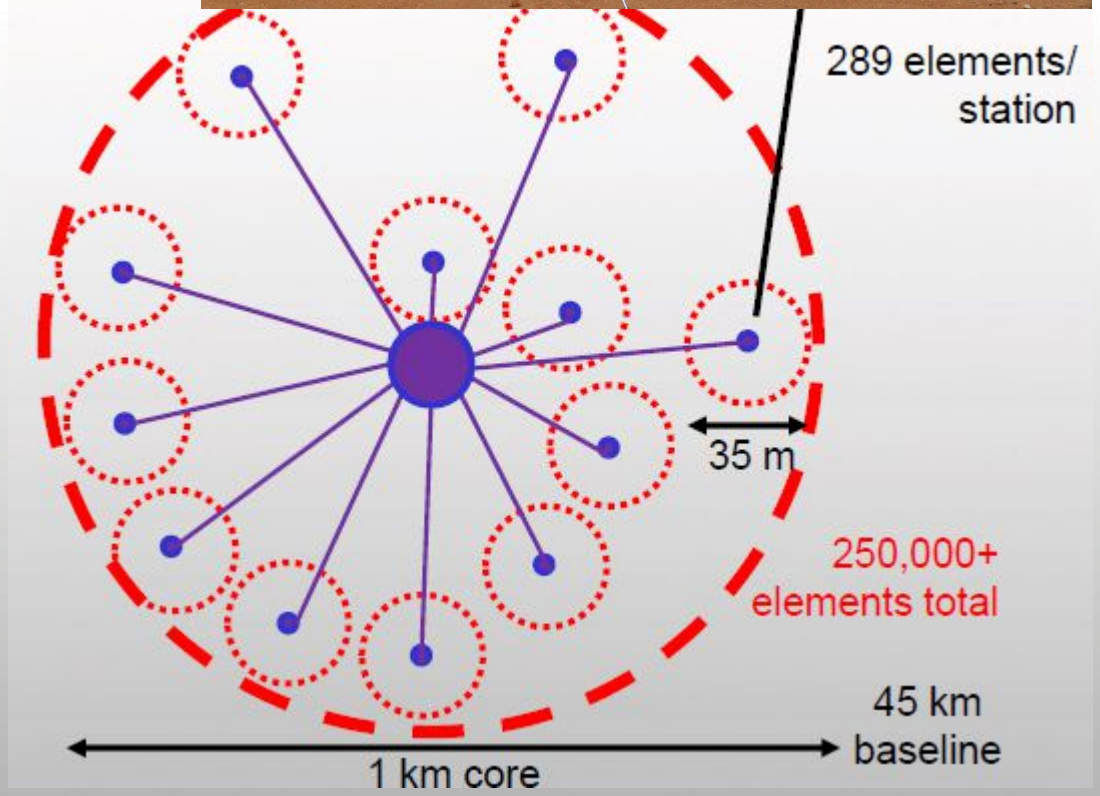
- Most sensitive radio telescope in the world
- International project
- Collecting area 1 km^2
- Location: Australia-NZ, Southern Africa

International Centre for Radio Astronomy Research (ICRAR)

- The University of Western Australia + Curtin University
- State (WA) and Federal support
- Contributor to SKA-Low (AAVP)

Introduction: SKA Low





Each antenna element needs power for

- LNA
- 2nd stage amplifier
- RoF link

Distributed photovoltaic modules:

