National Centre for Radio Astrophysics

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Internal Technical Report

GMRT/Feeds/001-August2013

Cone-Dipole Feed 250-500MHz for the upgraded GMRT

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Objective: This paper describes the ongoing development of next generation wideband feed for the upgraded GMRT. The new broadband feed covered in this paper is cone-dipole feed for 250-500 MHz, Design techniques and performance results for this is described.

Revision	Date	Modification/ Change
Ver. 1	02 August 2013	Initial Version

1. Introduction: The Giant Metrewave Radio Telescope (GMRT) is an international facility for Radio Astronomy, operational since 2002. The GMRT consists of 30 fully steerable parabolic dishes, each of 45 m diameter, spread over an area with an effective radius of about 15 km. The GMRT has prime-focus feeds at four faces of a rotating turret, covering frequency bands at 150, 233, 327, 610 & 1420 MHz. Currently, the GMRT is going through an upgrade to provide seamless frequency coverage from 50 to 1500 MHz, with a maximum instantaneous bandwidth of 400 MHz for increased sensitivity. For this, new broadband feeds are being designed with octave bandwidths.

2. Target performance specifications : As part of the ongoing upgrade of the GMRT, the plan is to provide seamless frequency coverage from 50 MHz to 1500MHz.To cover this range efficiently, the following wideband feeds (octave or more bandwidth) are being designed (using the WiPL-D software): 130-260 MHz, 250-500 MHz and 550-900 MHz. This paper describes 250-500 MHz feed.

3. Design description: In particular, the asymmetric radiation causes an excessive cross polarisation. A numerical approach for optimising the dipole-disc antenna was used by Kildal and Skyttemyr. They used a conducting ring in front of the dipole to shape the feed pattern. The beam-forming ring does not significantly affect the dipole-disc radiation pattern in the E-Plane, but compresses its H-Plane pattern to form a symmetric radiation pattern. This feed has a narrowband performance, since both the dipole and ring are resonant structures.
The asymmetry of the dipole-disc feed is due to the flat sub reflector which forms an approximate image of the dipole. However, since the dipole-radiation pattern is asymmetric the resulting pattern one must use an antenna which also has a symmetric radiation pattern. This can be achieved with an electric dipole by bending its arms towards the disc and optimizing the dimensional parameters. However, this solution is not attractive since it affects the antenna impedance and power-carrying capability.
An alternative and more desirable solution is to keep the dipole in its standard form, but bend the disc, This modifies the disc to a cone reflector. The radiation patterns for this feed shows good pattern symmetry and low backlobe level and crosspolarisation. For this feed, key parameters are the cone angles, the separation of the dipole from the one apex, paraboloid reflectors. The best cone angle for minimum cross polarisation is 70 deg. For the best overall feed performance, the cone size is between 1.0 lamda and 1.2 lamda.

4. Design validation: The prototype feed that has been designed and tested employs a crossed-dipole with a conical reflector (figure 1). Test results indicate a BW ratio of 1:1.8 for a return-loss of -10 dB or less (figure 3), with the following radiation properties: (a) good pattern symmetry and fairly good match of E and H plane patterns (on the primary lobe, especially within the angular spread of -62.5 to + 62.5 deg., being the edge-angle of the GMRT's parabolic dish over 250 to 500 MHz (figure 4), see **Annexure-A** (b) a cross-polar minimum of -27 dB at 327 MHz and -15.5 dB at 250 as well as 500 MHz, see **Annexure-B**, After extensive tests of prototypes on GMRT antennas (figure 5 & 6), this feed is now accepted for mass production.

