**IEEE Africon 2013/URSI**

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# An Overview of the MITRA Radio Telescope Signal Chain


**Dominique Ingala**

Durban University of Technology


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# Background and Specifications

- Project proposal: by Prof. Girish Beeharry
- Locations: UoM and DUT
- Operational frequency range: 200 – 800 MHz
- Antenna type: Dual Polarized LPDA
- 2 arrays (8 LPDA’s per array)
- Front-End RF and IF stage: Analog components
- Digital Back-End: Software Defined Radio
- Fiber optic links
- Cost effective design

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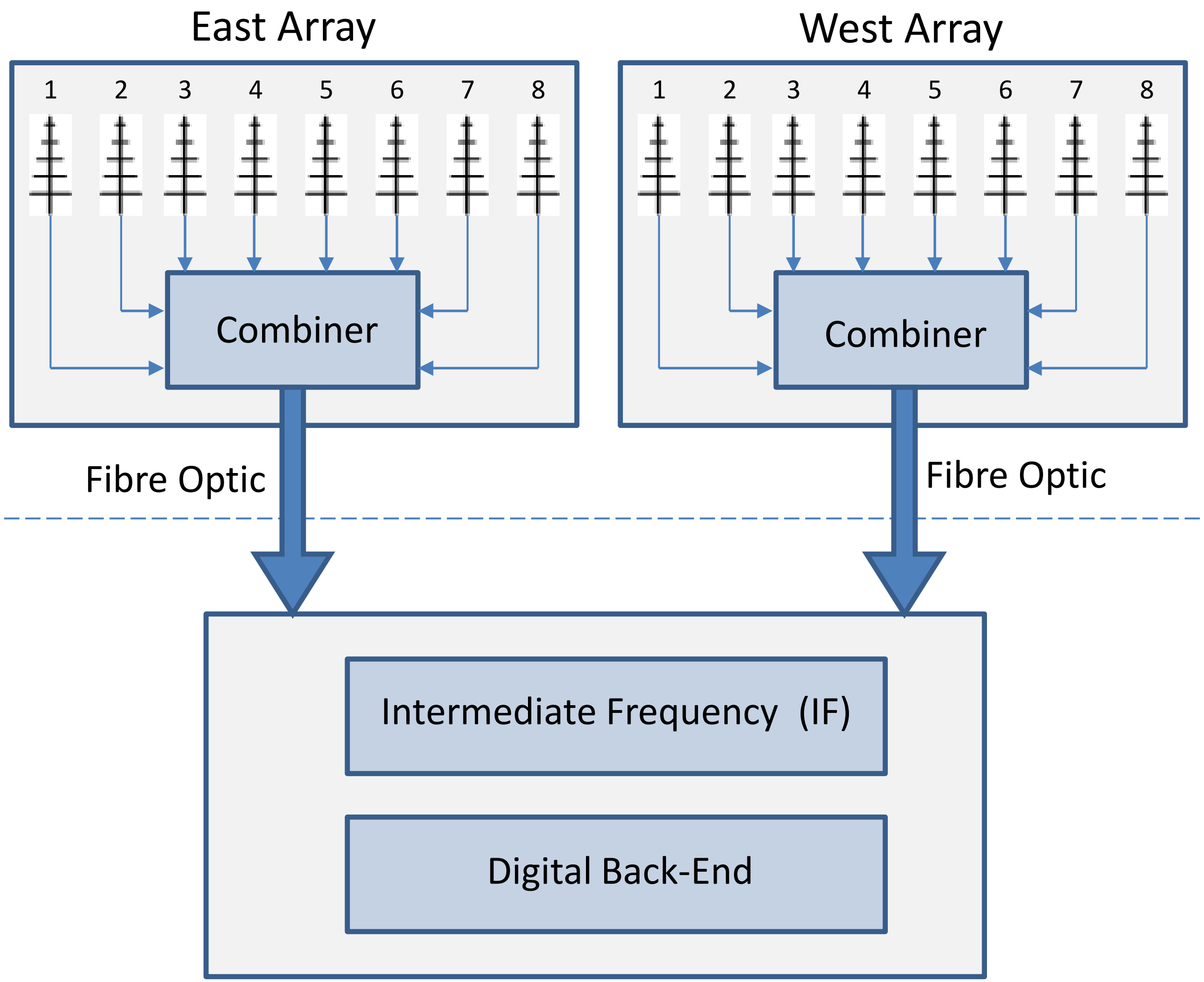
# General Block Diagram

Two main segments:

1. Outdoor Segment

2. Indoor Segment



# Antenna Design

- Type: Dual-polarized
  Log-Periodic Dipole Antenna (LPDA)
- Frequency band: 200-800 MHz
- Directivity: 8.5 dBi
- Scaling factor $\tau$: 0.892
- Spacing factor $\sigma$: 0.165
- Element diameter: 6 mm
- Boom width: 15 mm

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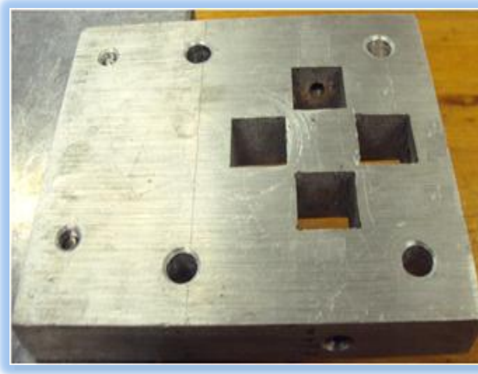
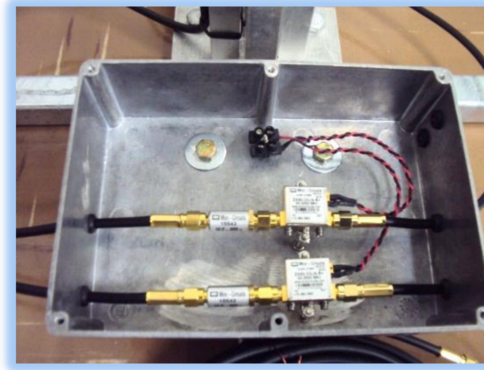
# MITRA Antenna

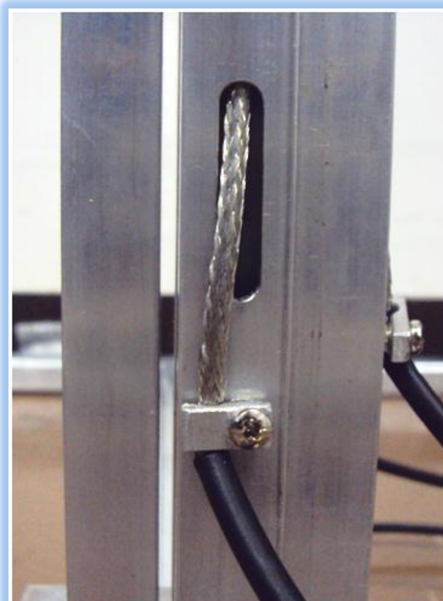
Shorting bar



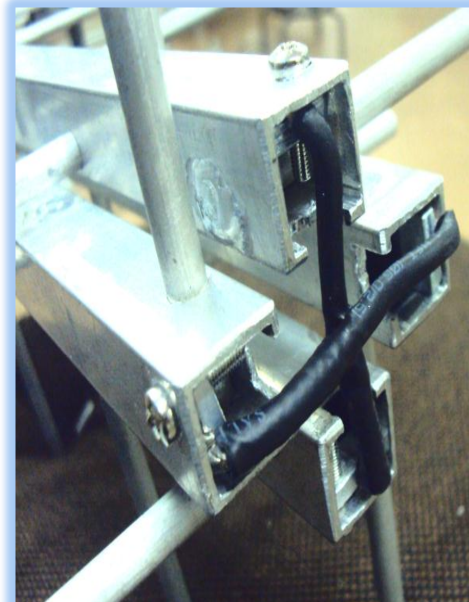
LPF and LNA



Infinite balun



Feed point



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# Antenna Testing

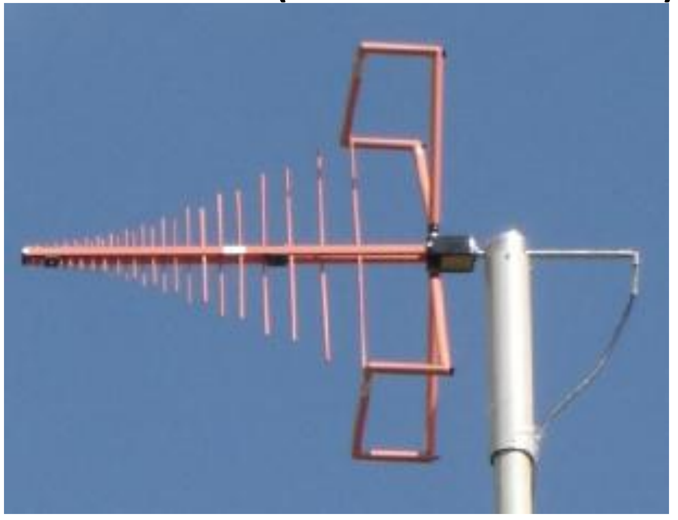
South African National Antenna Test Range (NATR)