- Solar panel
- Controller/Regulator
- Battery

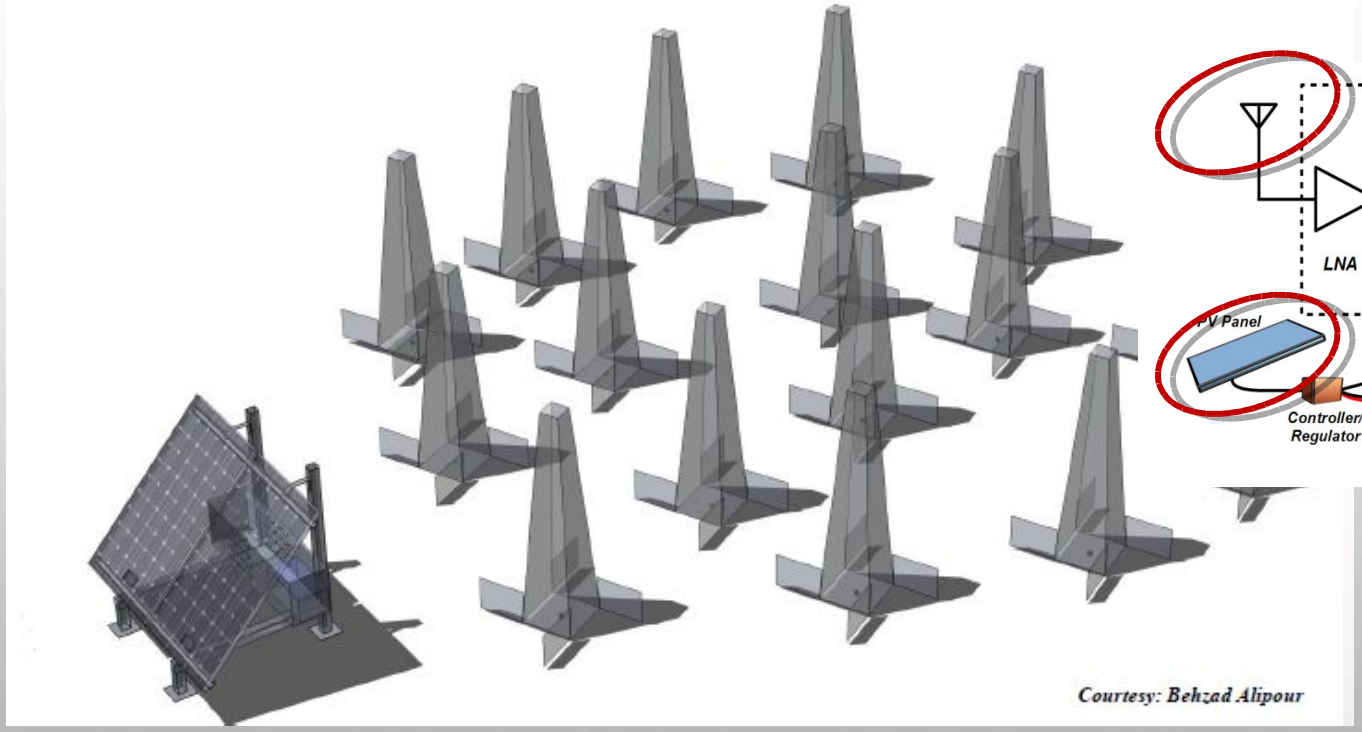
Interference model

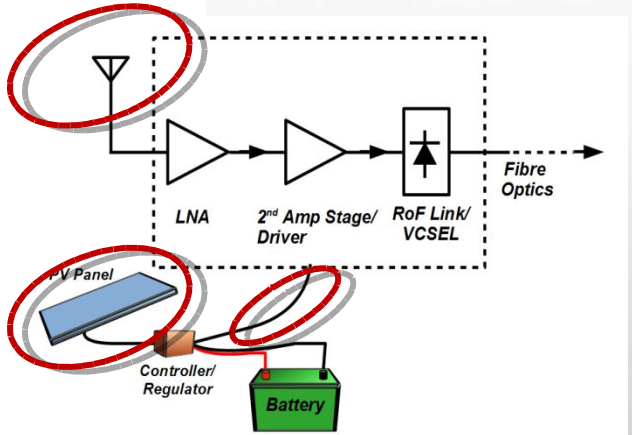
Controller/Regulator is the main noise source

Conducted noise can interfere with performance of LNA

Conducted noise can lead to radiation from:

- Solar panel and the connecting cable
- Battery and the connecting cable
- SKA-Low antennas and the connecting cables





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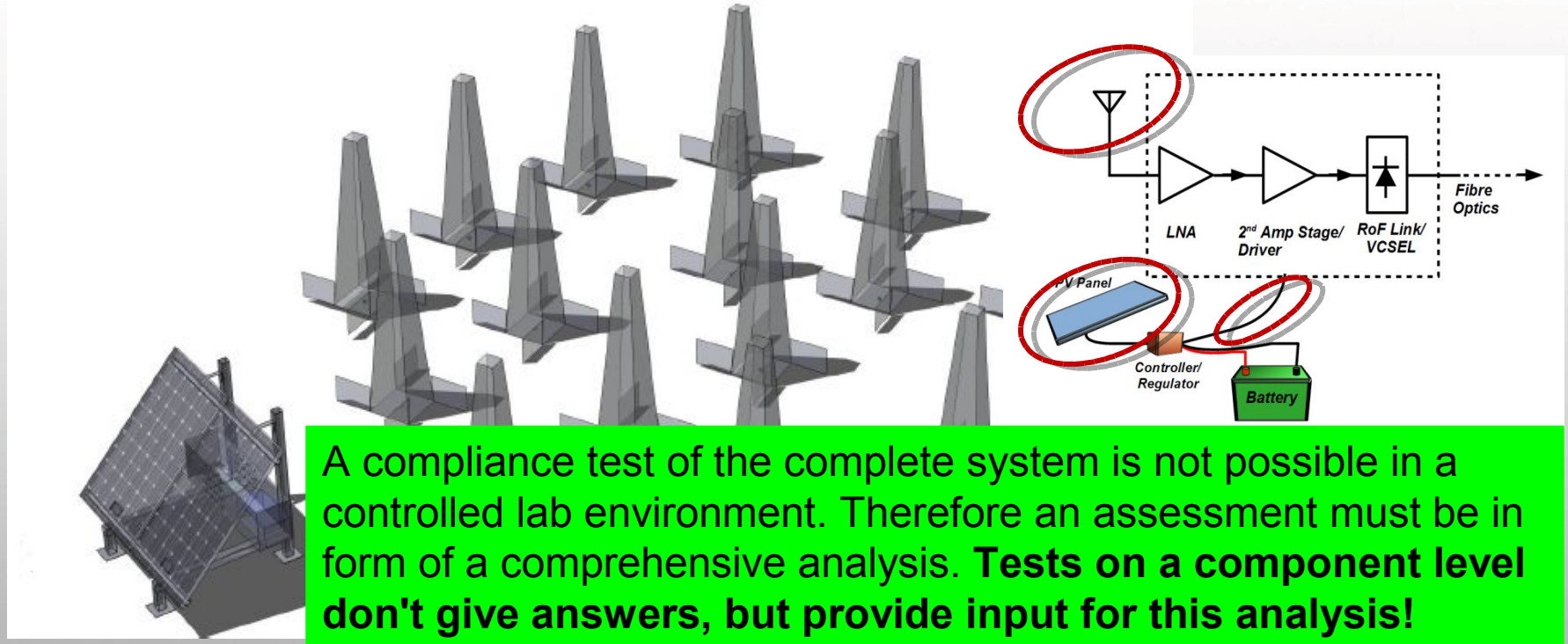
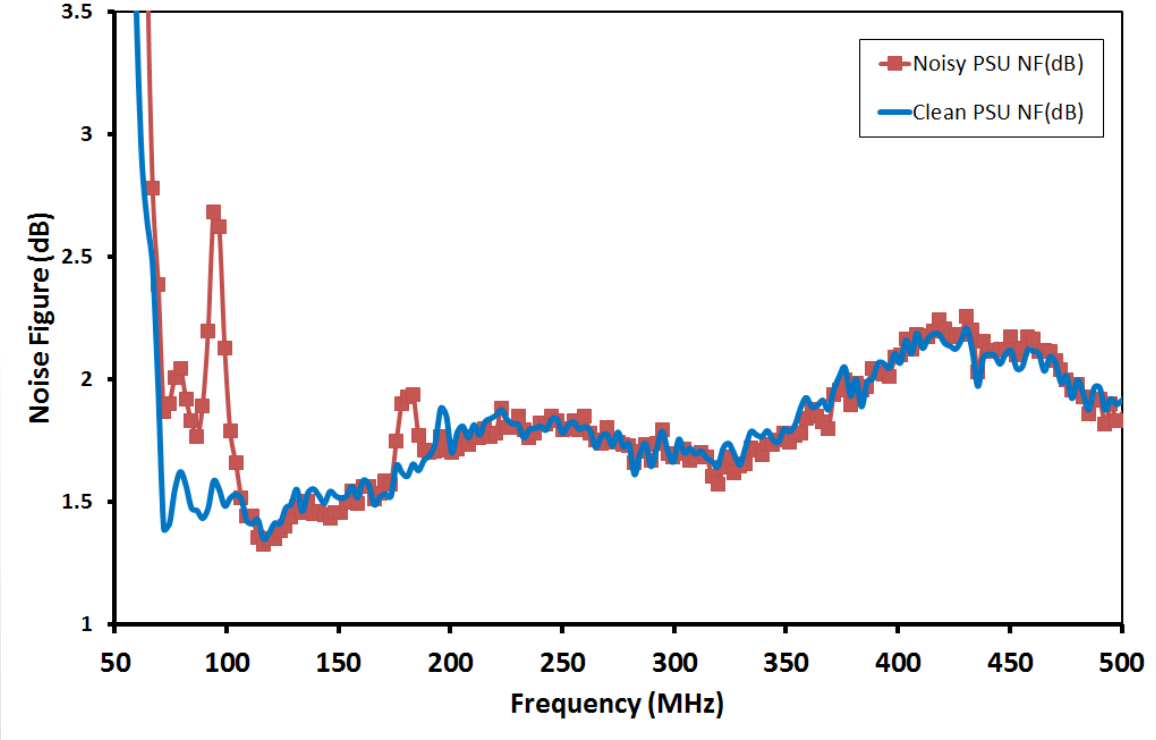