Figure 1: CDF 250-500 MHz mounted on antenna

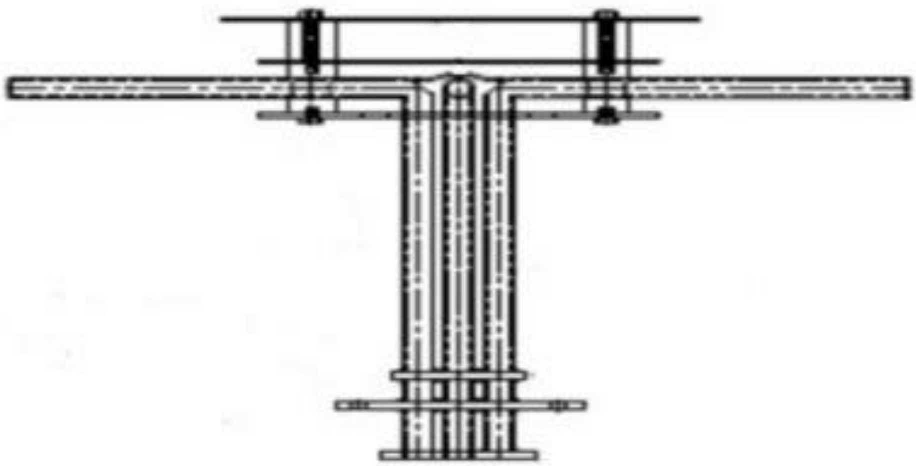

Figure 2: Schematic of dipole with triple-sleeve

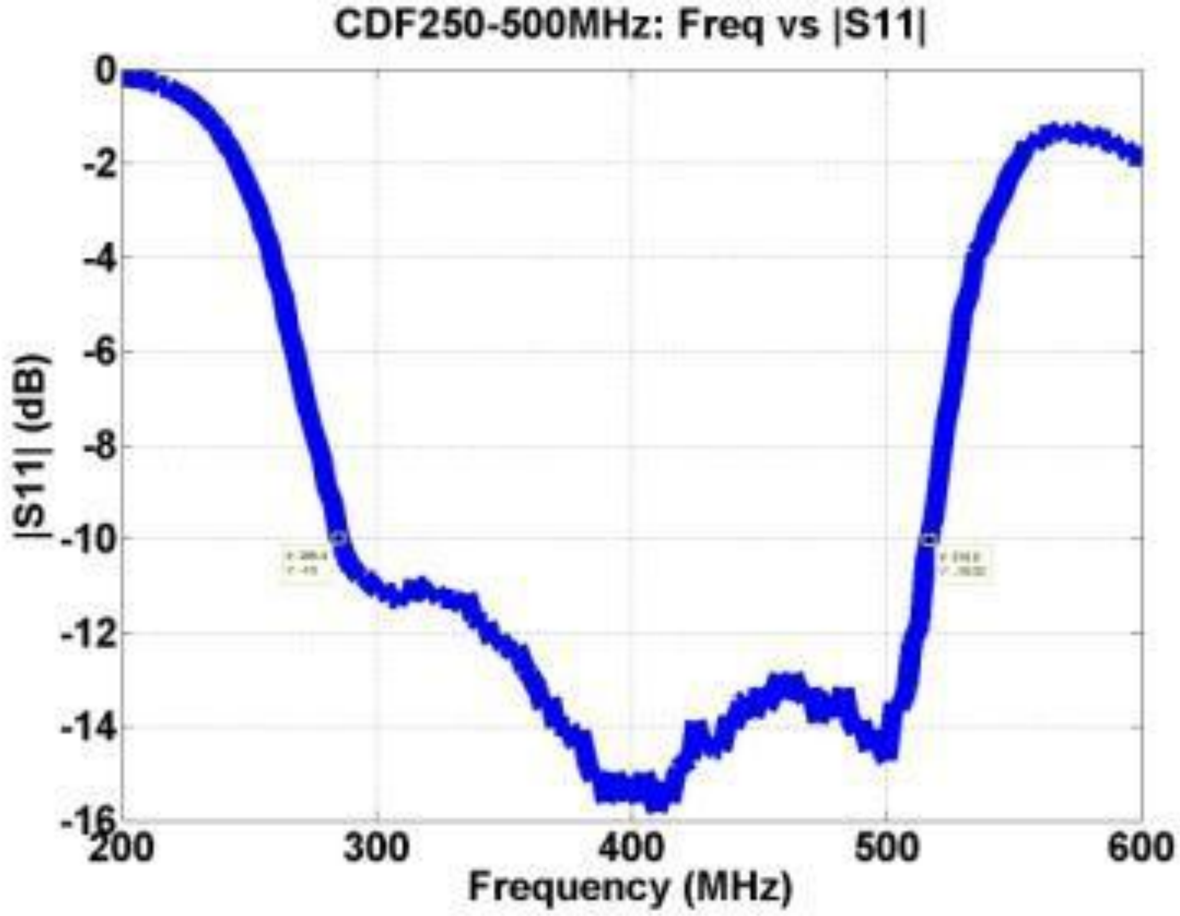

Figure 3: Return Loss (measured)