3 parameters:

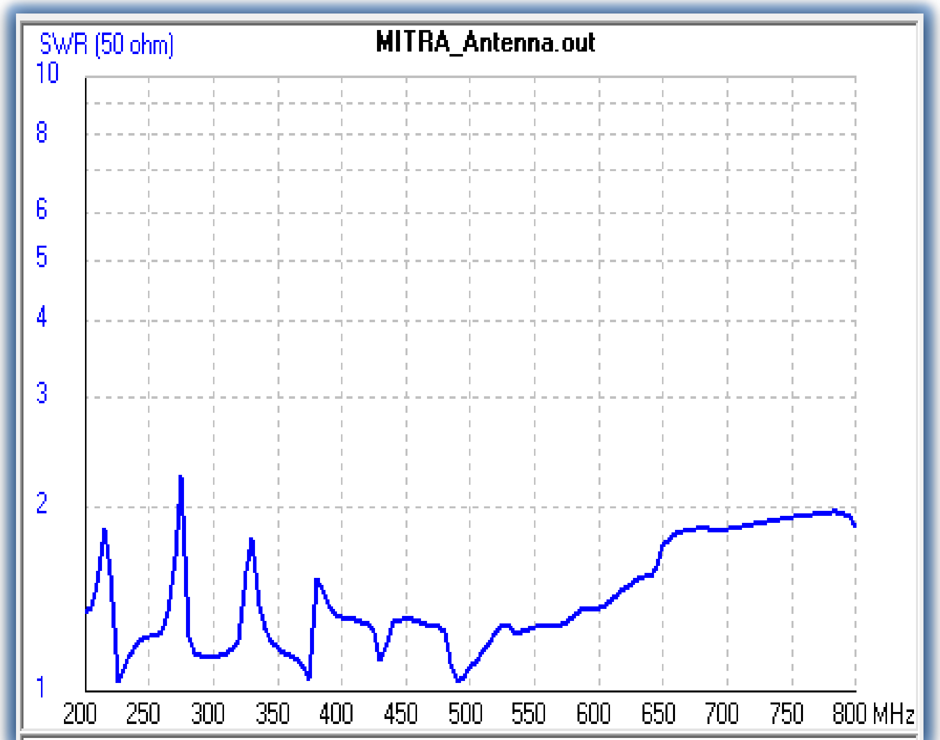
- VSWR
- Radiation pattern
- Directivity (Gain)

Source ant. (ETS-Lindgren 3142D)

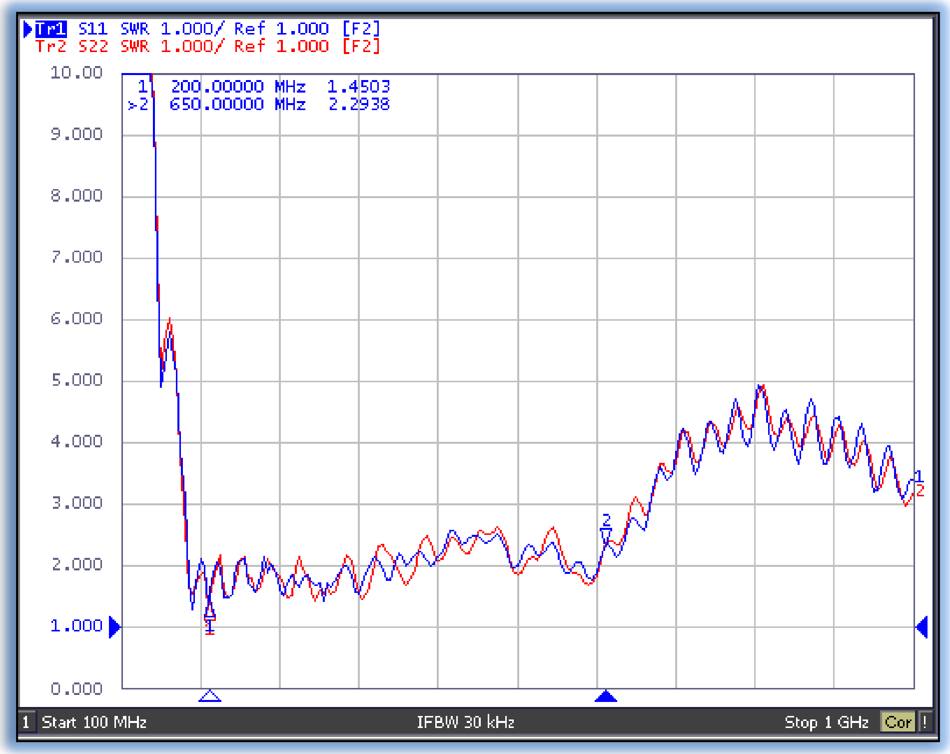
Reference ant. (Schaffner CBL 6143 A)



# VSWR Measurement




Simulated




Measured

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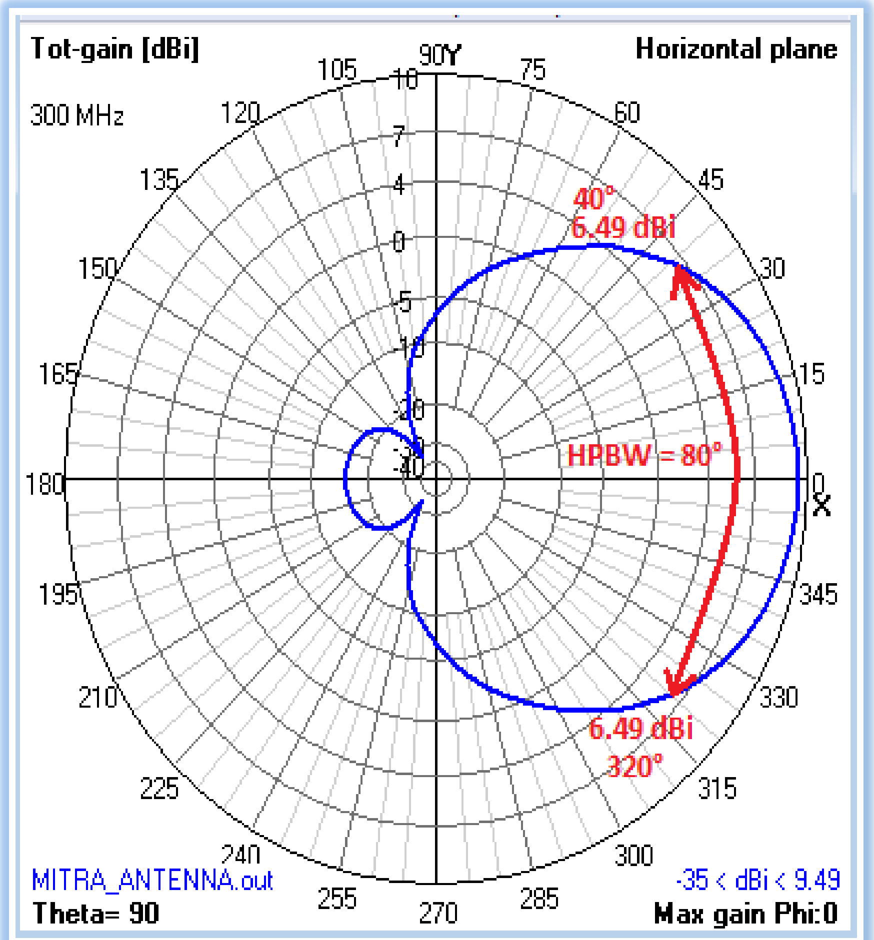
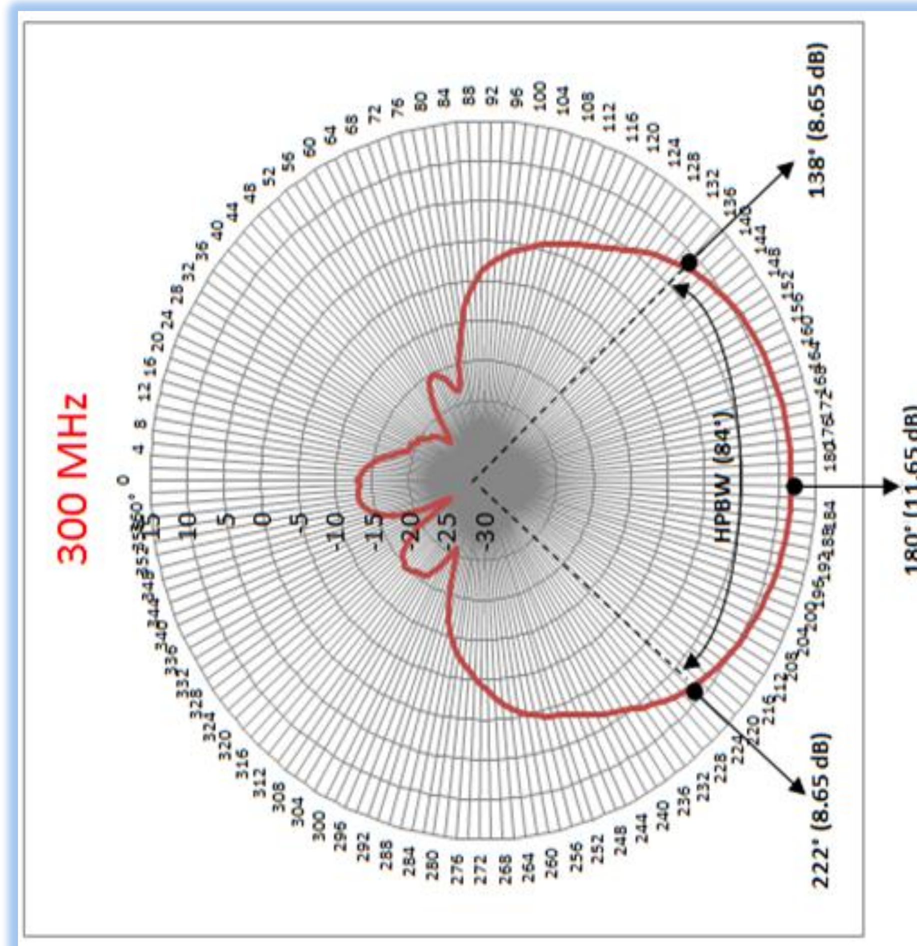
# Radiation Pattern Measurement

