

# A novel RFI mitigation technique to reject out of band RFI signals before LNA using metamaterial design

By  
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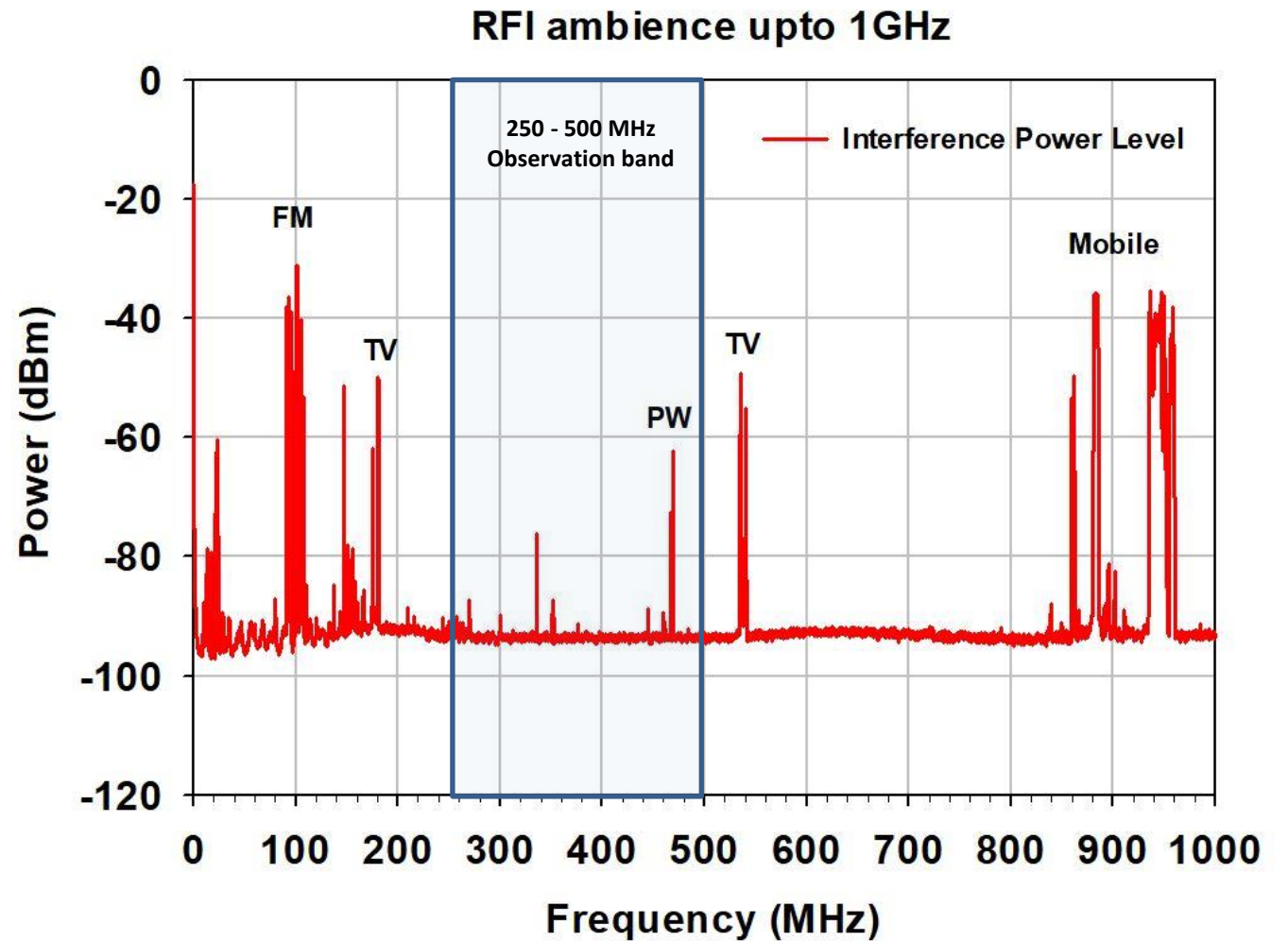
- What is out of band interference ??
- Effect of out of band interference.
- Brief view of RFI ambience
- Novel mitigation technique using metamaterial structure
  - Design
  - Fabrication and characterization
  - Comparison with existing receiver
- Implementation
- Conclusion and Future scopes
- References

# Upgraded GMRT operating bands

Earlier GMRT Bands	Radio Astronomy band	Upgraded GMRT Bands	
		Frequency range	Bandwidth (MHz)
150MHz	150-153.6MHz	130 - 260MHz	130
235MHz	230-235MHz	250 - 500MHz	250
327MHz	322-328.6MHz		
610MHz	604-616MHz	550 - 900MHz	350
1060-1420MHz	1400-1427MHz	1.0 - 1.4 GHz	400

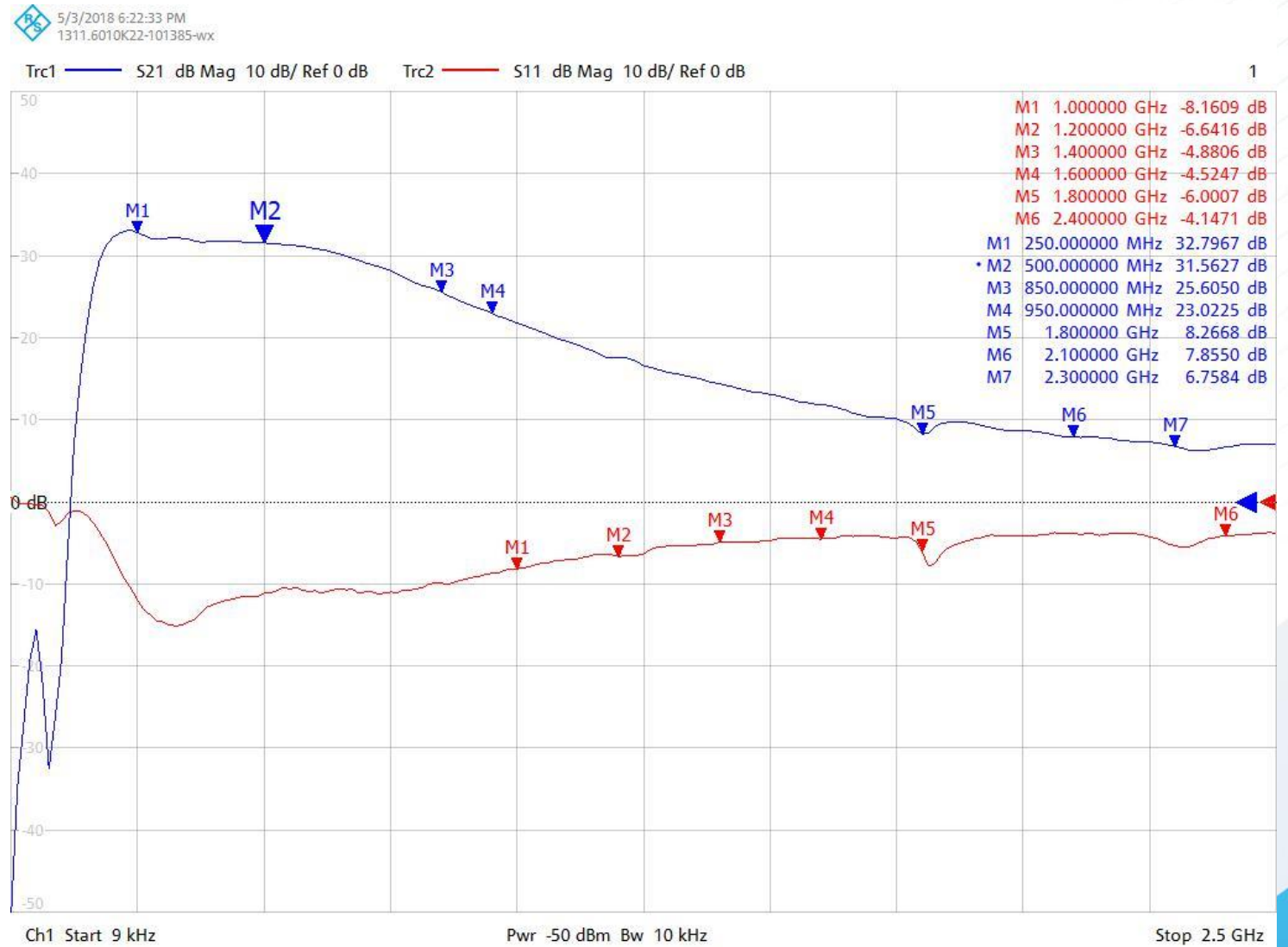
- Band-3 i.e. 250-500 MHz of observation band has a lot of out of band commercial transmissions e.g. Mobile, TV, FM, ATC.

The figure shows the spectrum up to 1GHz using RFI monitoring setup.