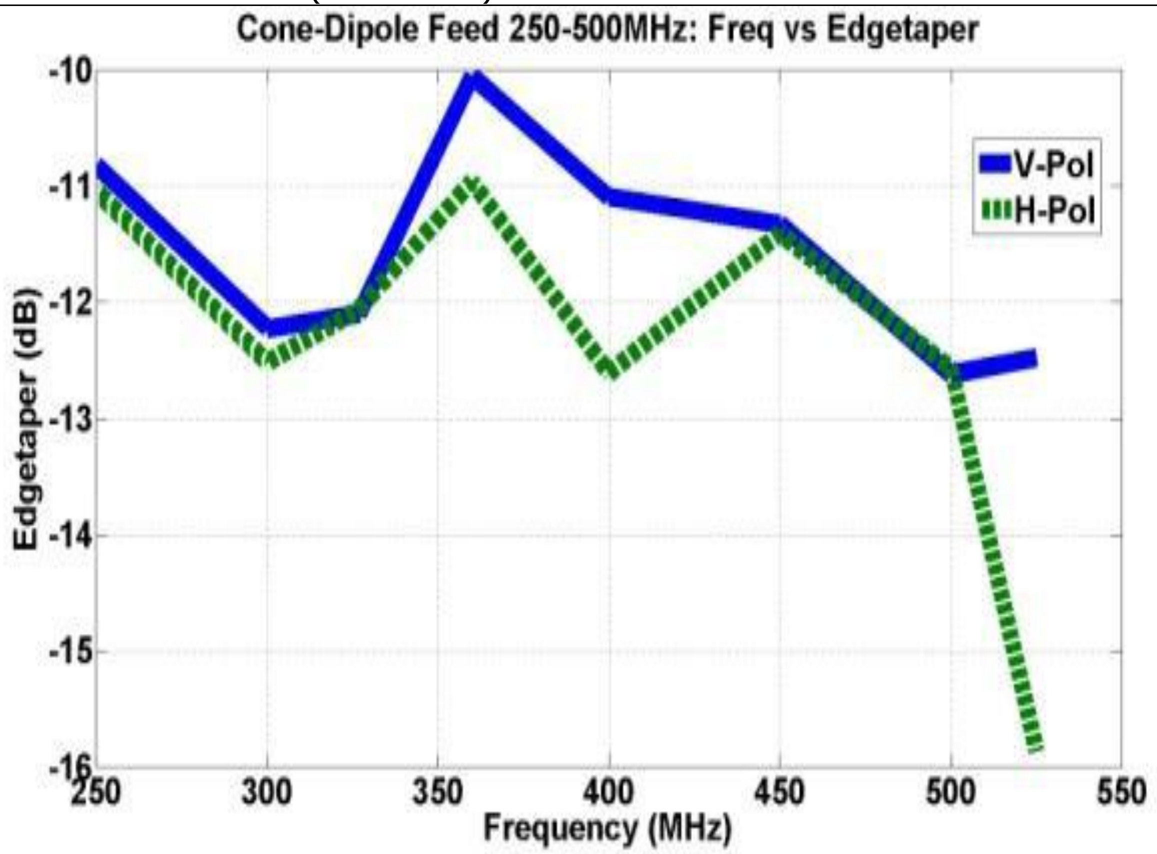

Figure 4: Edgetaper (measured)