# Radiation Pattern Measurement

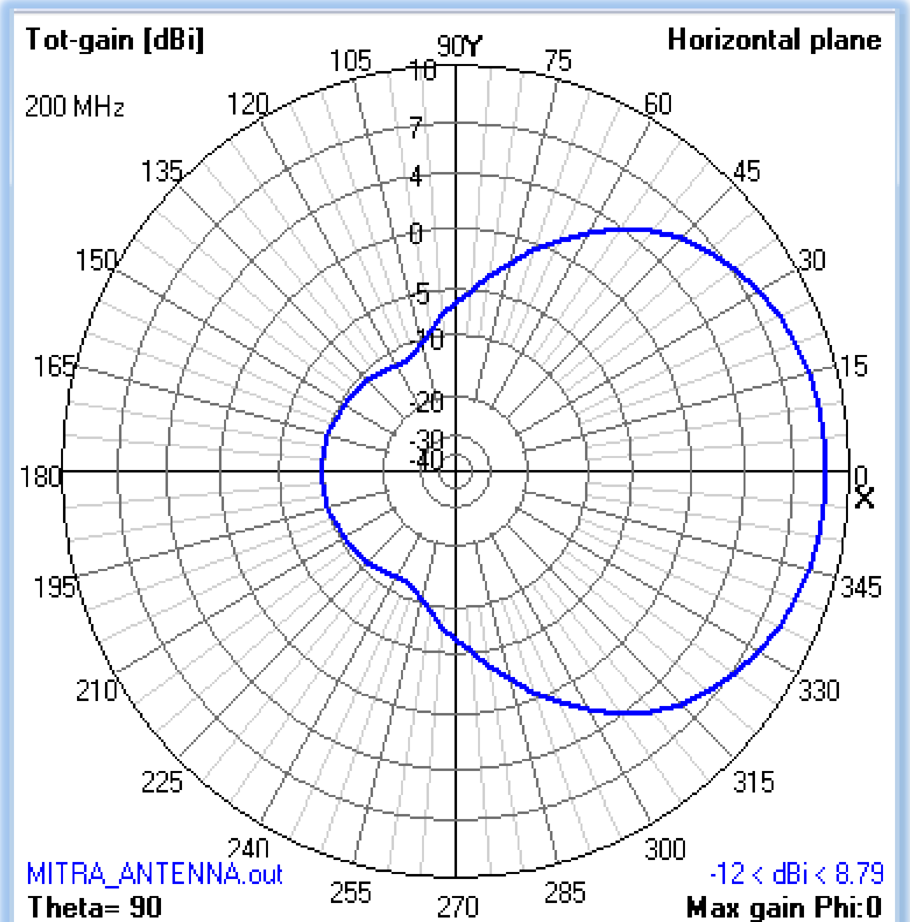



Simulated

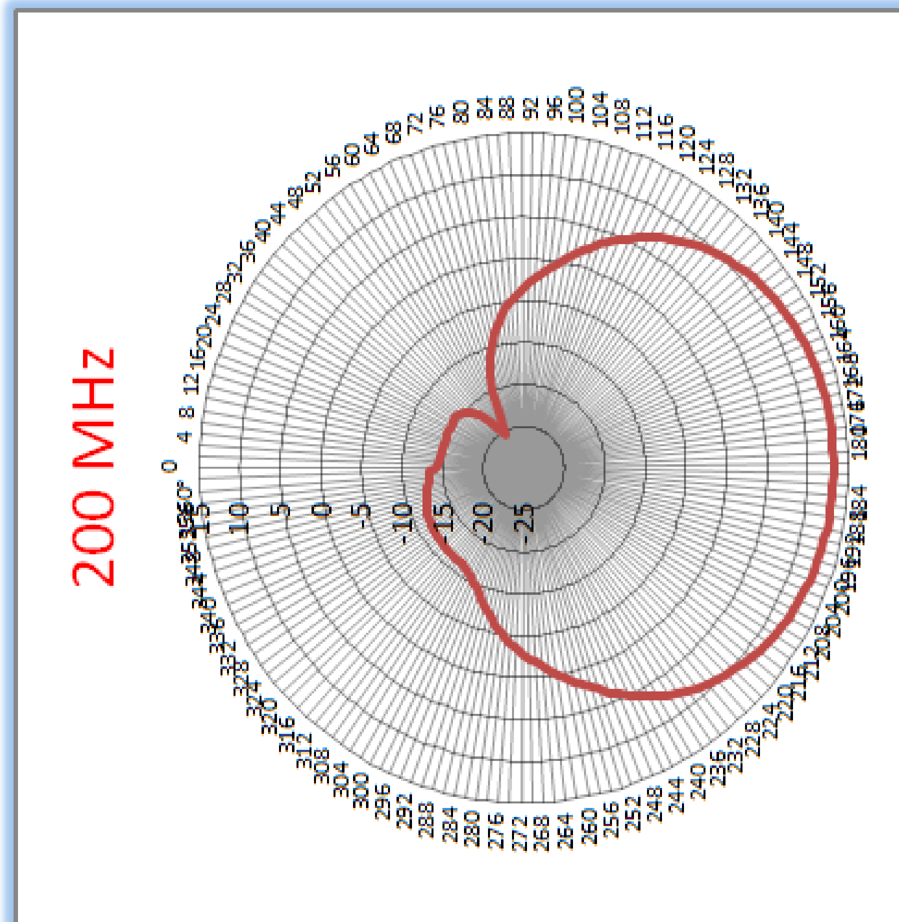



Measured (H-plane)

# Radiation Pattern Measurement




Simulated




Measured (H-plane)