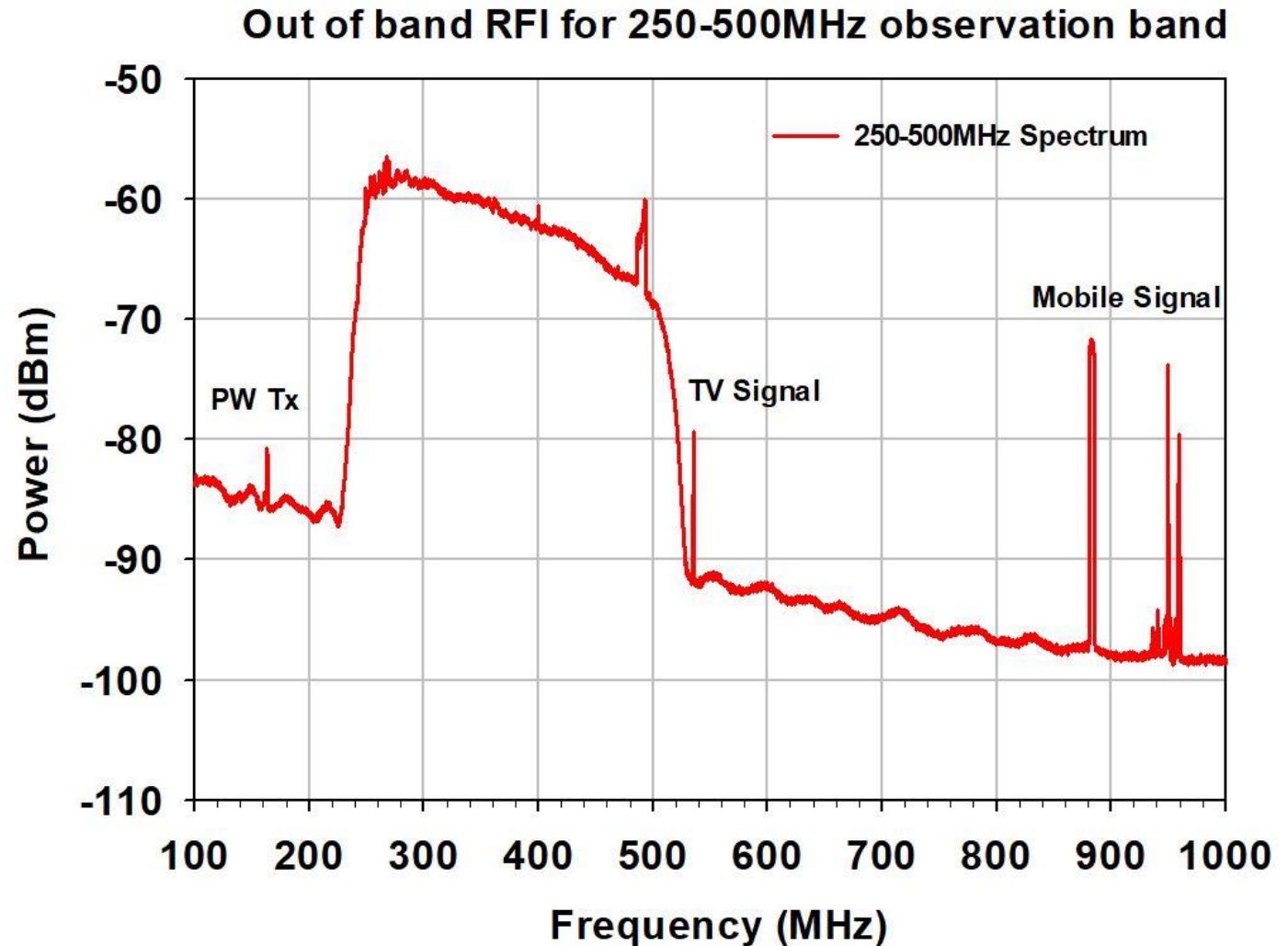


# LNA Response

- The wideband LNA has gain outside the band of interest and amplifying equally out of band commercial interfering signals.



- Selected observation band is 250-500MHz band of uGMRT.
- uGMRT antenna receives various out of band mobile transmission, TV transmission and Police wireless transmission.
- Mobile transmission is one of the stronger one to saturate the receiver.



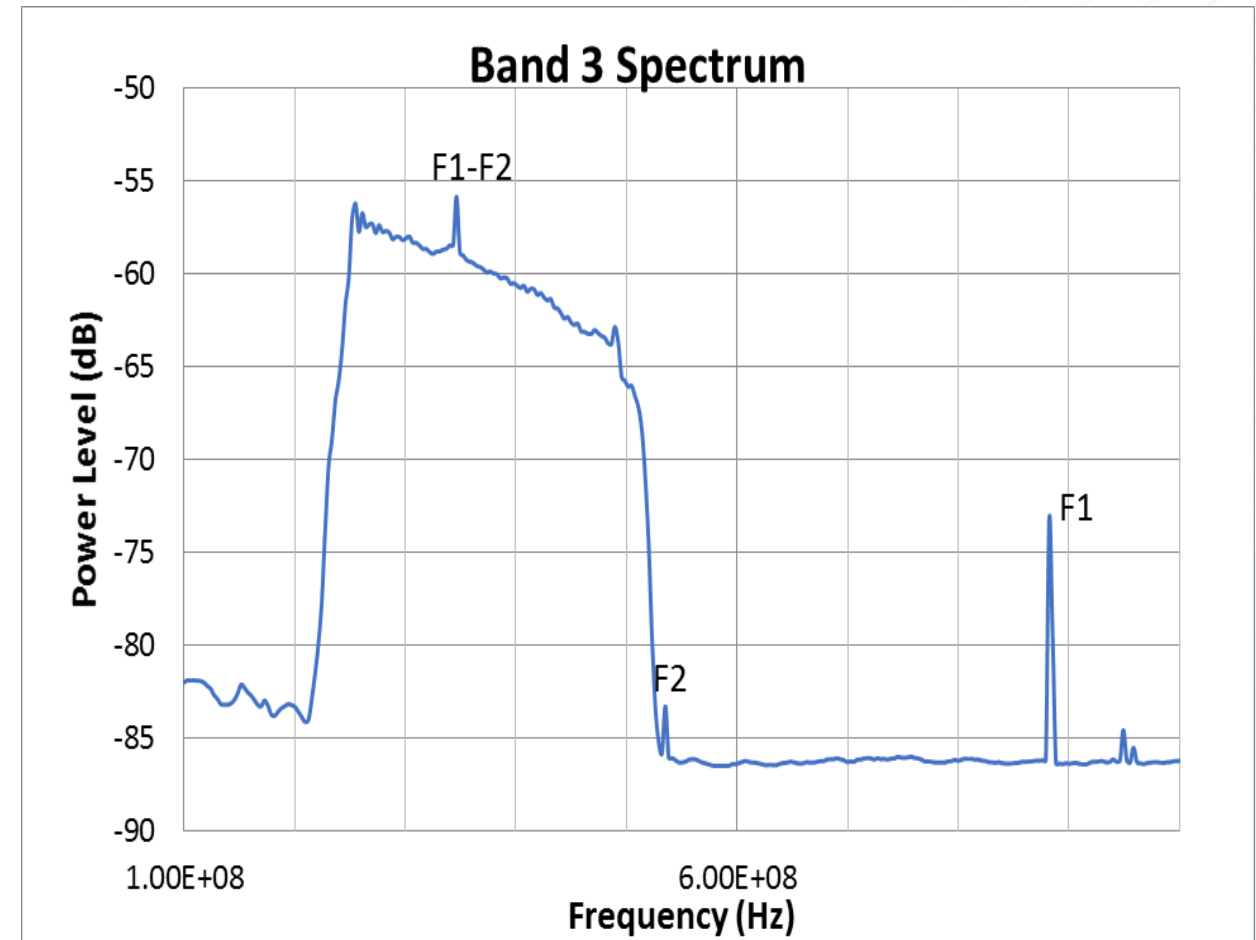
# Effects of Out of Band RFI

- It may cause non linearity of receiver and make observation unusable.
- Out of band transmission may produce Inter Modulation that may fall within the observation band.
- For example, we can observe the mobile transmission and TV transmission beating together and generating the IMD product within the band of interest.