A compliance test of the complete system is not possible in a controlled lab environment. Therefore an assessment must be in form of a comprehensive analysis. **Tests on a component level don't give answers, but provide input for this analysis!**

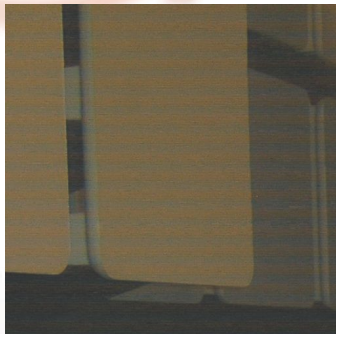
Internal EMC



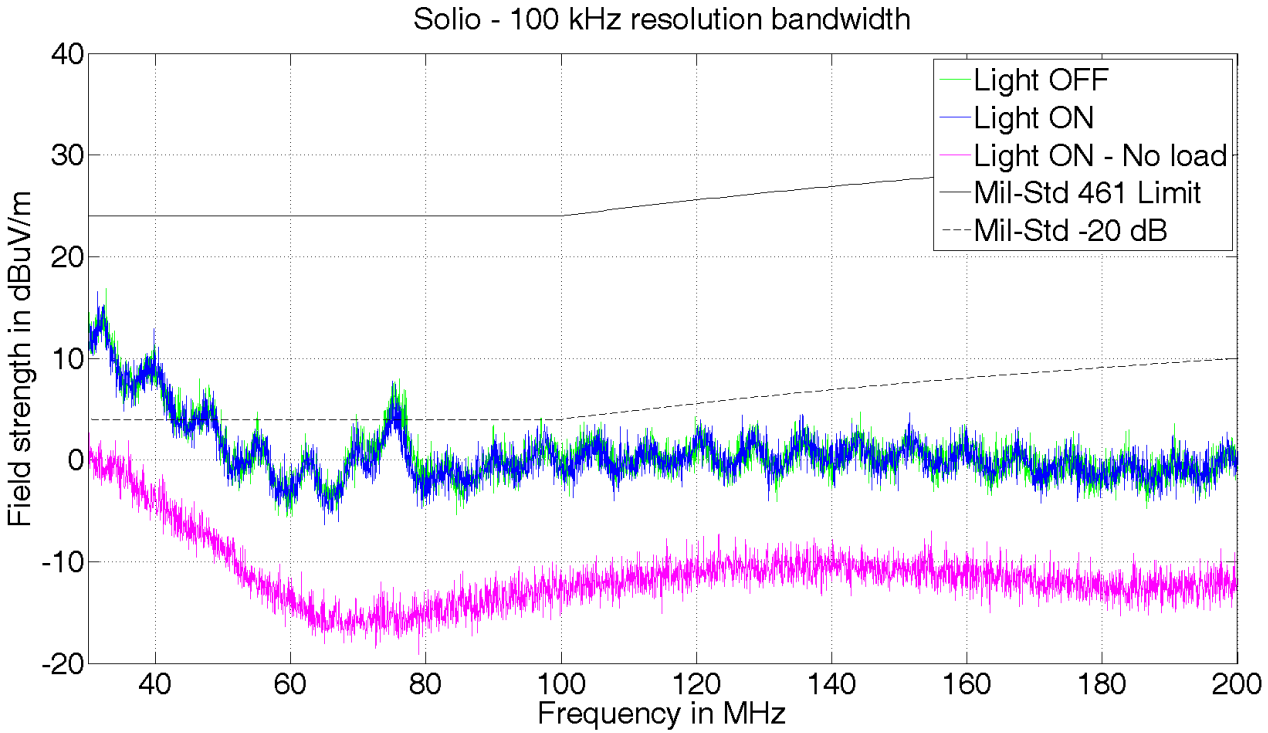
Increase of noise figure due to a noisy power supply

Commercial PV modules

Commercial PV modules



http://store.solio.com/Solio-Store/CLASSIC2-Solar-Battery-Charger-S13-AF1RW



No difference between Light OFF and Light ON (charging)
Connecting the load makes a difference!