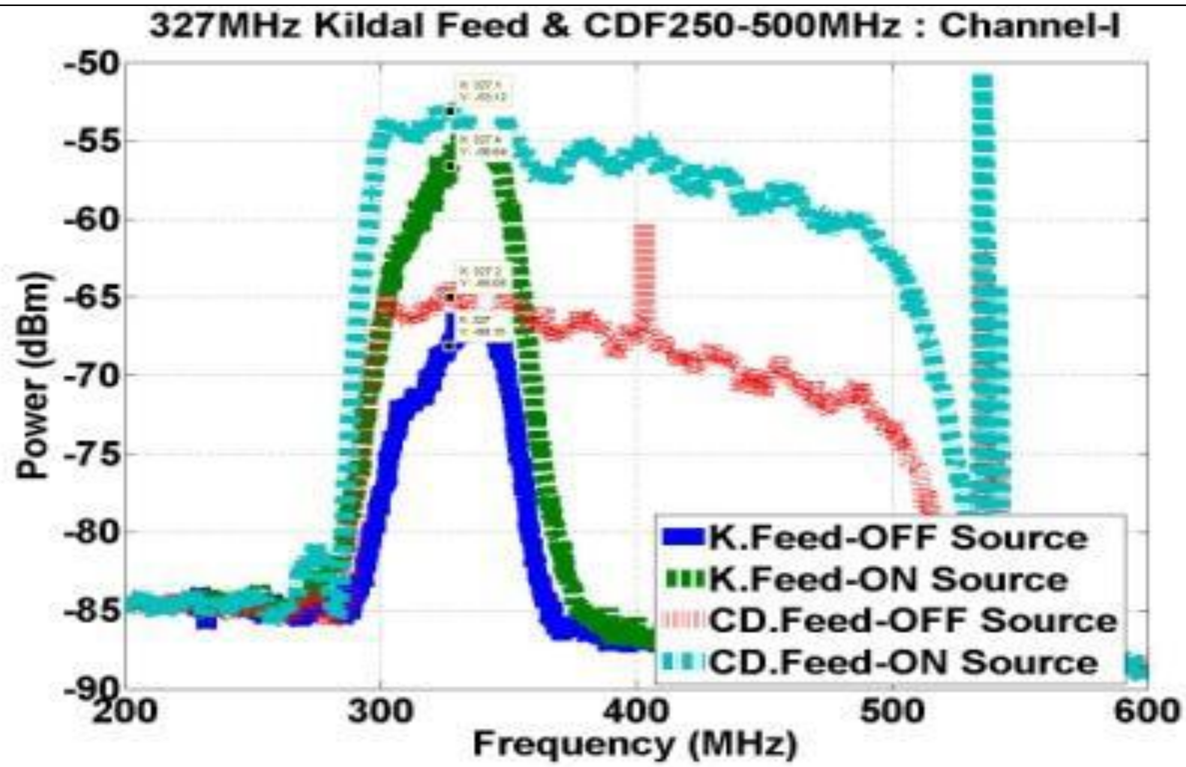

Figure 5: Deflection tests on calibrator (Cass-A) CH-I; the narrower curves are for the existing narrow band 325 MHz feed.