F1 : 885 MHz Mobile signal

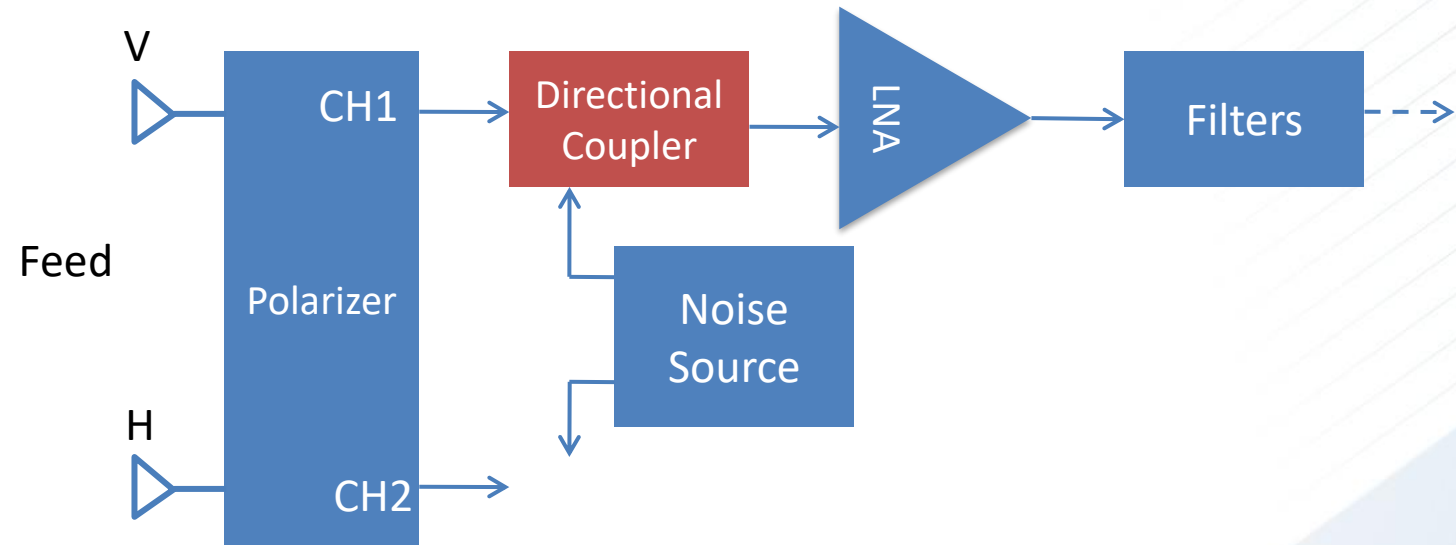
F2 : 535 MHz TV Transmission

F1-F2 : IMD product @350MHz



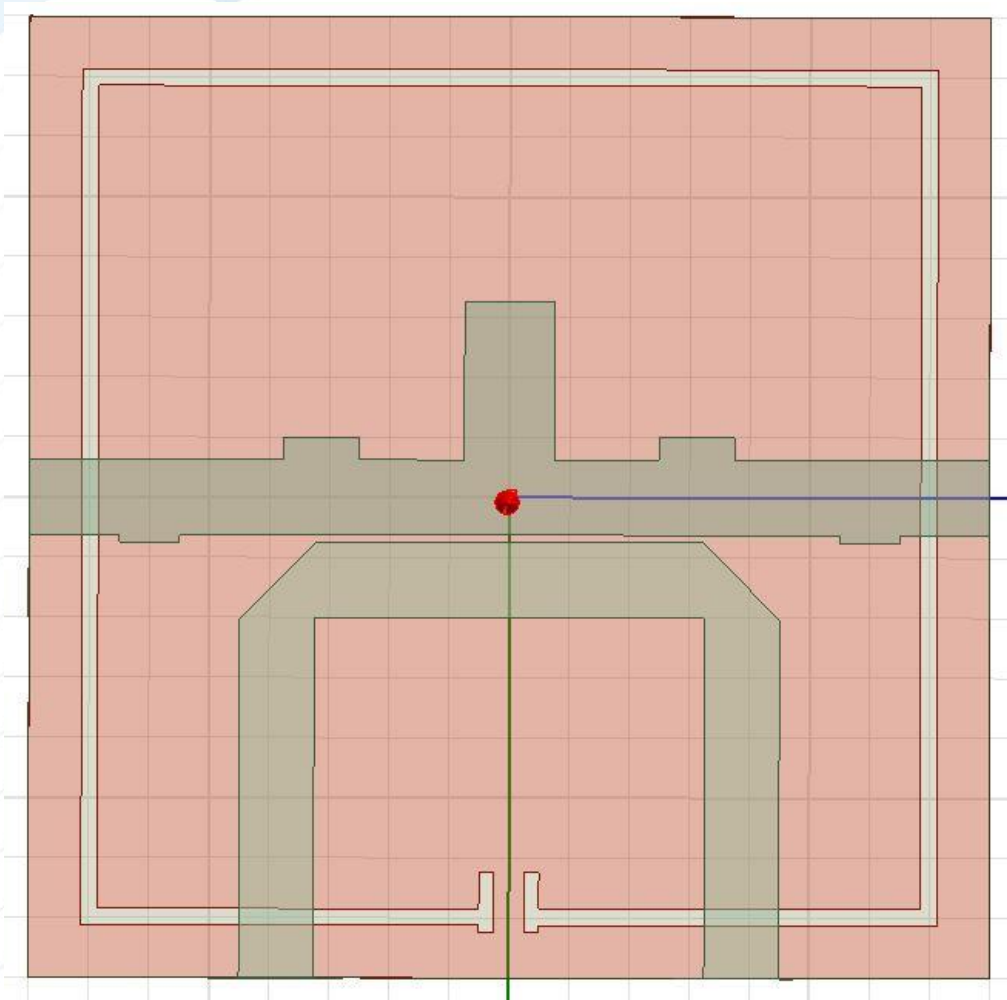
# Front End system configuration

- In uGMRT receiver directional coupler is used before the LNA and after quadrature hybrid (QH).
- It is used to inject the noise to calibrate the antenna and coupled port (3) is connected to noise source to inject the noise and other port (4) is terminated.



Block diagram of FE system

# HFSS model for the Metamaterial based Directional coupler



Details :

Substrate : RT Duroid 5880

Thickness : 0.8 mm

Dielectric constant : 2.20

Top Layer :

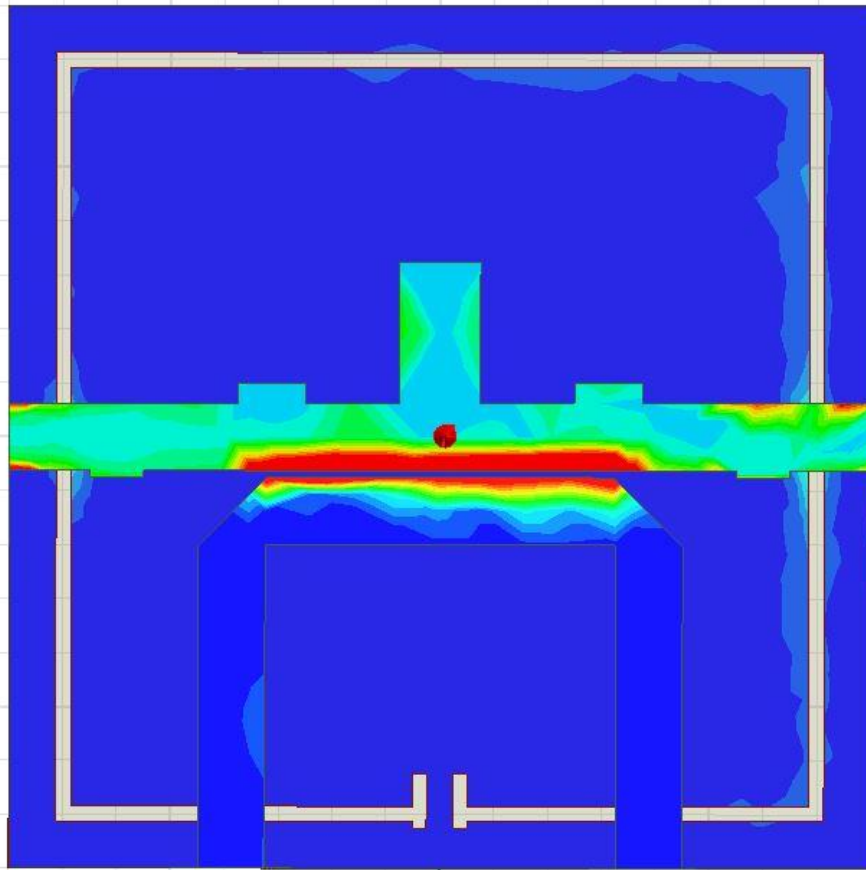
Main transmission path has 5 Stubs for matching.