Commercial PV modules

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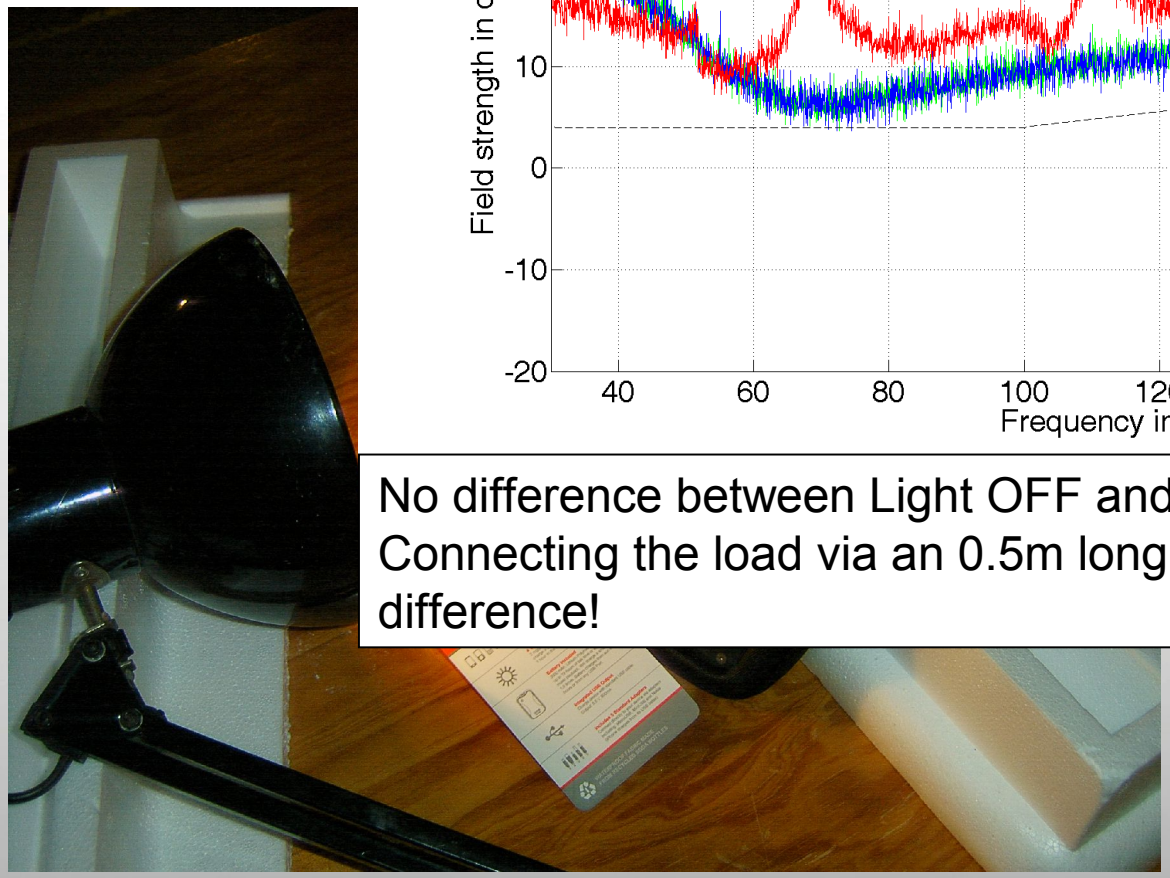
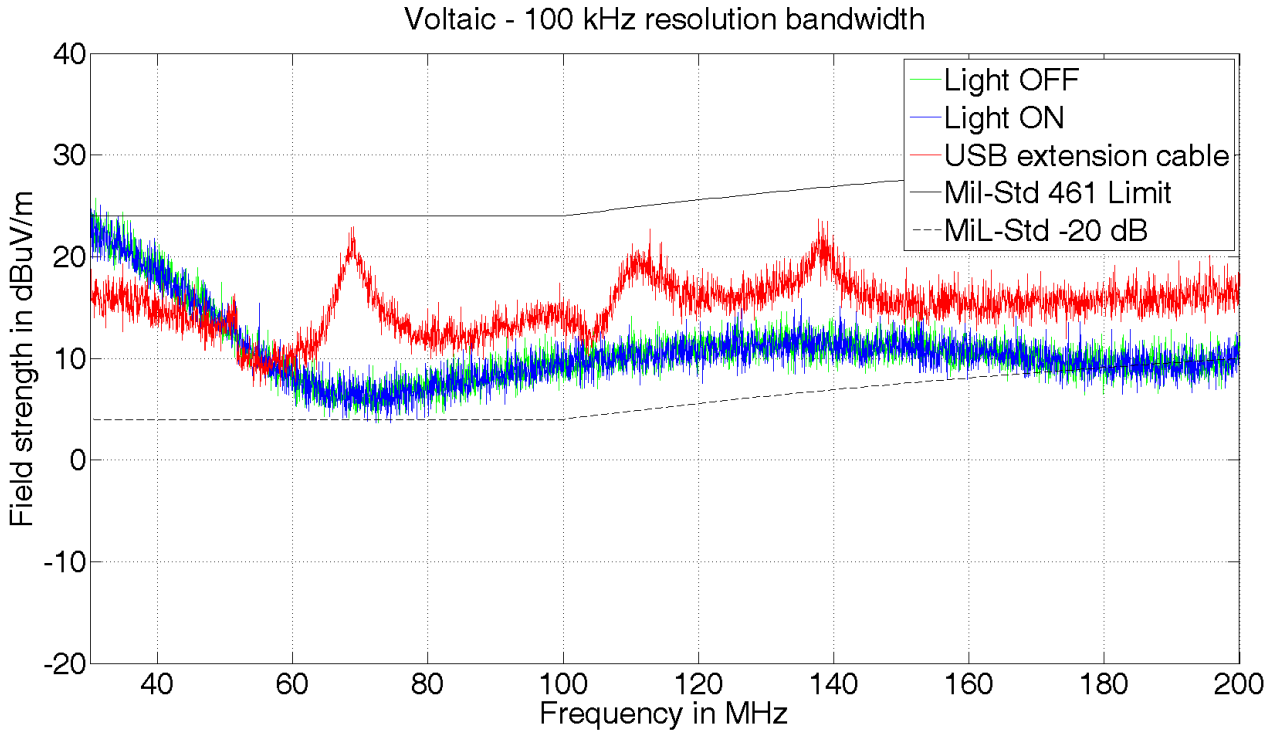
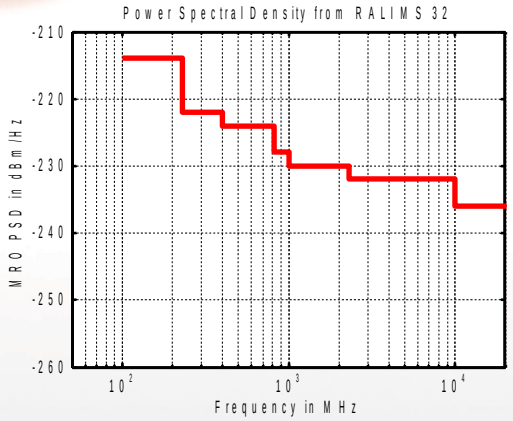