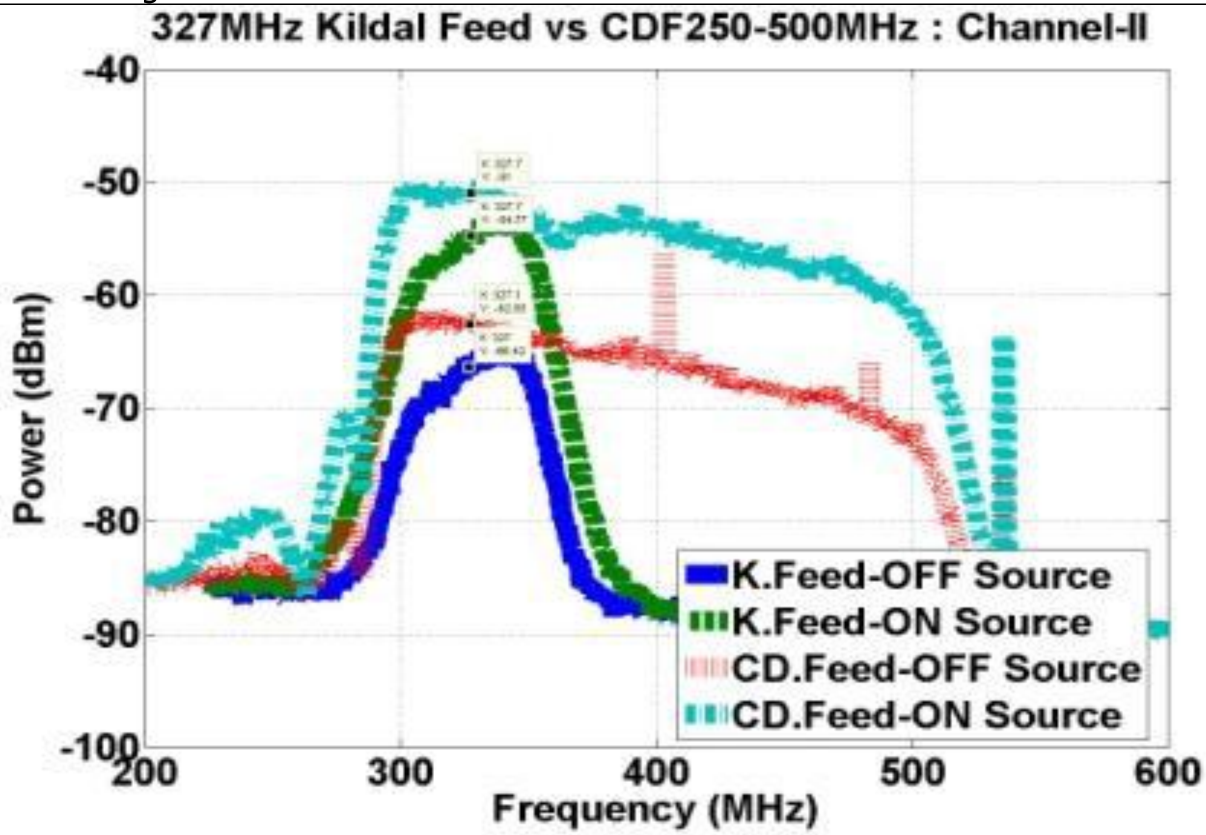

Figure 6: Deflection tests on calibrator (Cass-A) CH-II; the narrower curves are for the existing narrow band 325 MHz feed.

5. Conclusion: A wide-band feed for the 250-500 MHz. band has thus been designed and installed on more than 15 GMRT antennas. Their initial deflection tests show consistent performance. Phase-centre adjustment for all the installed and the future ones will improve the performance. This task of re-positioning the feeds will be taken up soon; most likely the feed will be fixed at the phase centre location as measured at 325 MHz, which implies some amount of defocusing (0.6 to 0.87 lambda) at higher frequencies, viz., 350 to 500 MHz. A trade-off between the best sensitivity and de-focussed placement will be necessary otherwise.

6. Future work: A scaled-down version at 550-900 MHz. (and later tweaked in WiPL-D software simulations) is being explored. The previous section about the measurements done on this cone-dipole configuration (at 250-500 MHz.) clearly points out that the polarization behaviour of this feed is not upto the mark. A wide-band characteristic is attained at the cost of losing the good polarization property – a fact vouched by many antenna designers. In case the demand for better polarization, a fall-back option is to install kildal feed of dual-ring configuration. This prototype has been designed and installed on 2 antennas and this has a marginally better performing feed in terms of polarization. A companion report on this design is under preparation.

6. References:

[1] Chengalur J N, Gupta Y and Dwarkanath K S 2007 Low Frequency Radio Astronomy 3rd Edition
NCRA-TIFR Pune

[2] Kolundzija B, Ognjanovic J, Tasic M, Olcan D, Sumic D, Paramentic M, Kostic M, Pavlovic M,
"WIPL-D Pro v7.0, 3D Electromagnetic Solver Prof. Edition," WIPL-D Ltd. 11070, Belgrade

[3] WongJ L and King H E, 1973, "A Cavity-Backed Dipole Antenna with Wide-Bandwidth Characteristics," *IEEE Trans. Ant. and Propg*., **AP-21**, 5, pp. 725-727

[4] Vivek Dholpuria, Devendra Singh, " Radiation Pattern Characterisation of GMRT feeds", Department of Avionics, Indian Institute of Space Science and Technology, Jan-April 2012.

Annexure-A

Radiation Patterns:

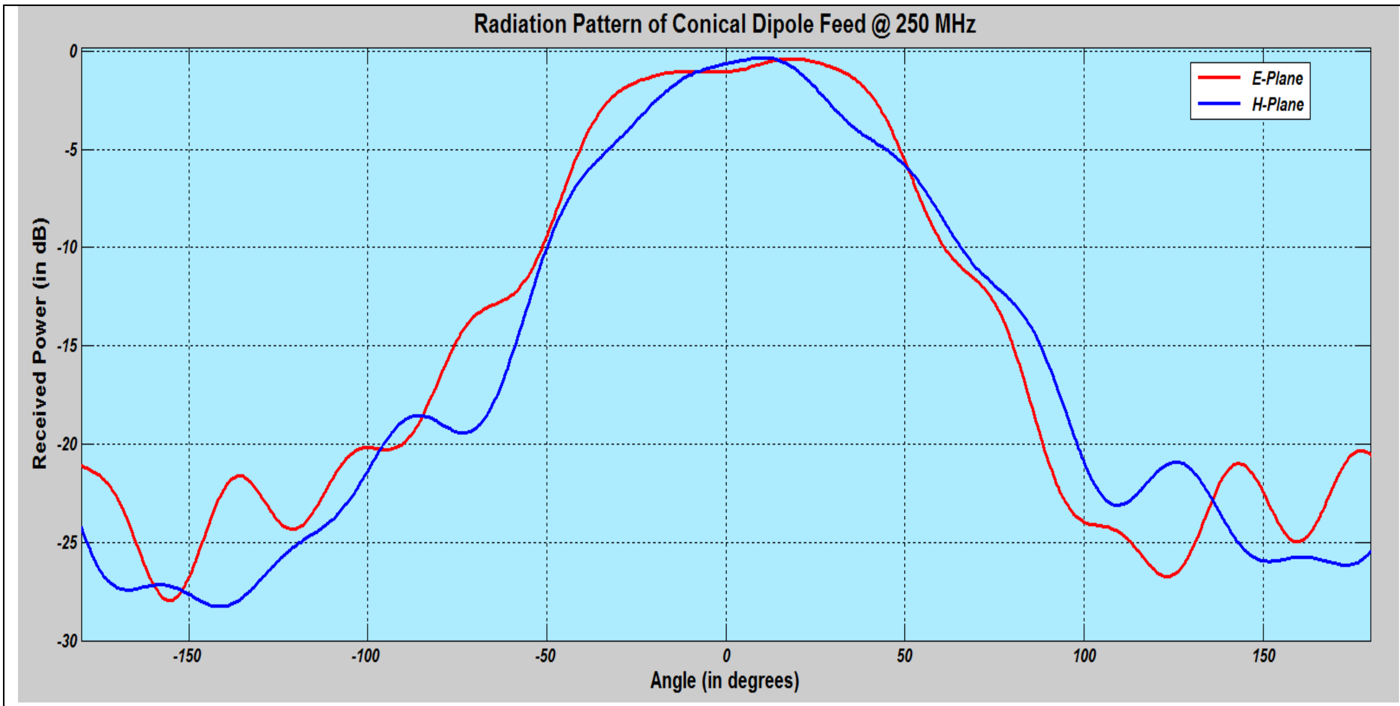

Figure 7 : E- & H-Plane pattern @ 250 MHz

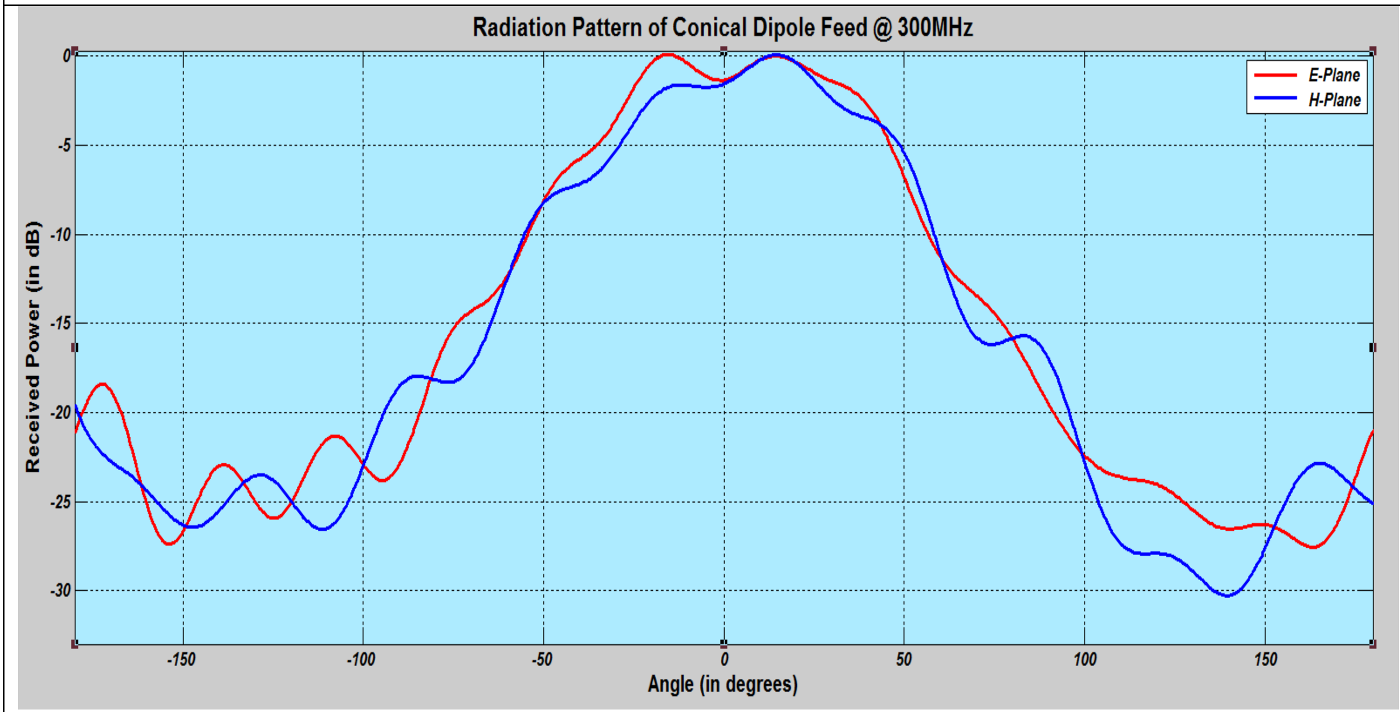