Coupled ports have -24dB of coupling

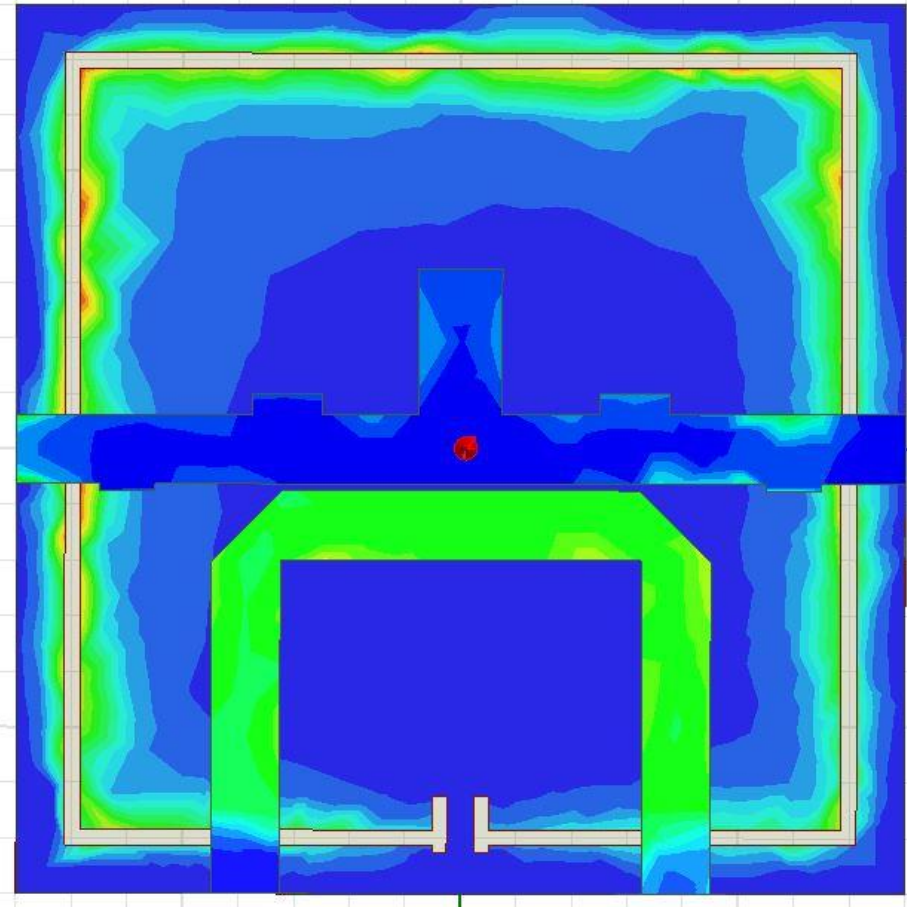
Bottom Layer :

CSRR (Complimentary Split Ring Resonator) is used as a defective ground structure.

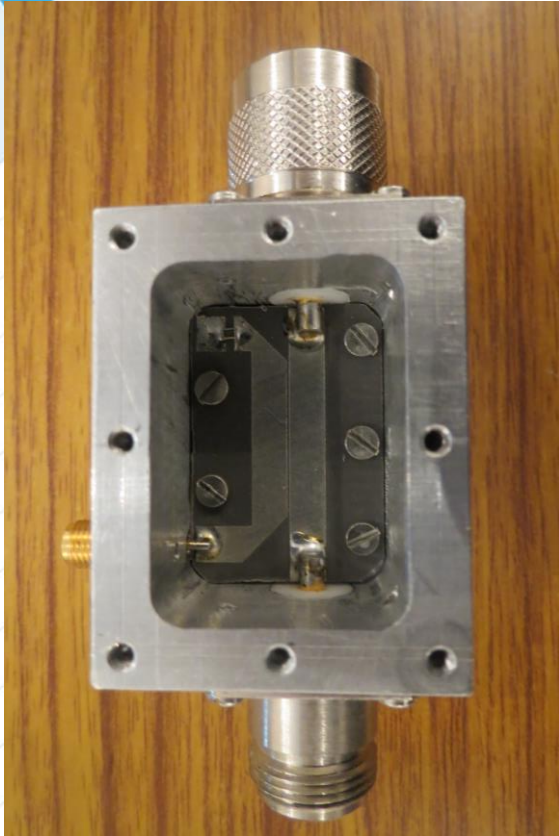
# Current distribution at resonance 900 MHz