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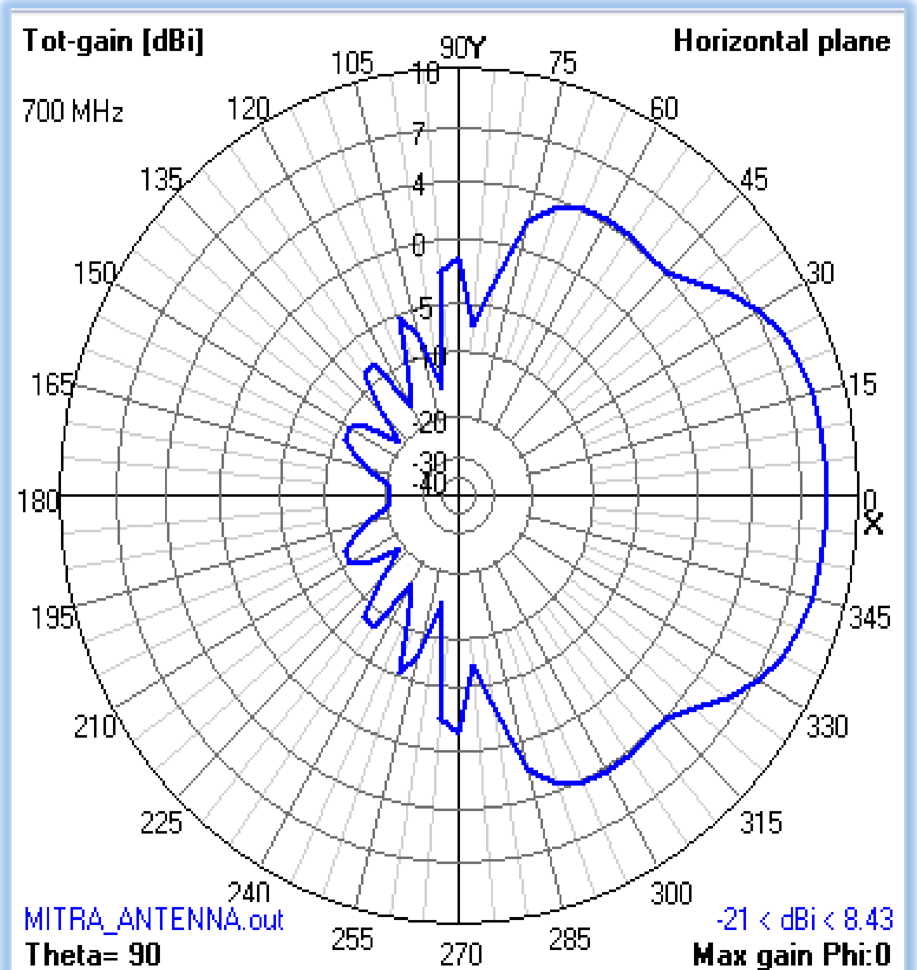
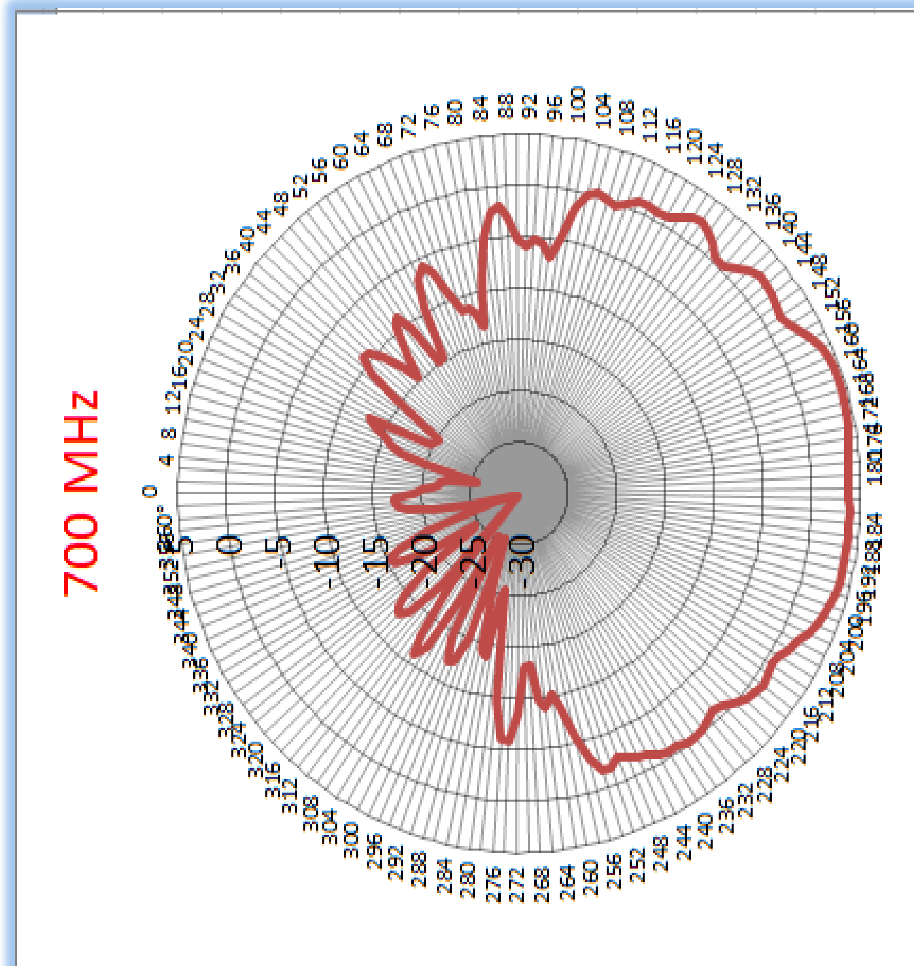
# Radiation Pattern Measurement

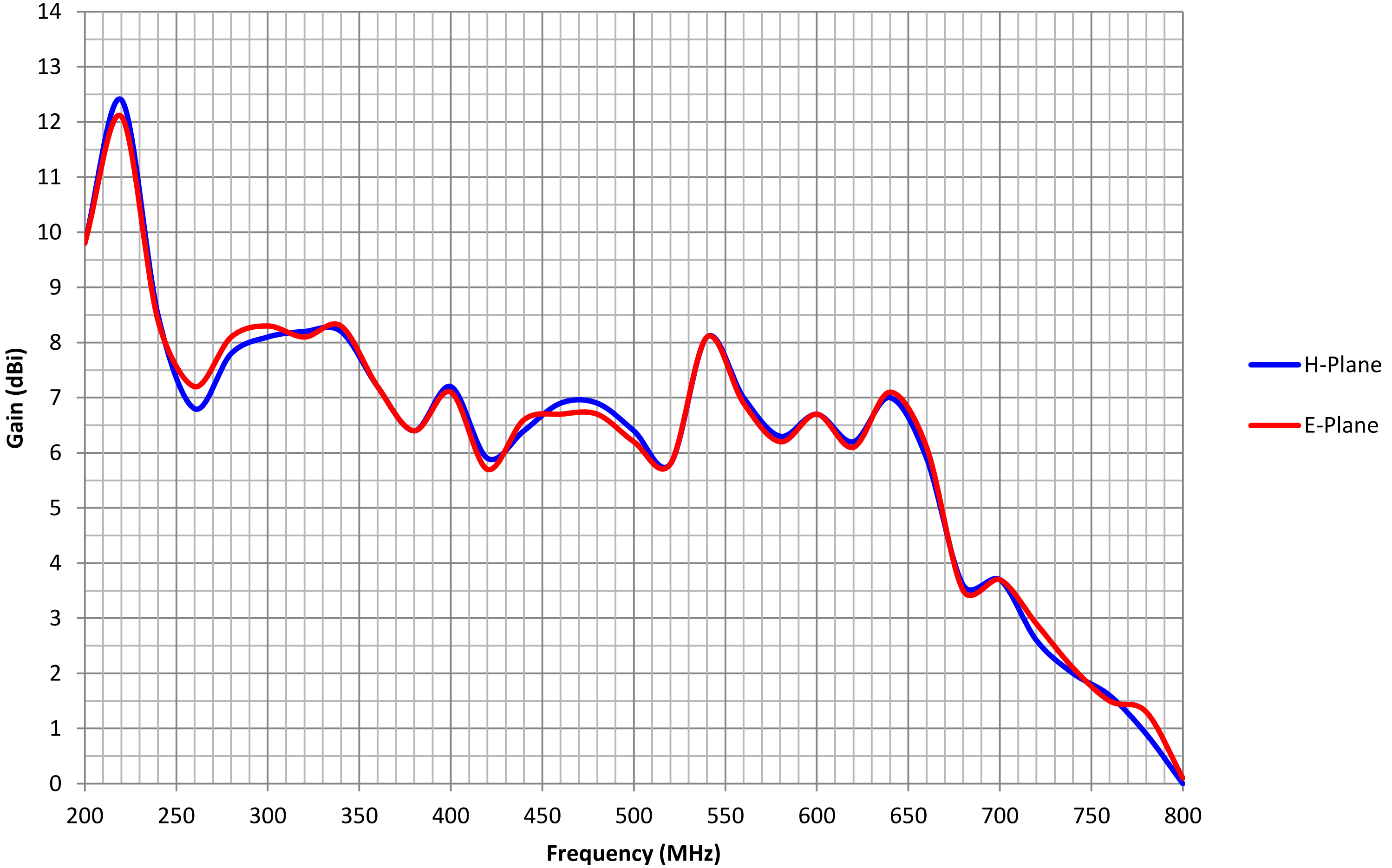



Simulated




Measured (H-plane)