Figure 8 : E- & H-Plane pattern @ 300 MHz

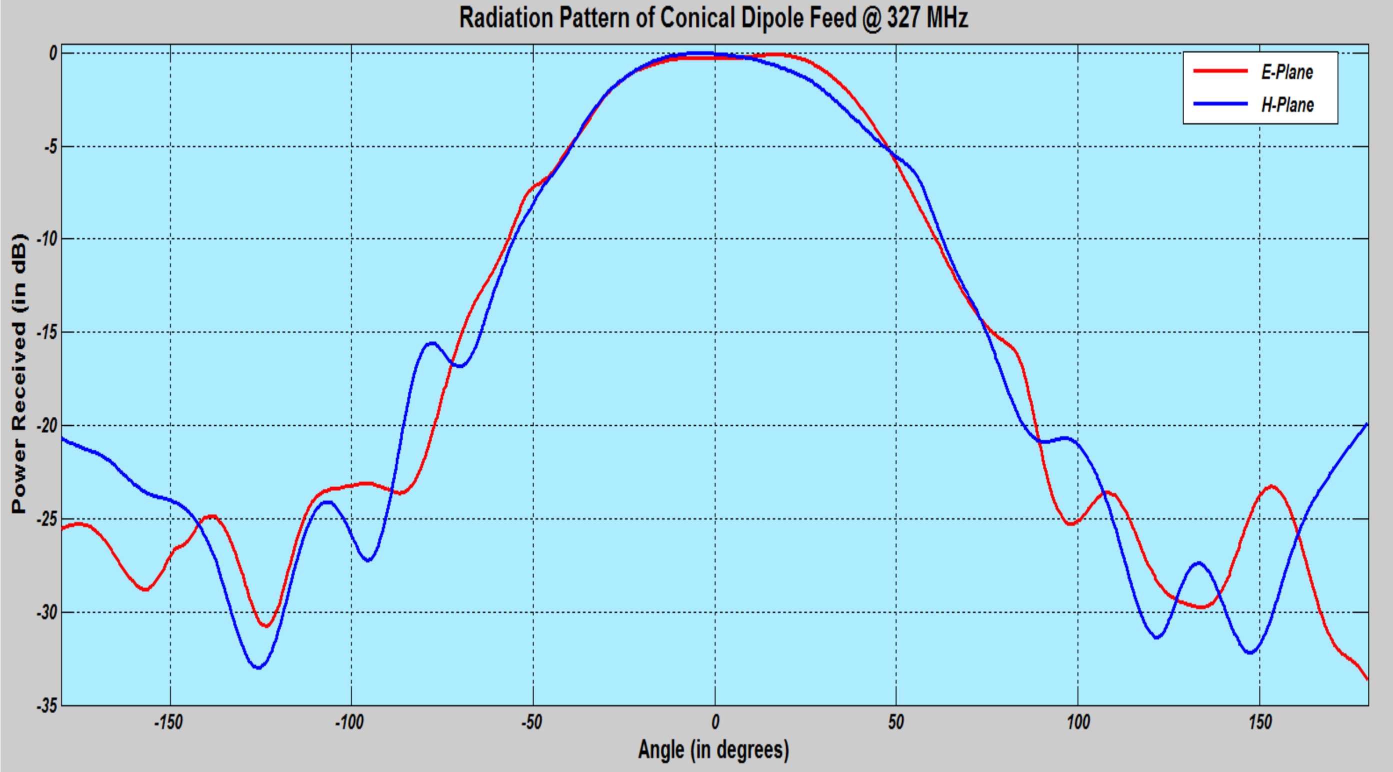