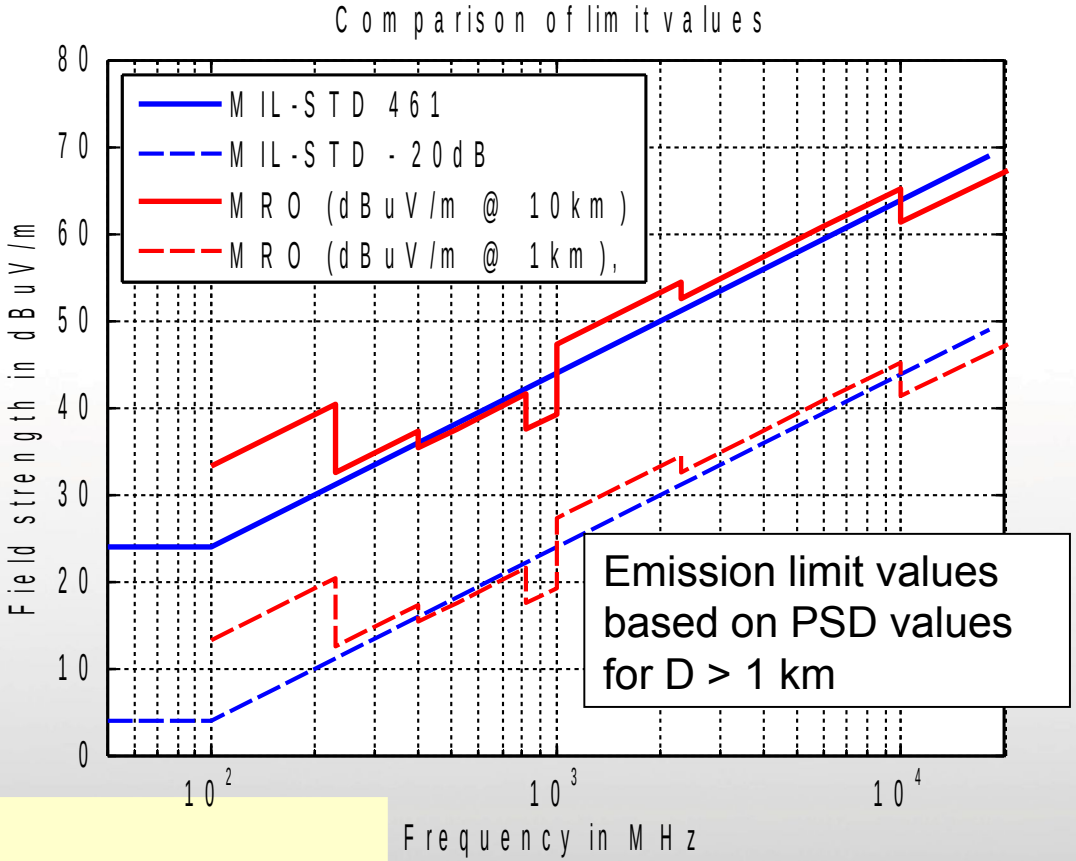


No difference between Light OFF and Light ON (charging)
Connecting the load via an 0.5m long extension cable makes a difference!

Selecting Limit Values



Power spectral density (PSD) permitted at location of radio telescope antenna



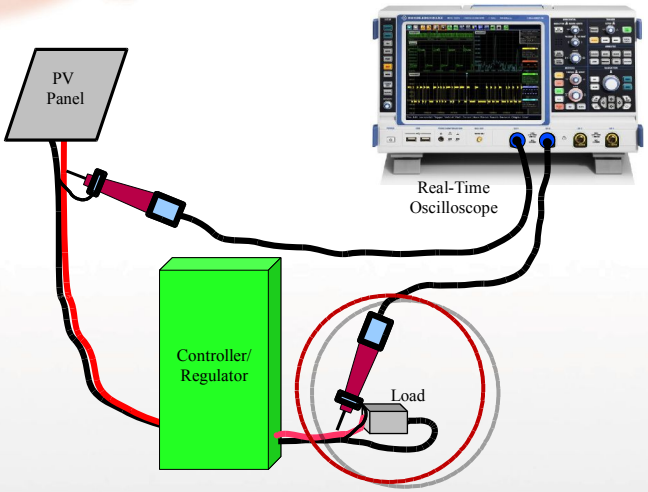
Emission limit values based on PSD values for D > 1 km

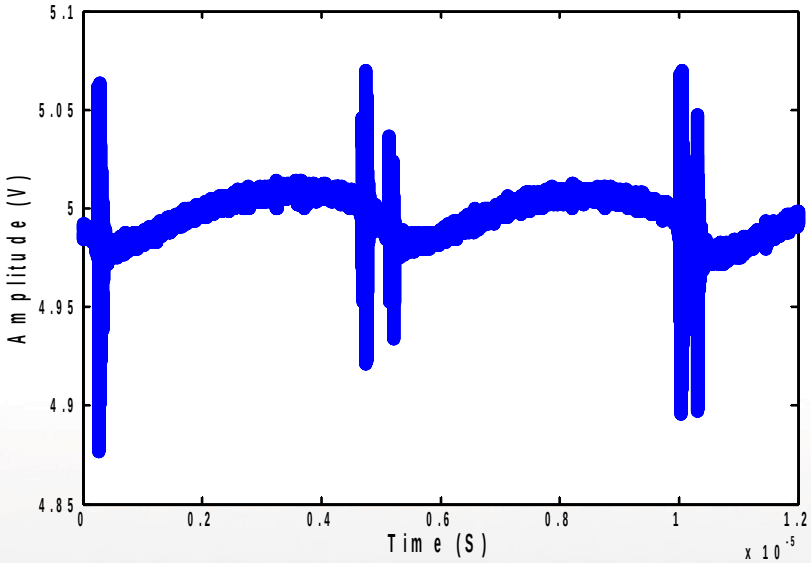
MRO Requirements

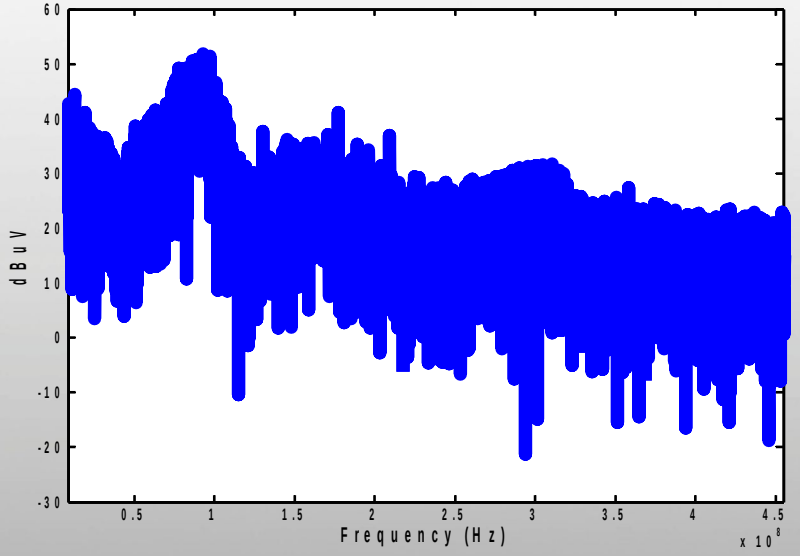
Distance > 10 km	MIL-STD 461 Limits
10 km > D > 1 km	20 dB below MIL-STD 461 Limits
1 km > D	80 dB below MIL-STD 461 Limits (permitted only on a case by case basis)

For SKA–Low there may be different limit values for different frequency ranges.