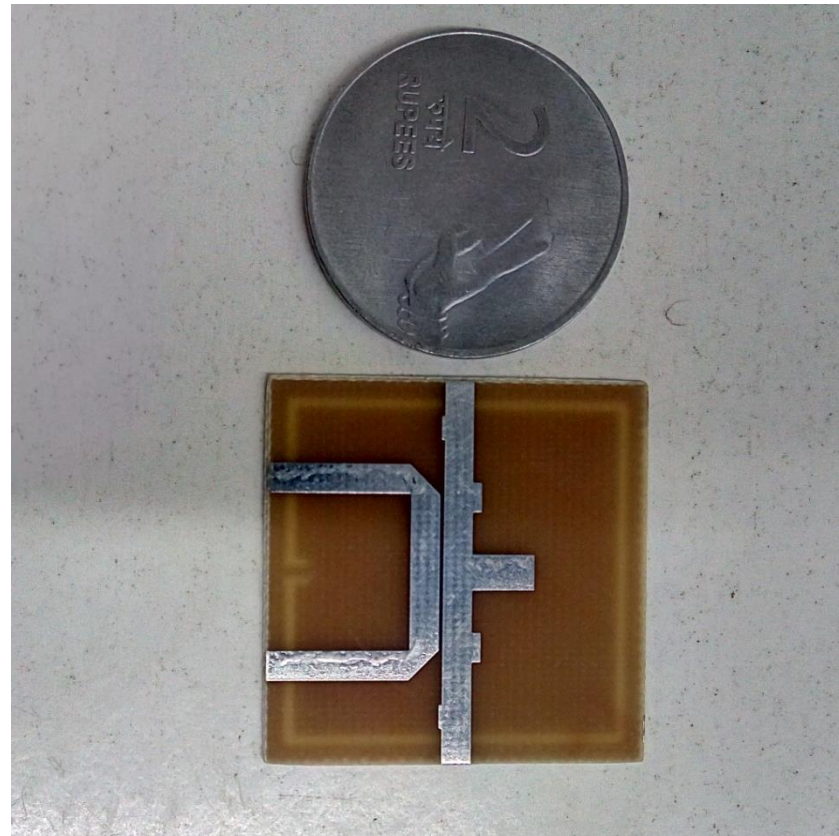
Current Distribution @ 375 MHz



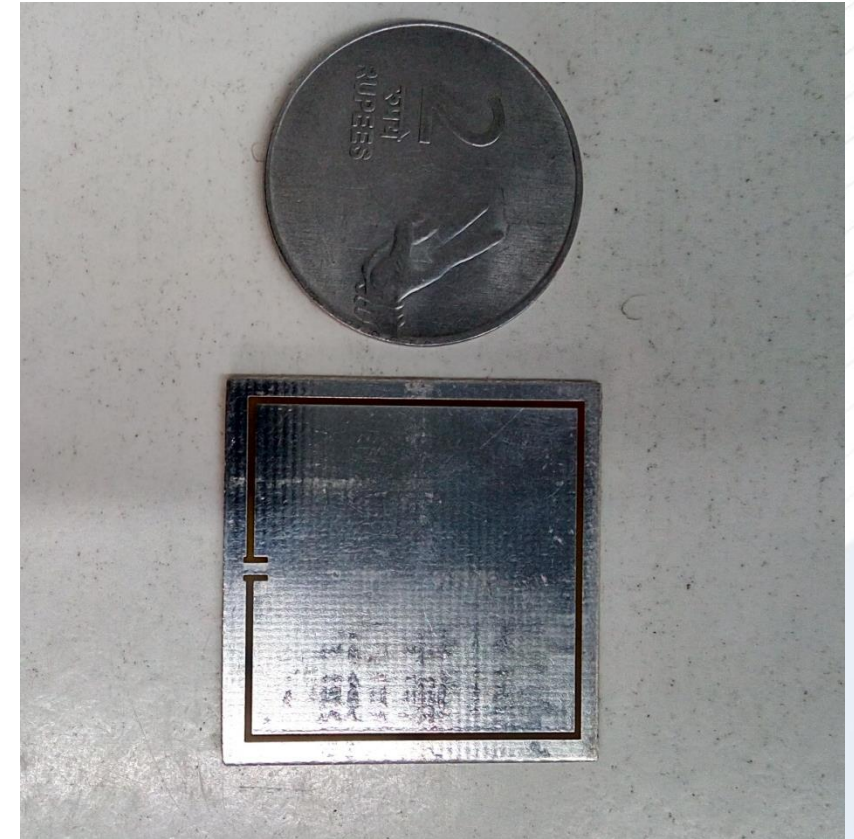
Current Distribution @ 900 MHz



Existing Directional Coupler



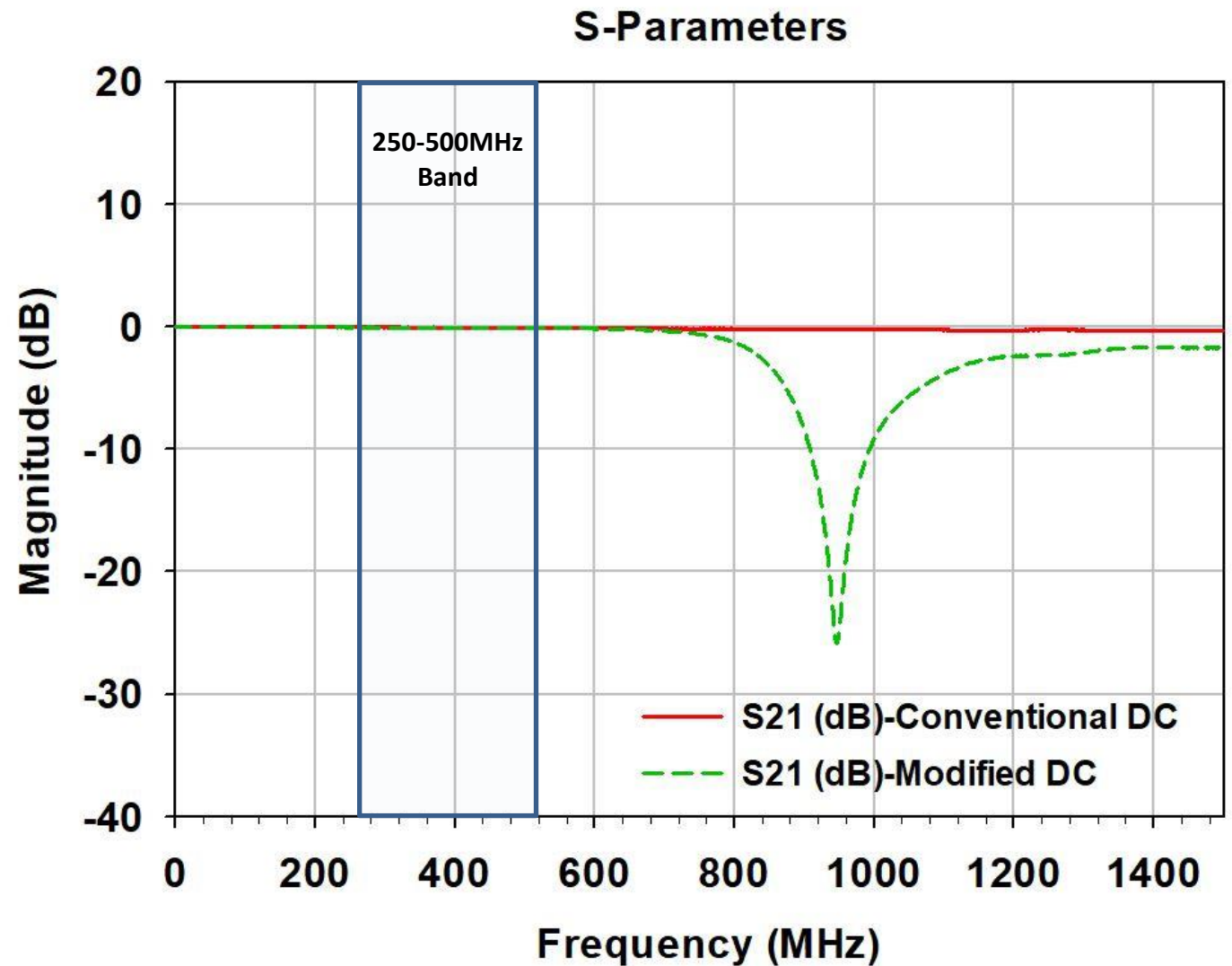
Top Layer of PCB



Bottom Layer of PCB

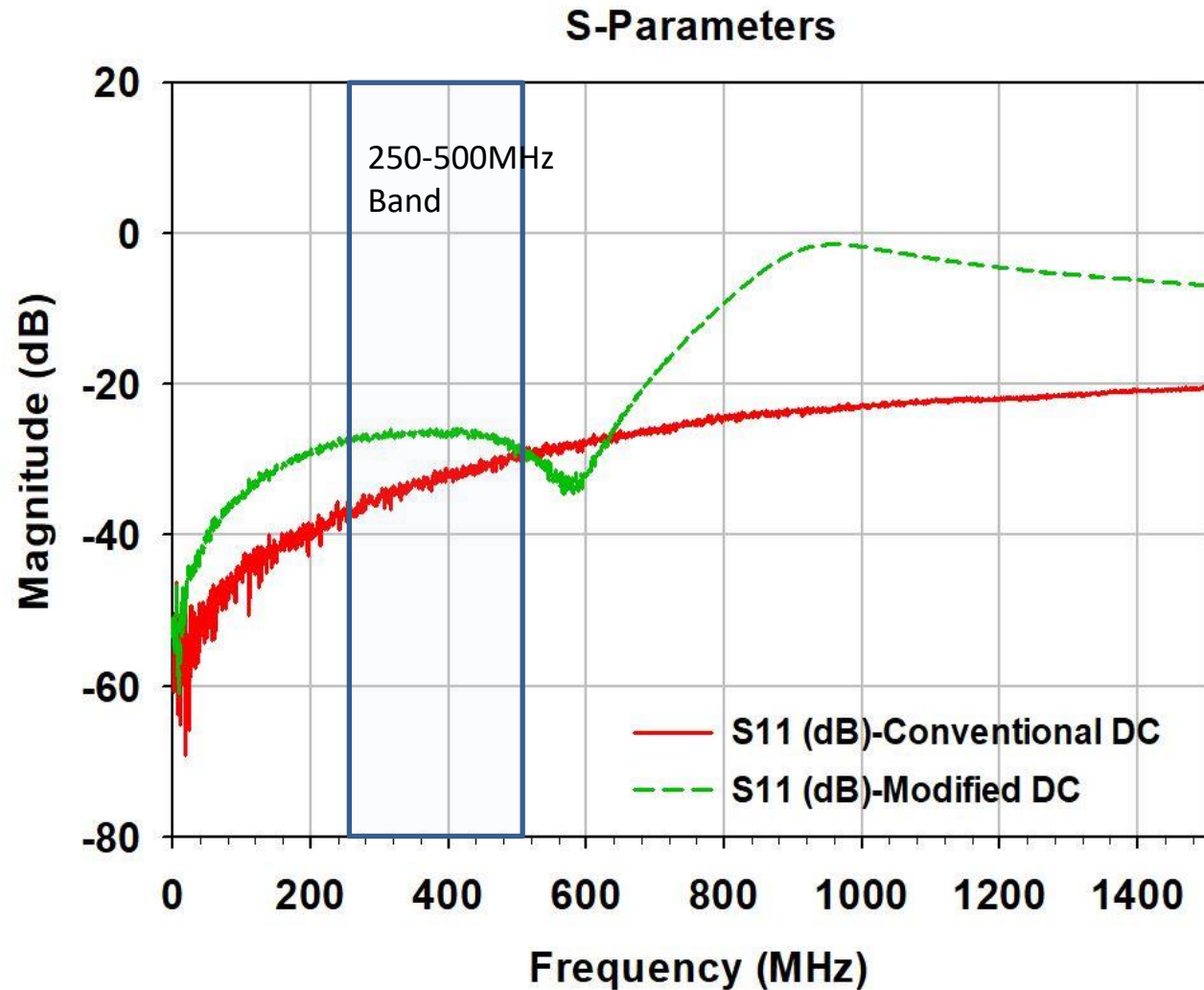
# Insertion loss performance

- The insertion loss performance of the modified directional coupler is same as the existing DC.
- Attenuation for the mobile communication at 900MHz is about 20 dB