# Gain Measurement

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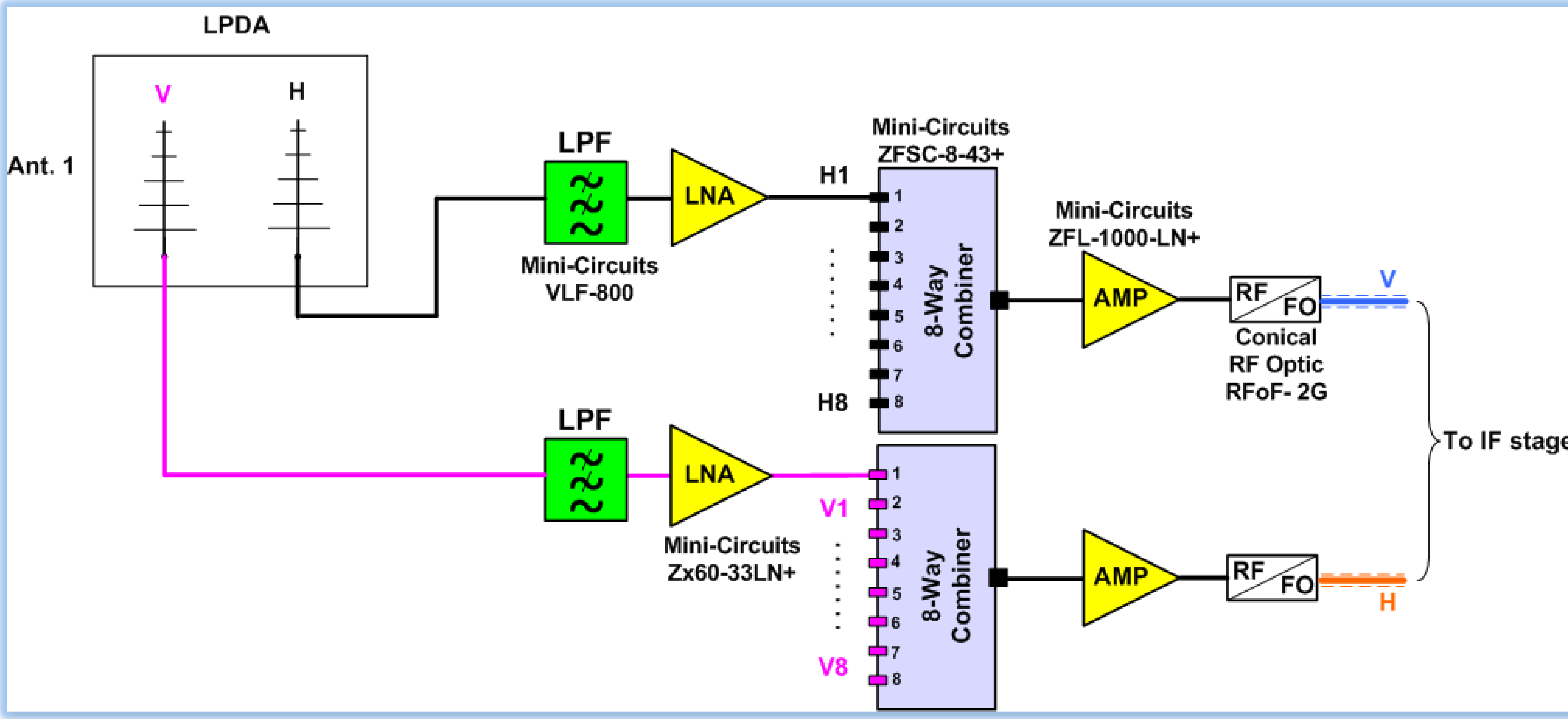
# MITRA Array

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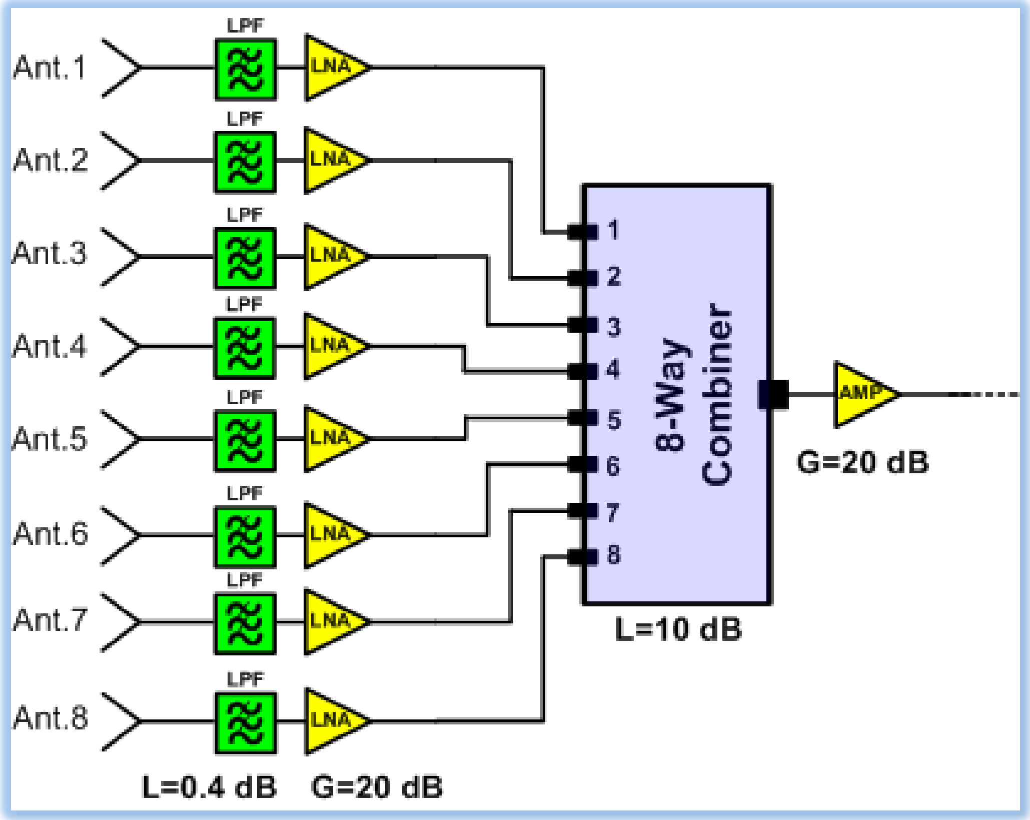
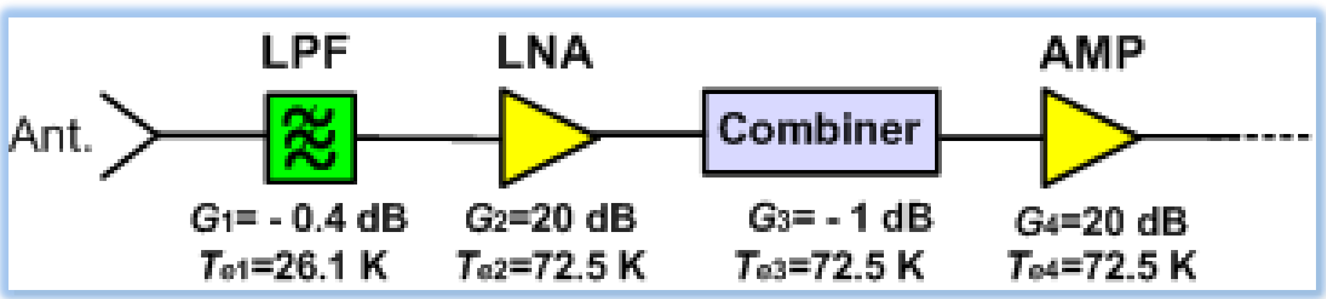
# Gain and Noise Temperature