Tests on the work bench

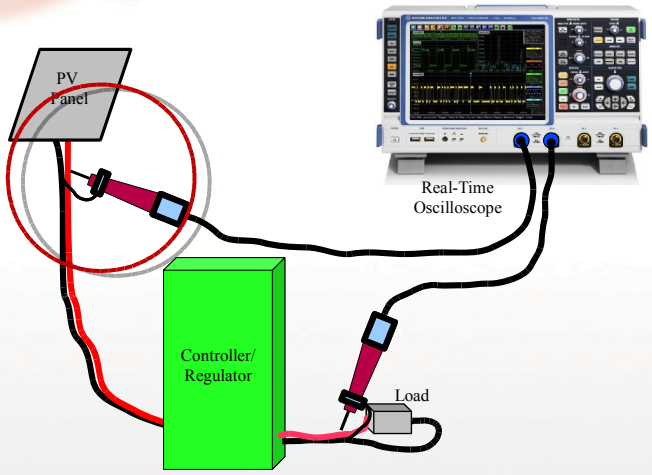


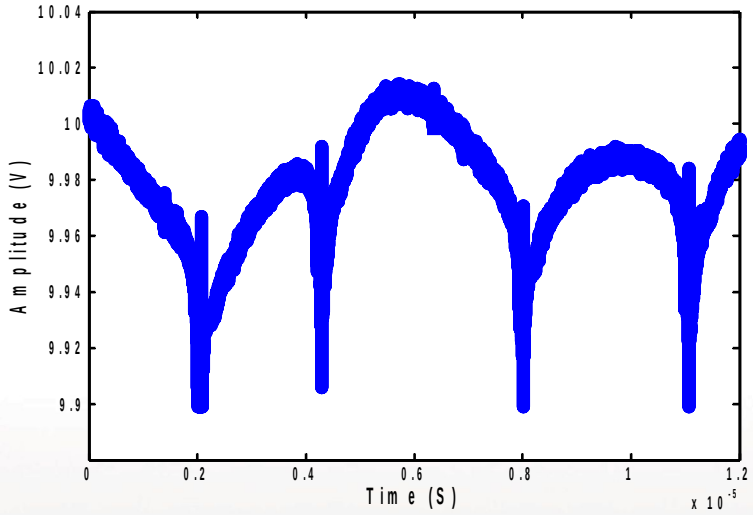


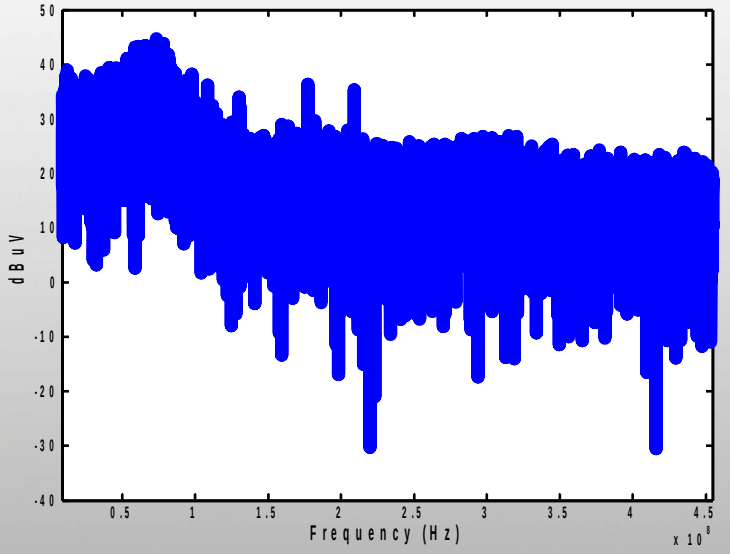


- RFI from a noisy SMPS: Ripple (low freq) and switching noise (high freq)
- Noise, including resonance effects, in the SKA-low band
- Reduce noise with filtering and selection of components
- Customize switch-mode regulator for SKA

Tests on the work bench



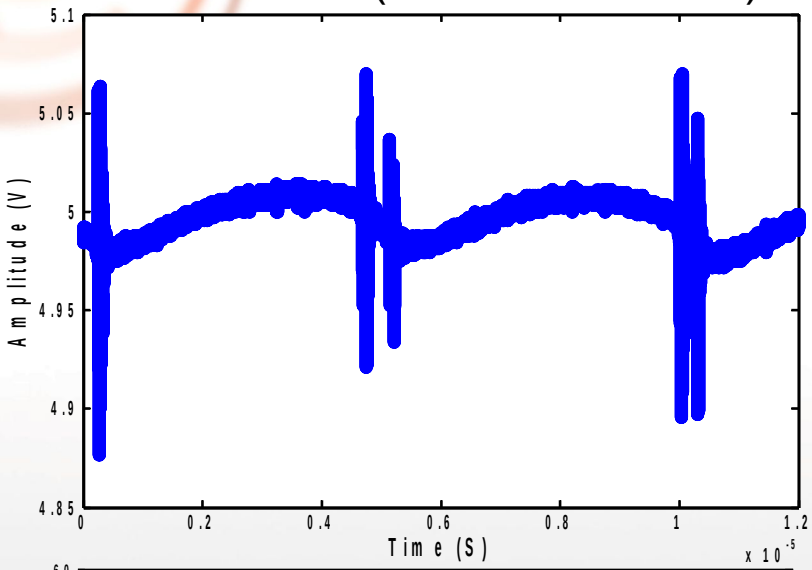


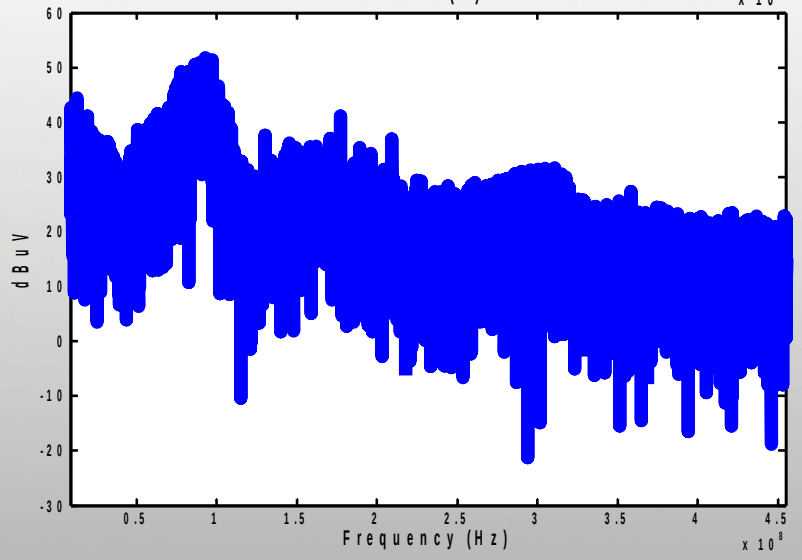


- Noise from the same SMPS
- Noise, including resonance effects, in the SKA-low band
- Common to both sides: 175 MHz narrow band signal (possible ambient signal)
- Broadband noise is different at PV panel and load