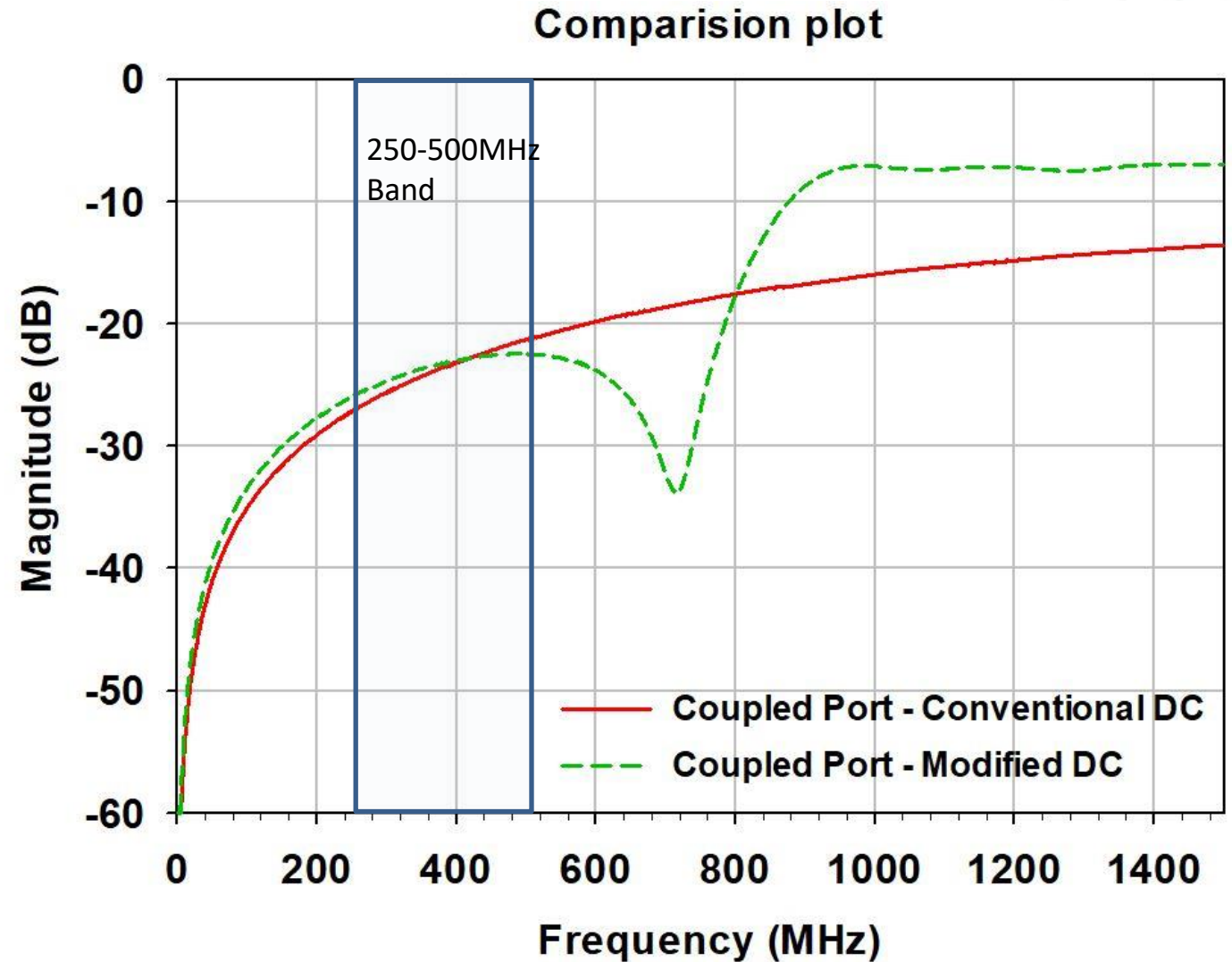
# Return loss performance of the Directional Coupler

- Return loss performance is below 20dB.



# Comparison of Coupling port

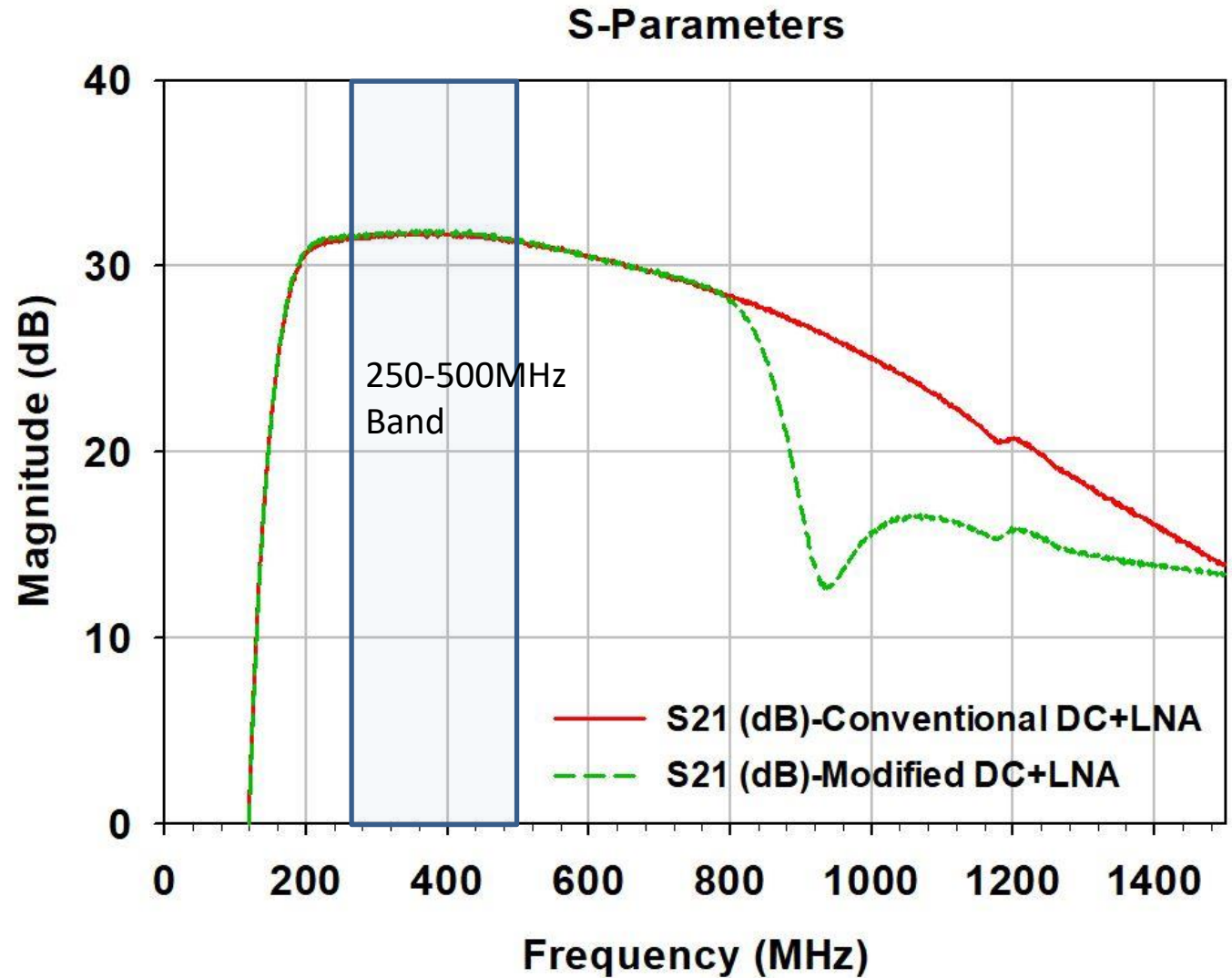
- Designed Coupled port have flat response compared to the existing design.
- The required coupled power is same for both the designs.