Beamformer




Equivalent system

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$G_t$ = 38.6 dB $T_e$ = 108.4 K *NF* = 1.37 dB

# RF Combiner and Power Compartment


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# Front-End View

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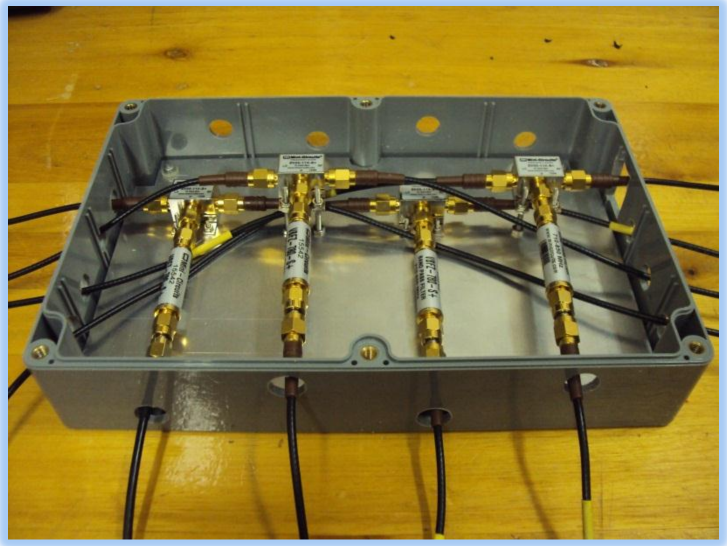
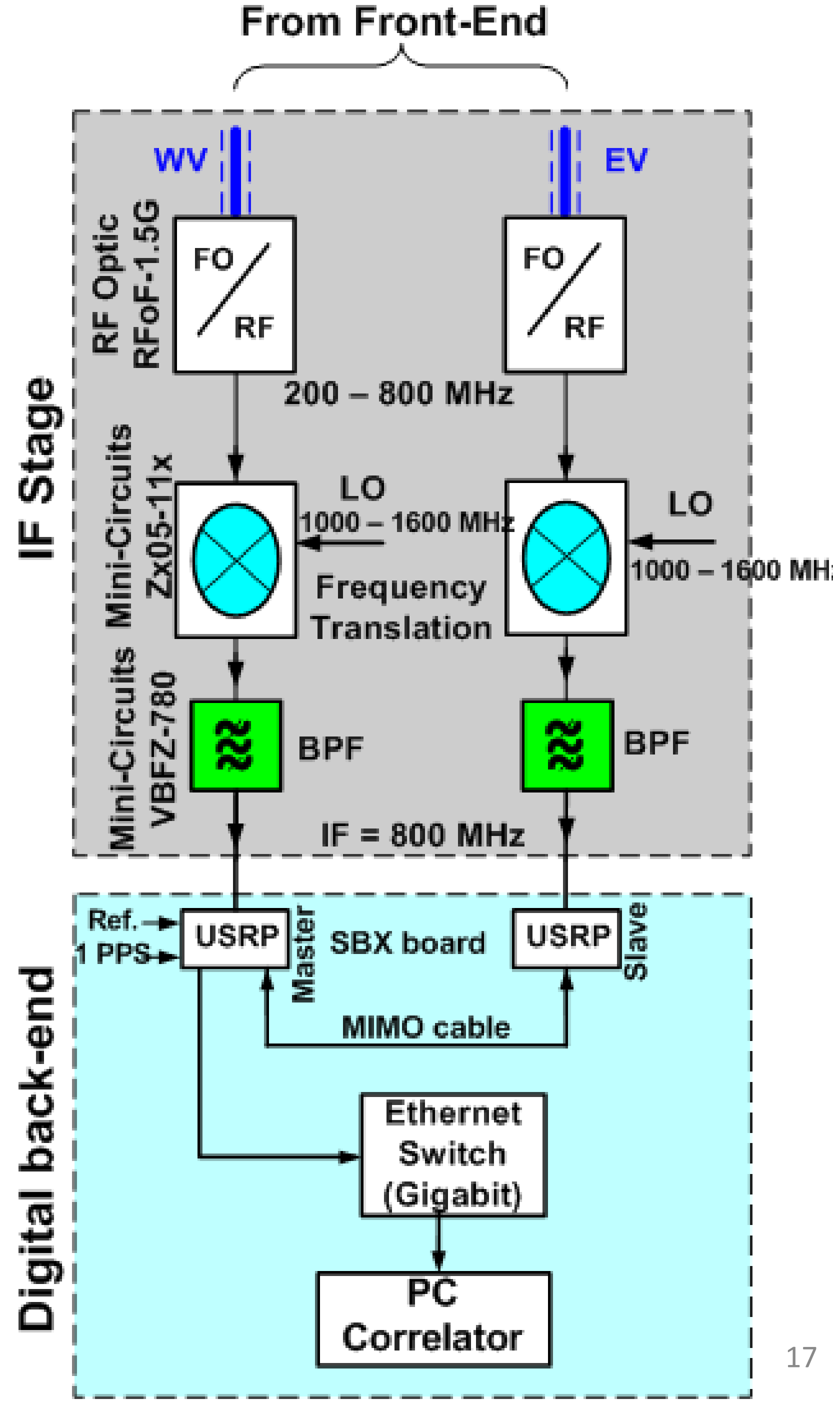
# Digital Back-End

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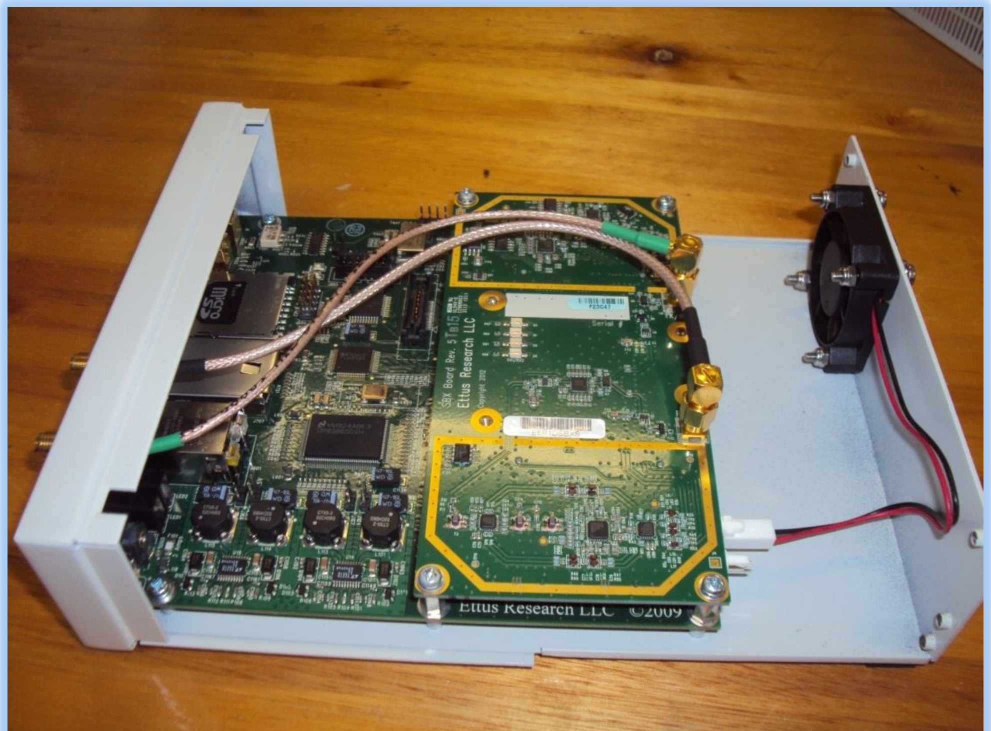
# Digital Back-End Hardware




**USRP 2 and SBX board**

**USRP 2 features:**

- FPGA: Xilinx Spartan 3A-DSP
- ADC sample rate: 100 Msps
- ADC resolution: 14 bits
- Gigabit Ethernet interface
- Bandwidth: 50 MHz (RX)
- MIMO capability (up to 8 antennas)
- 10 MHz ext. ref. clock
- 1 PPS
- Software: Gnu-Radio