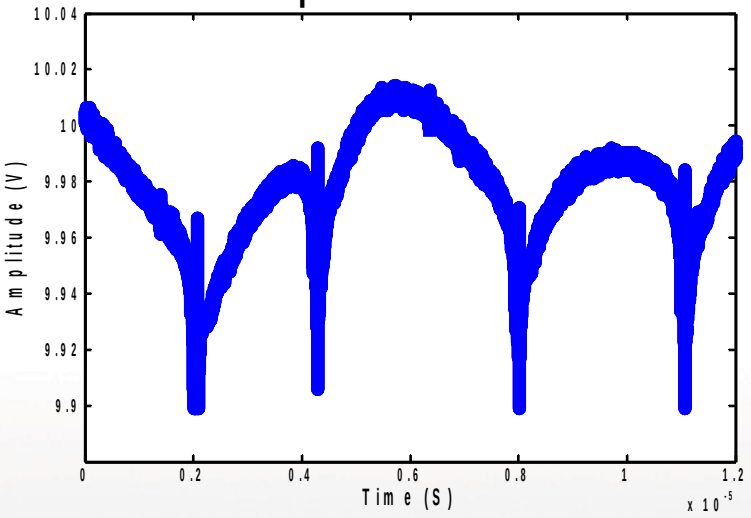
Tests on the work bench

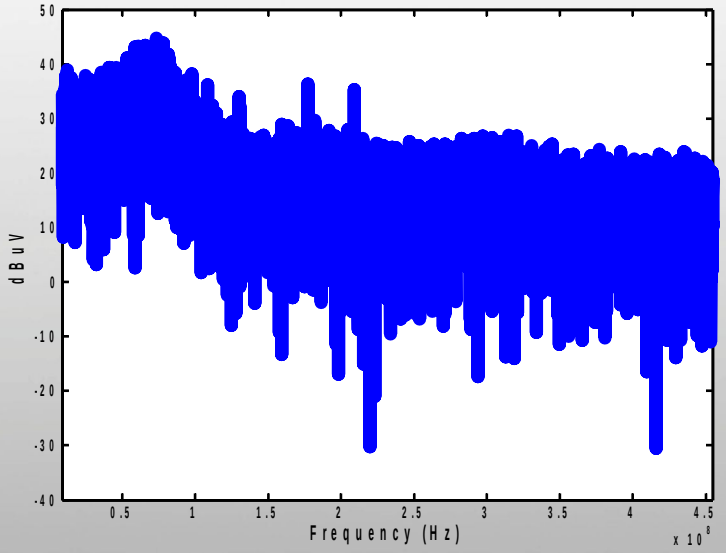
Load side (antenna element)