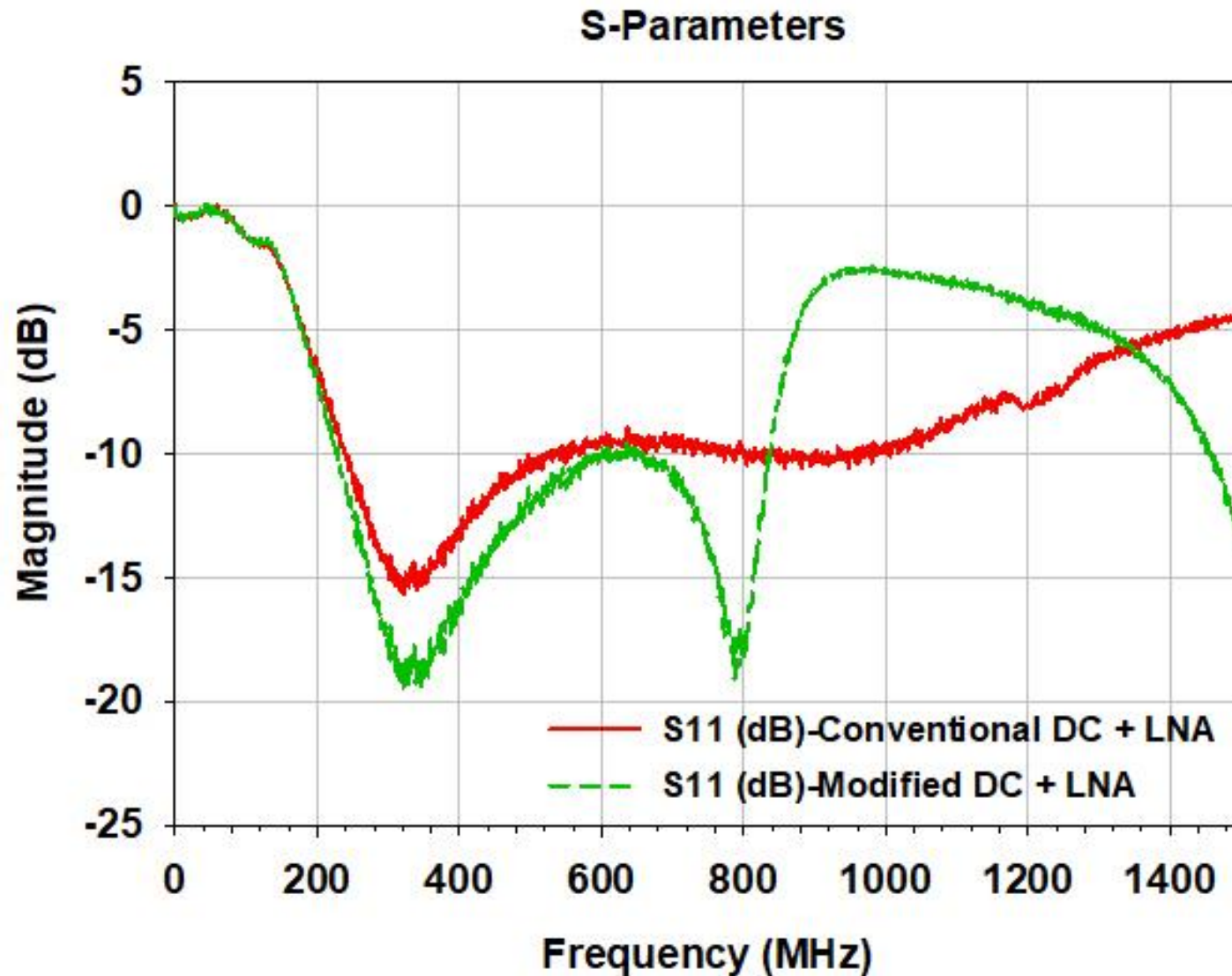
# Gain response with LNA

Parameters	LNA + Con. DC	LNA + Mod. DC
Gain (dB) @ 375 MHz	32	32
Gain (dB) @ 900 MHz	27	12

Gain at the desired band is same as the existing combination but gain at 900 MHz is suppressed by 15 dB