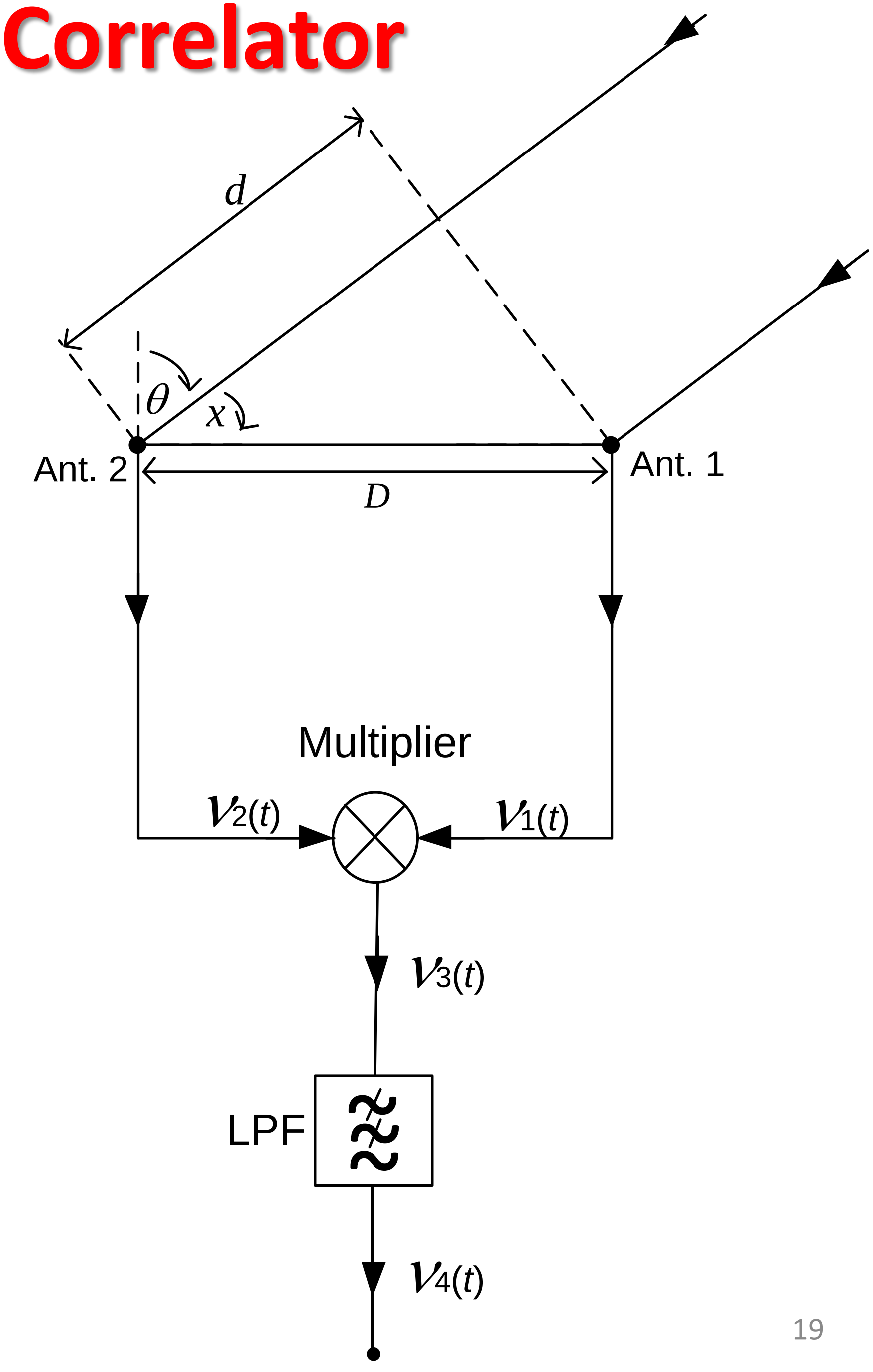
**SBX board features:**

- Frequency range: 0.4 – 4.4 GHz
- Bandwidth: 40 MHz
- Transceiver: TX/RX Full duplex
- MIMO capability
- Phase coherence with LO

# Multiplying Correlator

$$v_4(t) = \frac{v_1 v_2}{2}\cos(\omega\tau_g)$$

- $\cos(\omega\tau_g)$ called fringe function.
- The variation of the angle $\theta$ as the earth rotates generates quasi-sinusoidal fringes at the correlator .

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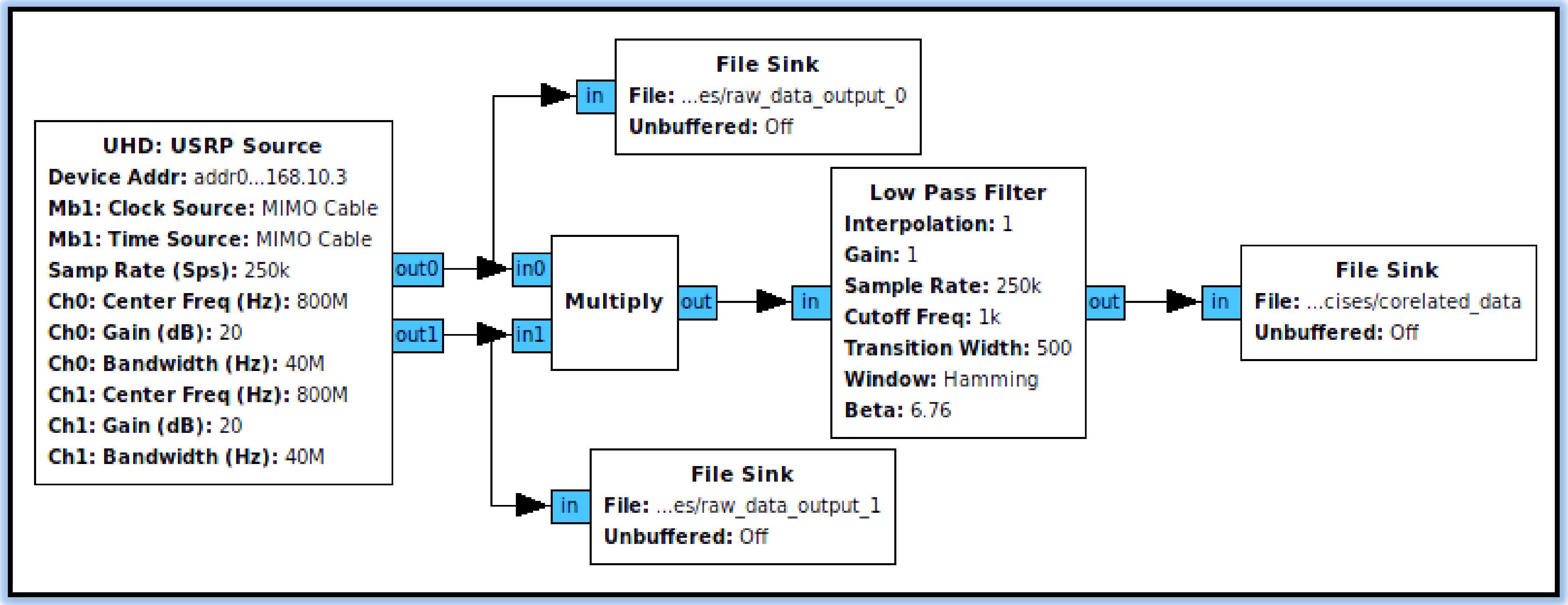
# Multiplying Correlator