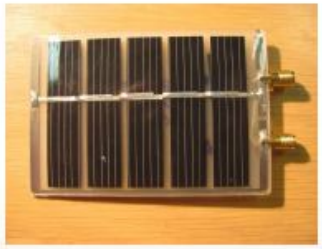


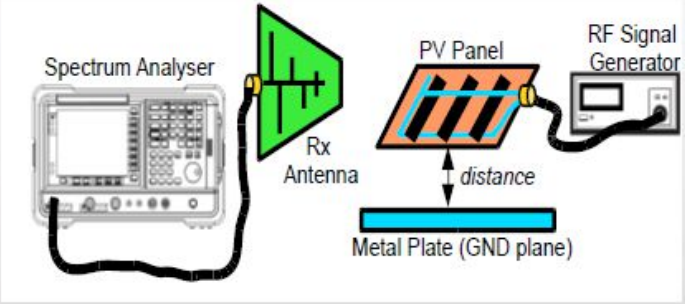
PV panel side

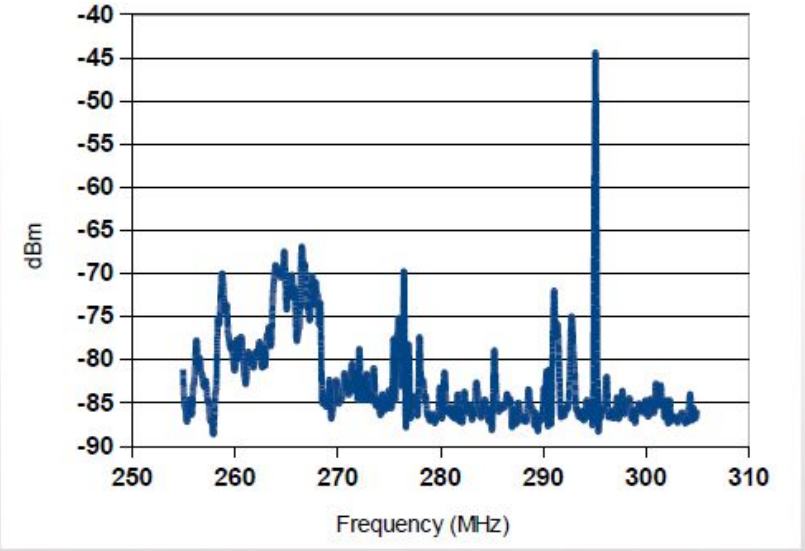




Tests on the work bench



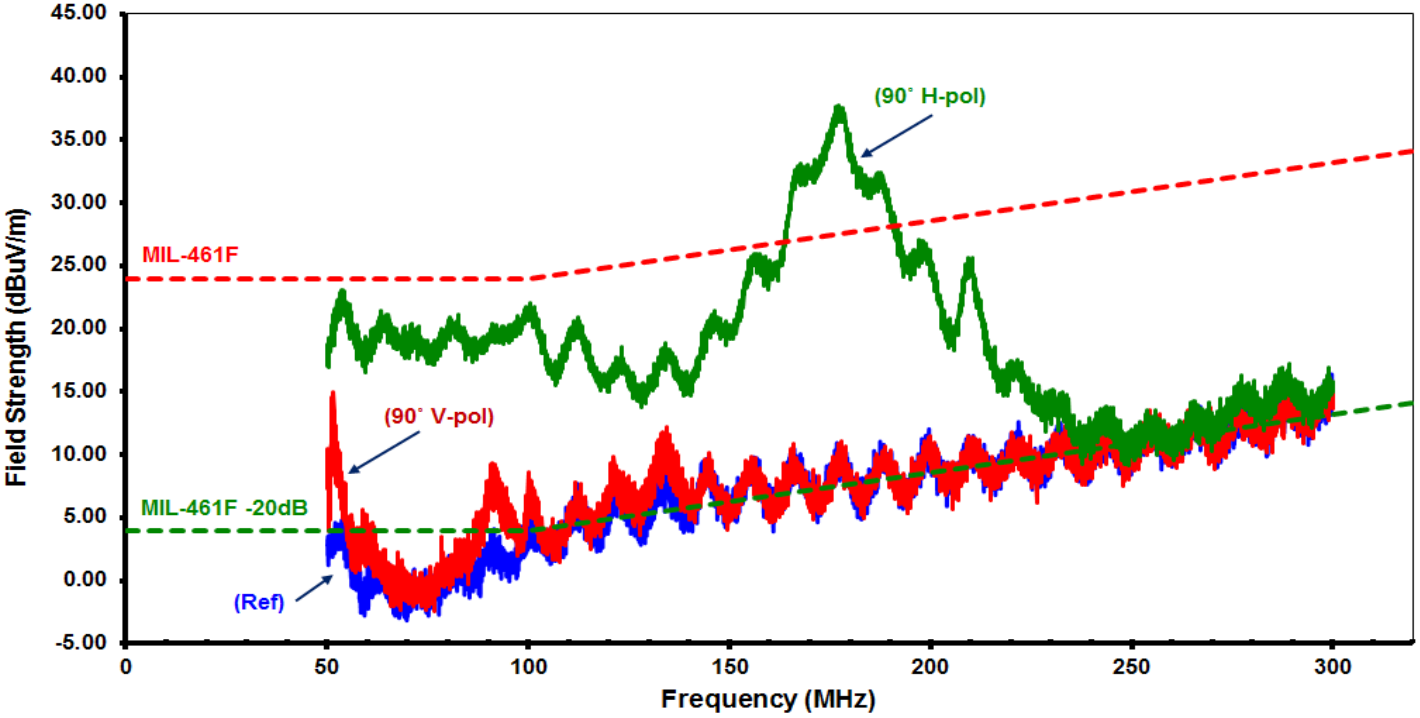


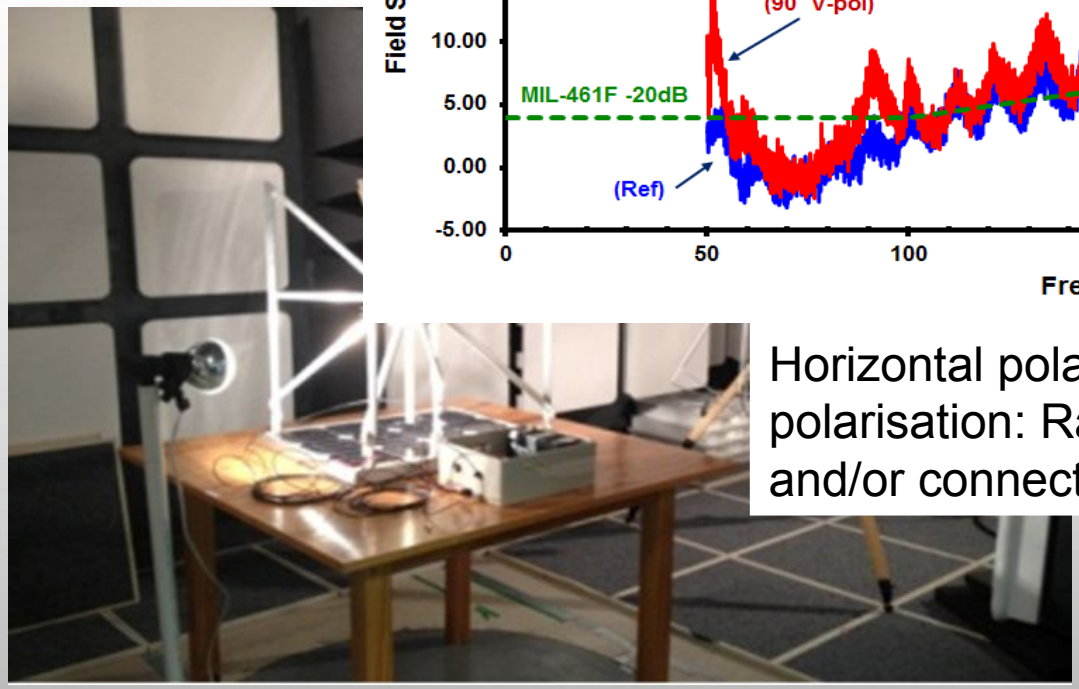


- **PV panel → Could potentially radiate EMI emission!**
- **Metallic objects nearby interact with the panel**
- **Grounding (distance and conductivity) has some influence**

Tests in the EMC lab

Tests in the EMC lab





Horizontal polarisation much higher than vertical polarisation: Radiation from dipole antennas and/or connecting cables likely

Conclusion

- ➢ Advantage of PV Solar modules
- Galvanic Isolation (with RoF links)
- Suitable for both SKA sites
- No need for power distribution network
- ➢ Preliminary EMI tests
- Emission from commercial-off-the-shelf equipment too high, custom design required
- Interaction from metallic objects near PV panel, and effect of long supply cables must be considered
- ➢ Tests on the work bench more convenient than measurements in EMC lab
- Preliminary tests on the work bench for comparison
- Determine Interface parameters (S11, conducted noise)

Conclusion

- ➢ Prediction of RFI/EMI - Strategy
- Determine antenna characteristics for: solar panels, SKA-low antennas, cabling (Analytically, simulation, measurements)
- Determine excitation based on: work bench measurements, EMC lab measurements and simulations
- Combine antenna characteristics and excitation
- Validate with measurements on representative configurations
- ➢ Purpose of EMC tests, in the early phase of the design
- Understanding the problem
- validation of the interference model
- Compliance assessment comes much later!

Conclusion

- Purpose of a standard
- Conventional standard: in case of compliance, the likelihood of interference in a 'standard' environment is below a certain threshold
- SKA environment: a device, when integrated in the large system 'radio telescope' does not:
  - compromise the the performance of the telescope
  - compromise the performance of other telescopes on the same site
- In conventional standards much emphasis is placed on repeatability and reproducibility.
- In the SKA environment test results are more likely basis for a wider assessment, not just a yes/now compliance decision.