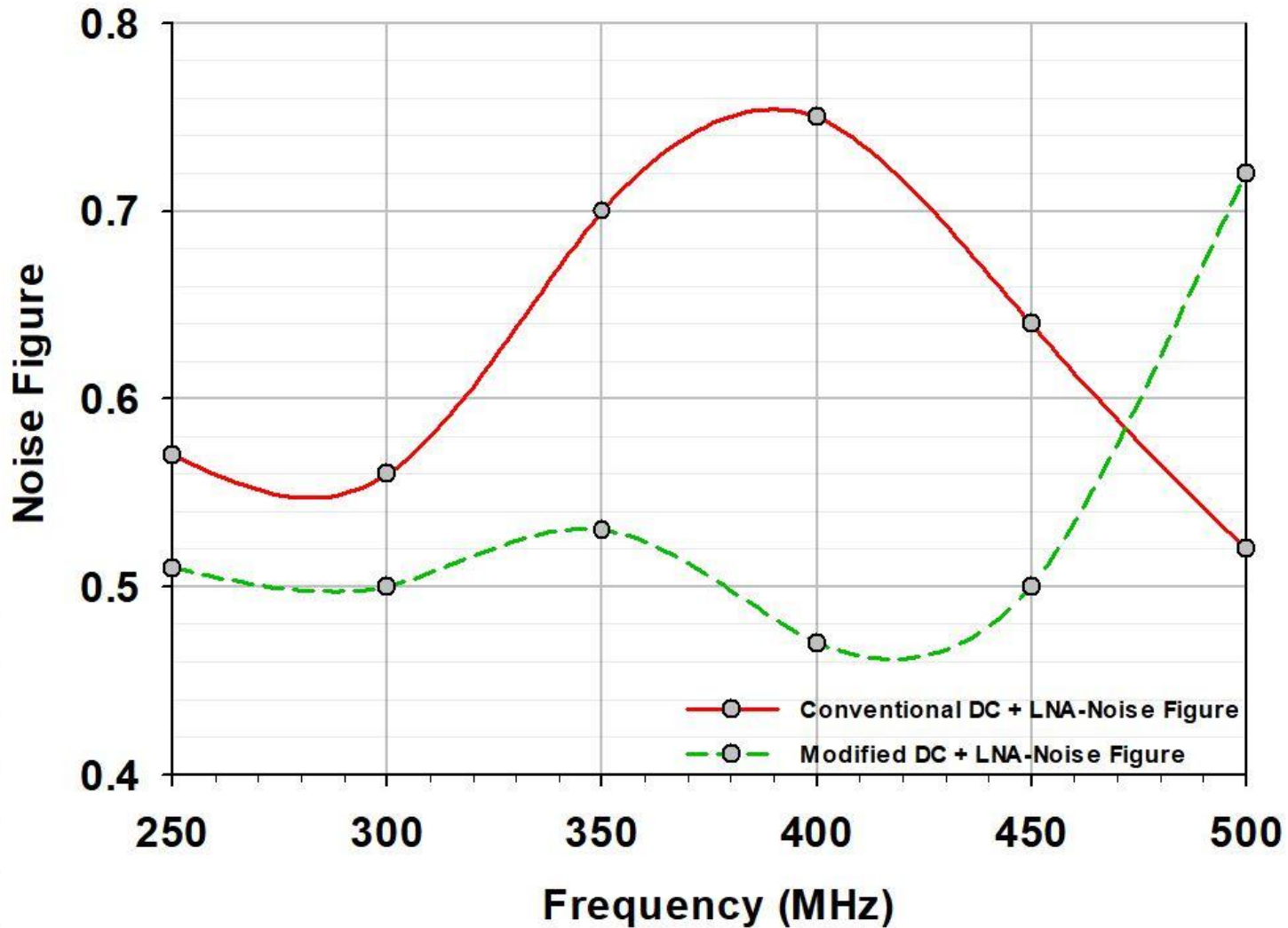


# The Metamaterial Directional Coupler have better impedance matching with LNA

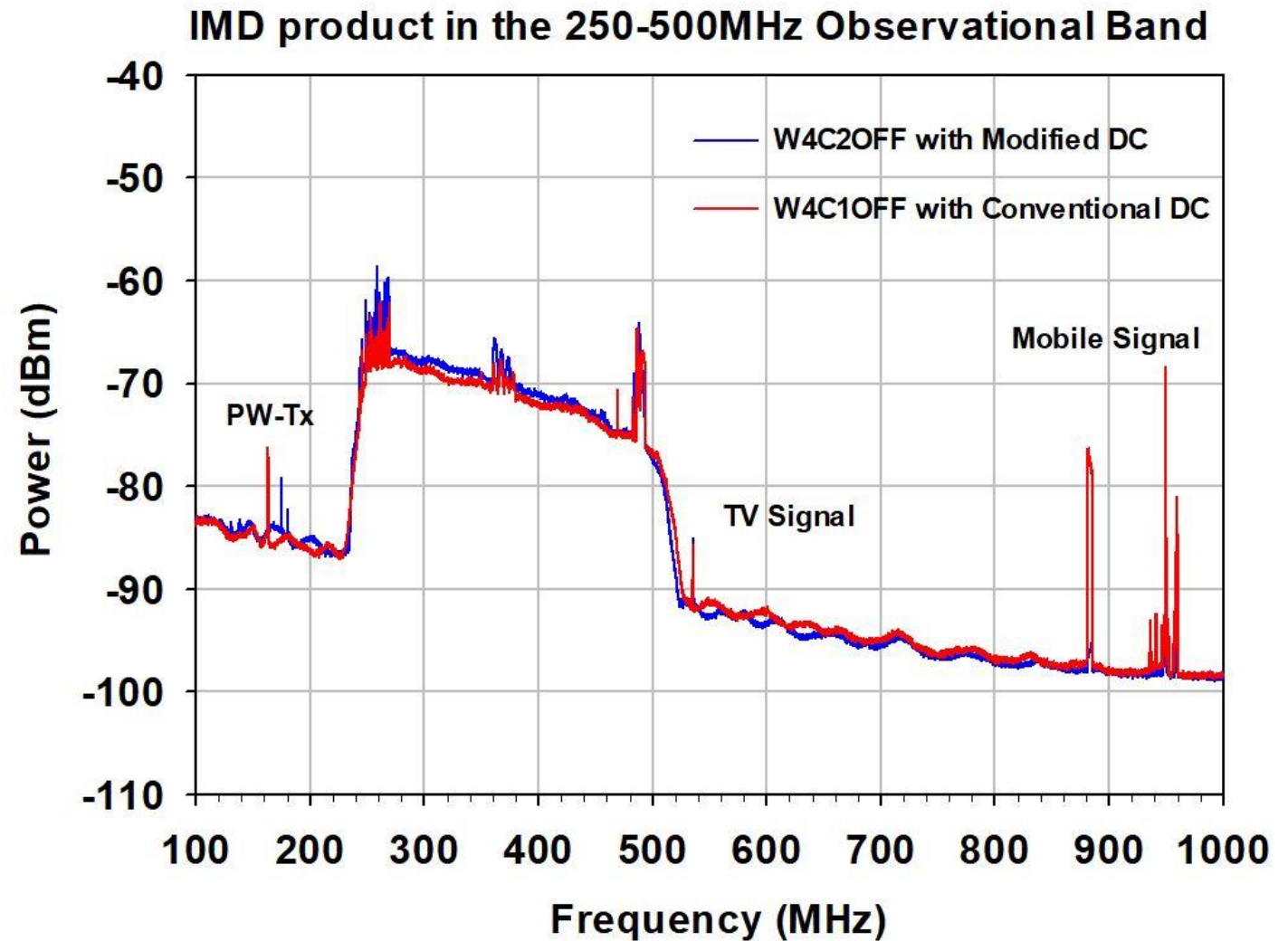


# Improved Noise Figure performance with LNA

**Cascaded Noise Figure Performance**

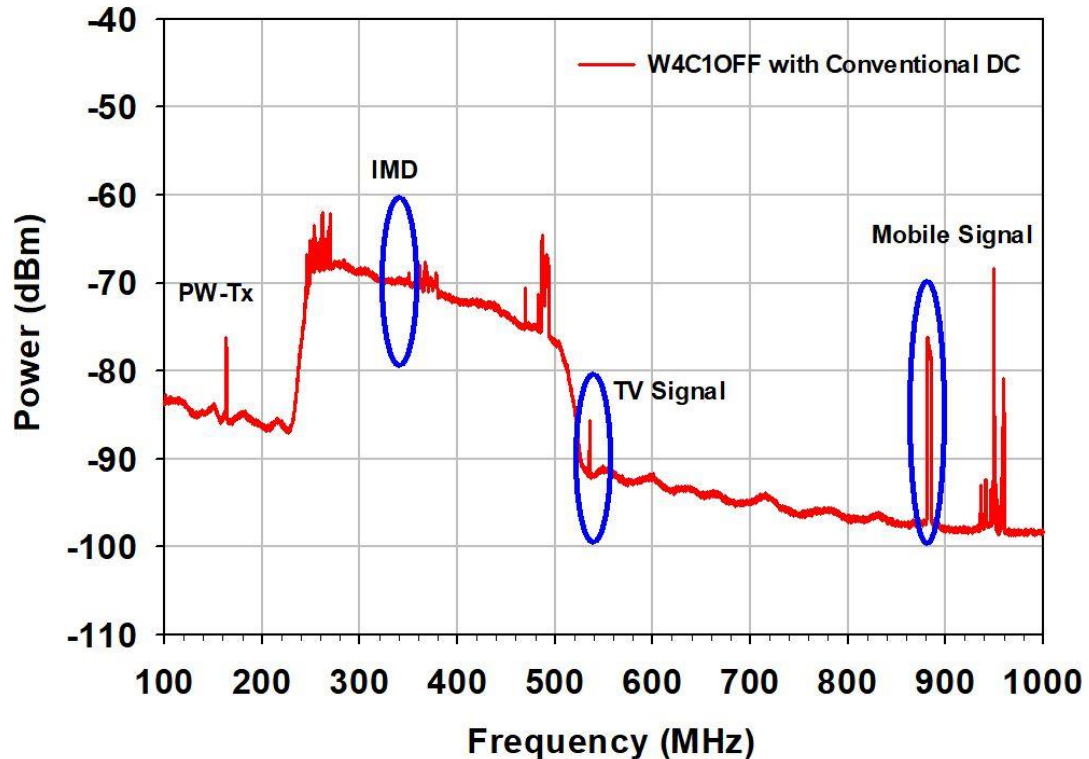


The Mobile signal at 880 MHz get rejected by the directional coupler by more than 15dB with modified metamaterial based Directional Coupler



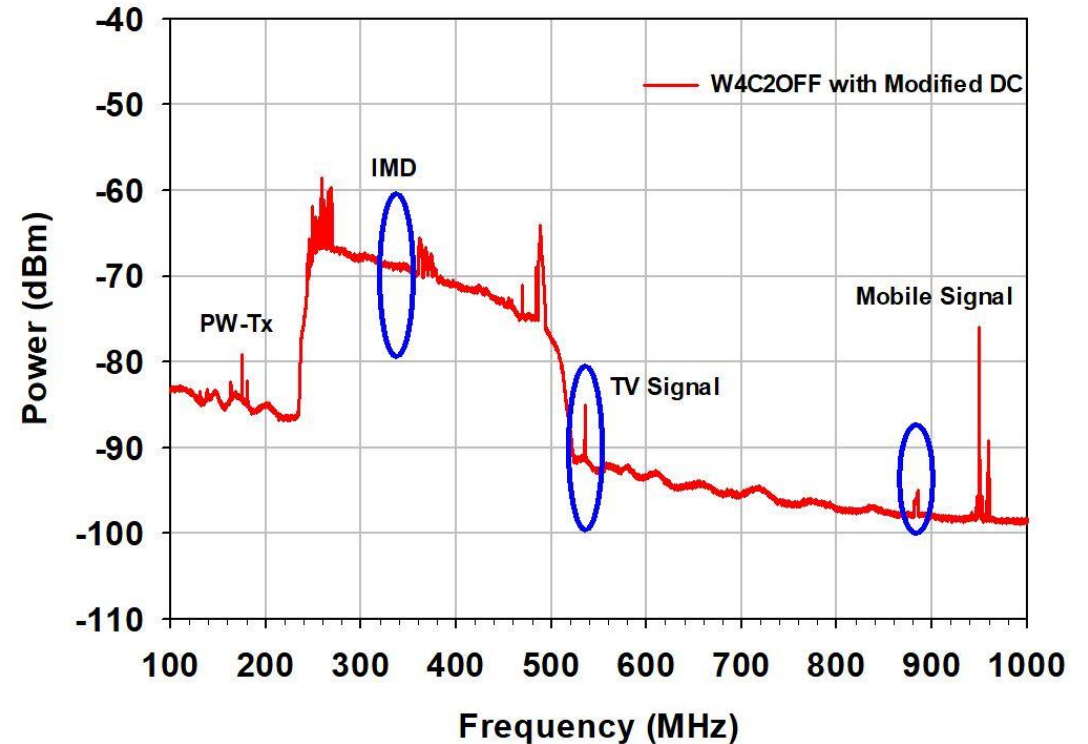
# Comparison of GMRT antenna response with Metamaterial based DC and Conventional DC

IMD product seen in the 250-500MHz Observational Band



Above image shows in-band intermodulation product due to high power of mobile signal and TV signals.

IMD product vanished in the 250-500MHz Observational Band



Above image shows in-band intermodulation product vanished out by using metamaterial based DC which suppresses the mobile signal.

# Conclusion

- Metamaterial based Directional coupler attenuates mobile RFI signal by more than 15dB to remove the in-band intermodulation products.
- The filter integrated metamaterial based directional coupler design meet the specifications of the conventional DC design without degrading the receiver noise.
- The dynamic range of the system in the presence of out of band signals is improved with this design and could be easily implemented for any frequency bands of radio astronomy.
- The metamaterial based directional coupler provides better matching with the LNA.

- Swarup, G., Ananthkrishnan, S., Kapahi, V.K., Rao, A.P., Subrahmanya, C.R., and Kulkarni, V.K. (1991) "The Giant Metrewave Radio Telescope", *Current Science*, vol. 60, pages 90-105.
- S. Sureshkumar, P. A. Raybole, S. Rai and Ankur, "RFI characterisation and mitigation at upgraded GMRT," *2016 Radio Frequency Interference (RFI)*, Socorro, NM, 2016, pp. 123-126, doi: 10.1109/RFINT.2016.7833545.
- S. Sureshkumar, PM Rubesh Anand, Ankur Prajapati, K Sakthidasan Sankaran, "Low pass filter design with CSRR as defected ground structure", *IEEE, International Conference on Communication and Signal Processing (ICCSP)*, 2018, pp 893-896.
- S. Sureshkumar, PM Rubesh Anand, Ankur Prajapati, K Sakthidasan Sankaran, "Negative index metamaterial based Dual-Band microwave absorber", *IEEE, International Conference on Communication and Signal Processing (ICCSP)*, 2018, pp 897-900.
- V. G. Veselago, "Electrodynamics of substances with simultaneously negative electrical and magnetic properties," *Soviet Physics Uspekhi*, vol. 10, no. 4, 1968, pp. 509-517.
- J. B. Pendry, A. J. Holden, W. J. Stewart and I. Youngs, "Extremely low frequency plasmons in metallic mesostructures," *Physical Review Letters*, vol. 76, 1996, pp. 4773-4776.
- J. B. Pendry, A. J. Holden, D. J. Robbins and W. J. Stewart, "Magnetism from conductors and enhanced nonlinear phenomena", *IEEE Transactions on Microwave Theory and Techniques*, vol. 47, no. 11, November 1999, pp. 2075-2084.
- Pravin Ashok Raybole and S. Sureshkumar, " External sources of RFI at the GMRT: Methods for control and co-existence with commercial users" in *Proceedings of Science 2010*.



Thank you !!