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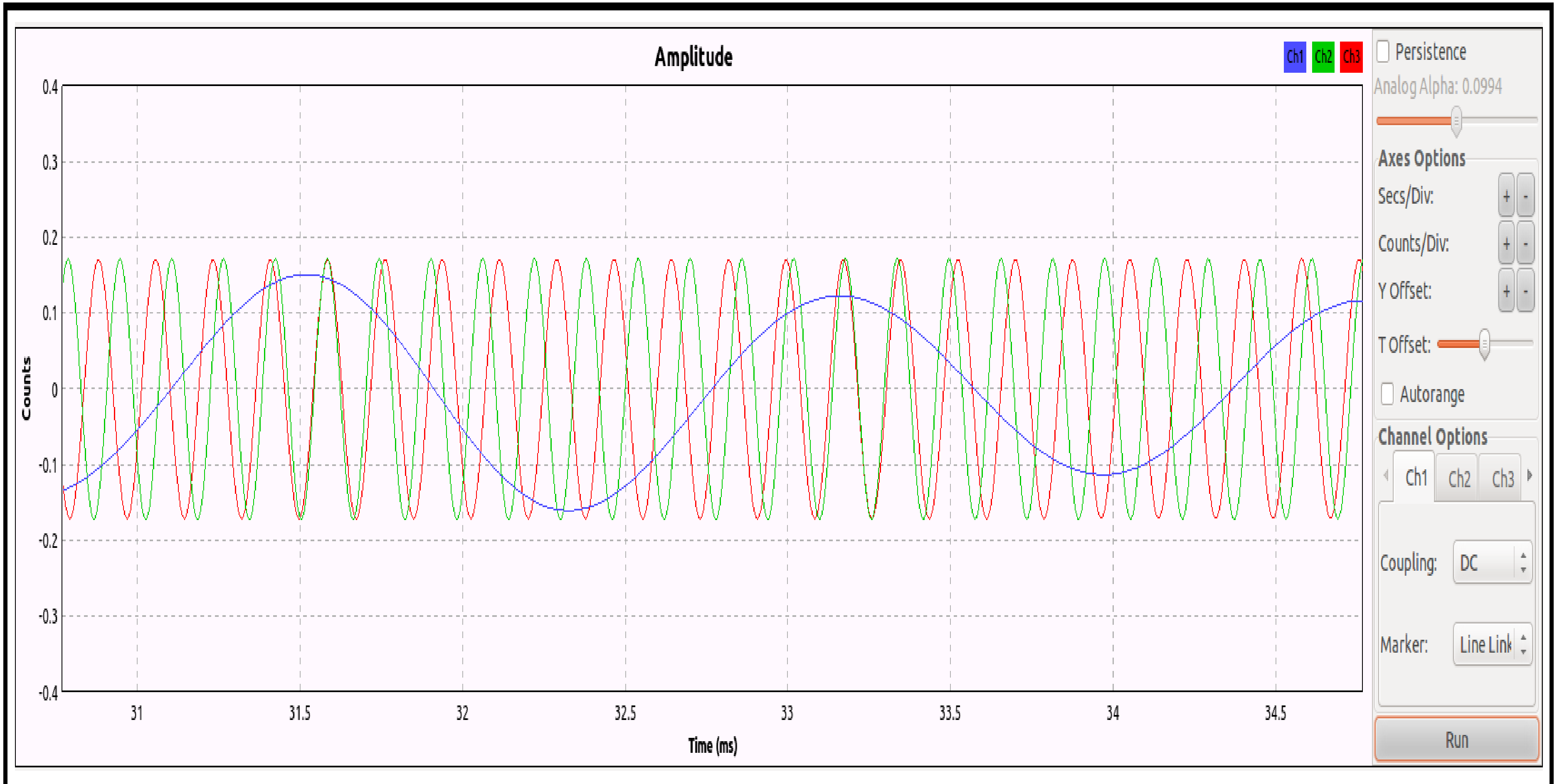
# Raw data and correlated signal

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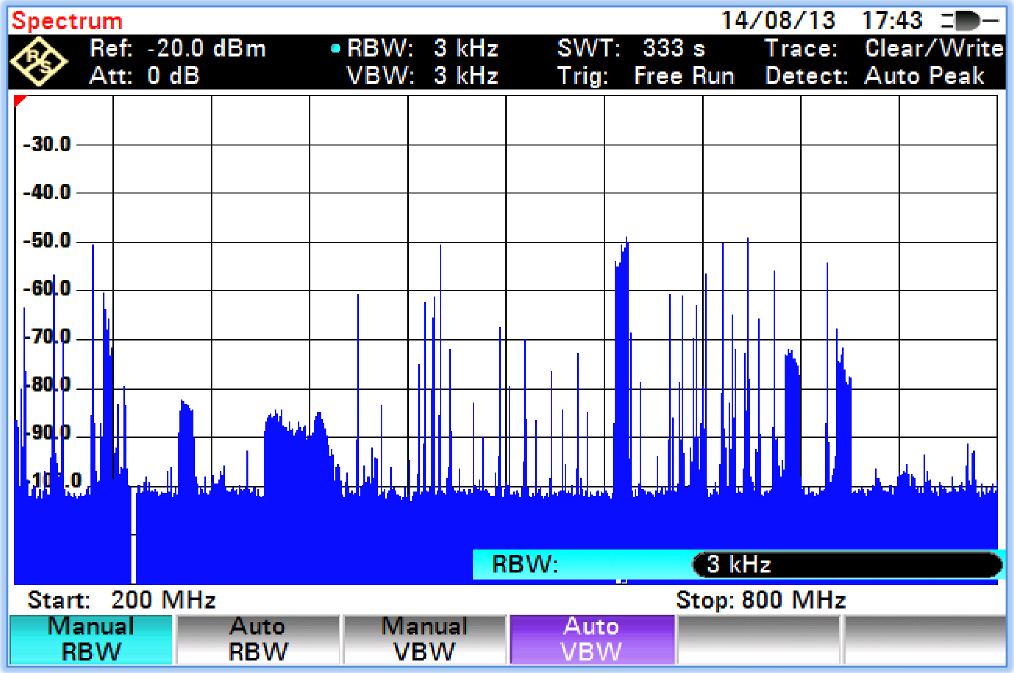
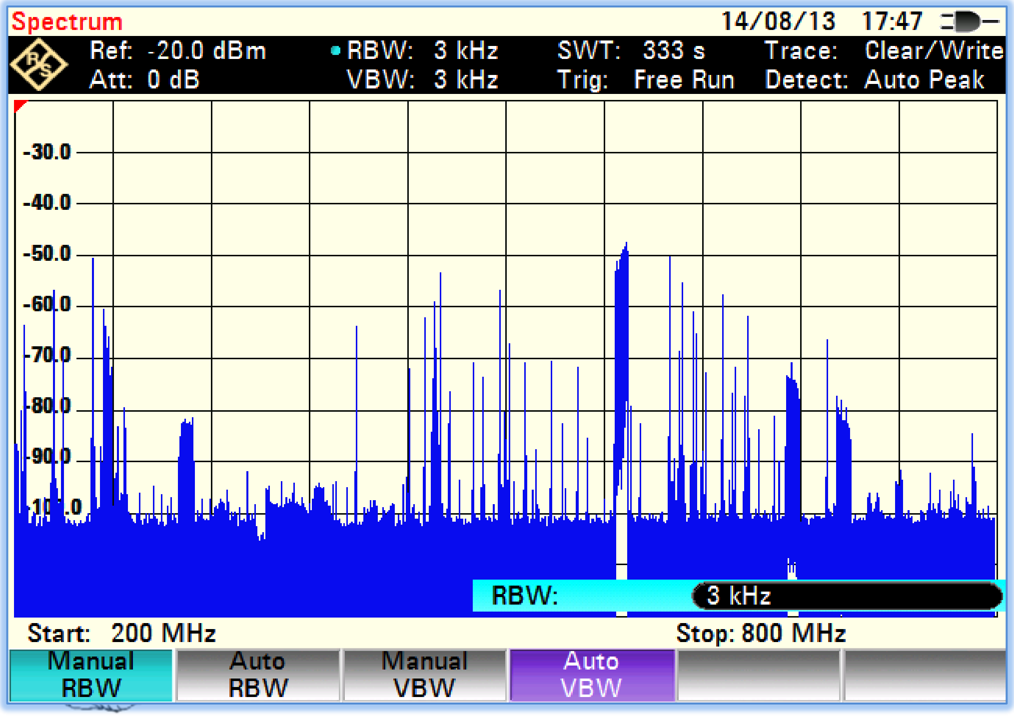
# RFI test

**WV: 200-800 MHz**




**EV: 200-800 MHz**

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# Current status of the project

- Front-End completed
- Digital Back-End completed
- Ready to monitor RF signals in the control room
- Control room being set up
- Normalizing the level of the received signal

# Immediate Future Activities

- Phase coherence with the USRP local oscillators
- Attempting to detect astronomical sources such as Sun, Sagittarius A, Centaurus A, Vela X.

# Long Term Aims

- Attempting to correlate signals from astronomical sources
- Signal and data processing
- Attempting to implement VLBI between UoM and DUT

# END

**Thank you very much**

**Merci beaucoup**