Figure 9 : E- & H-Plane pattern @ 327 MHz

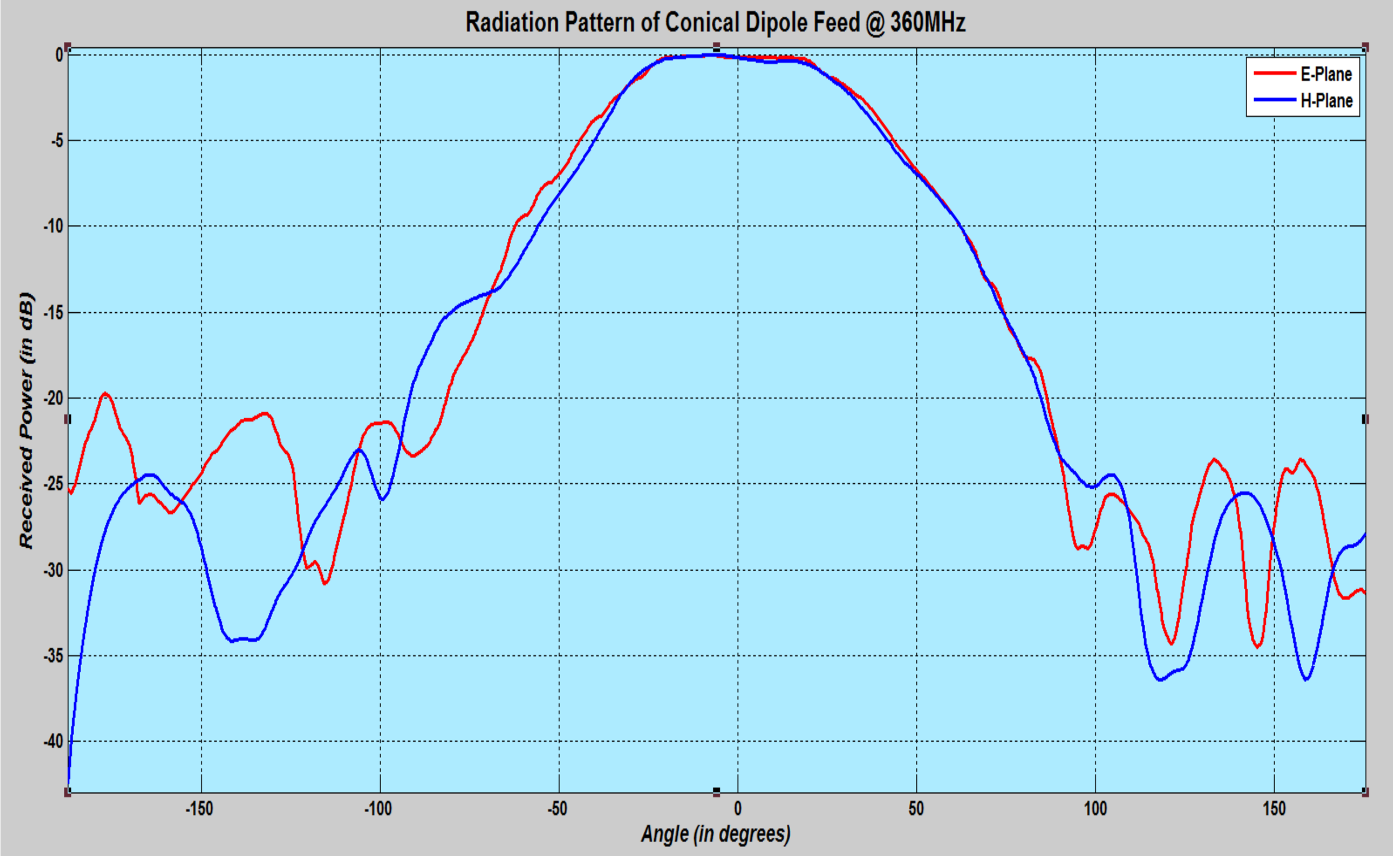

Figure 10: E- & H-Plane pattern @ 360 MHz

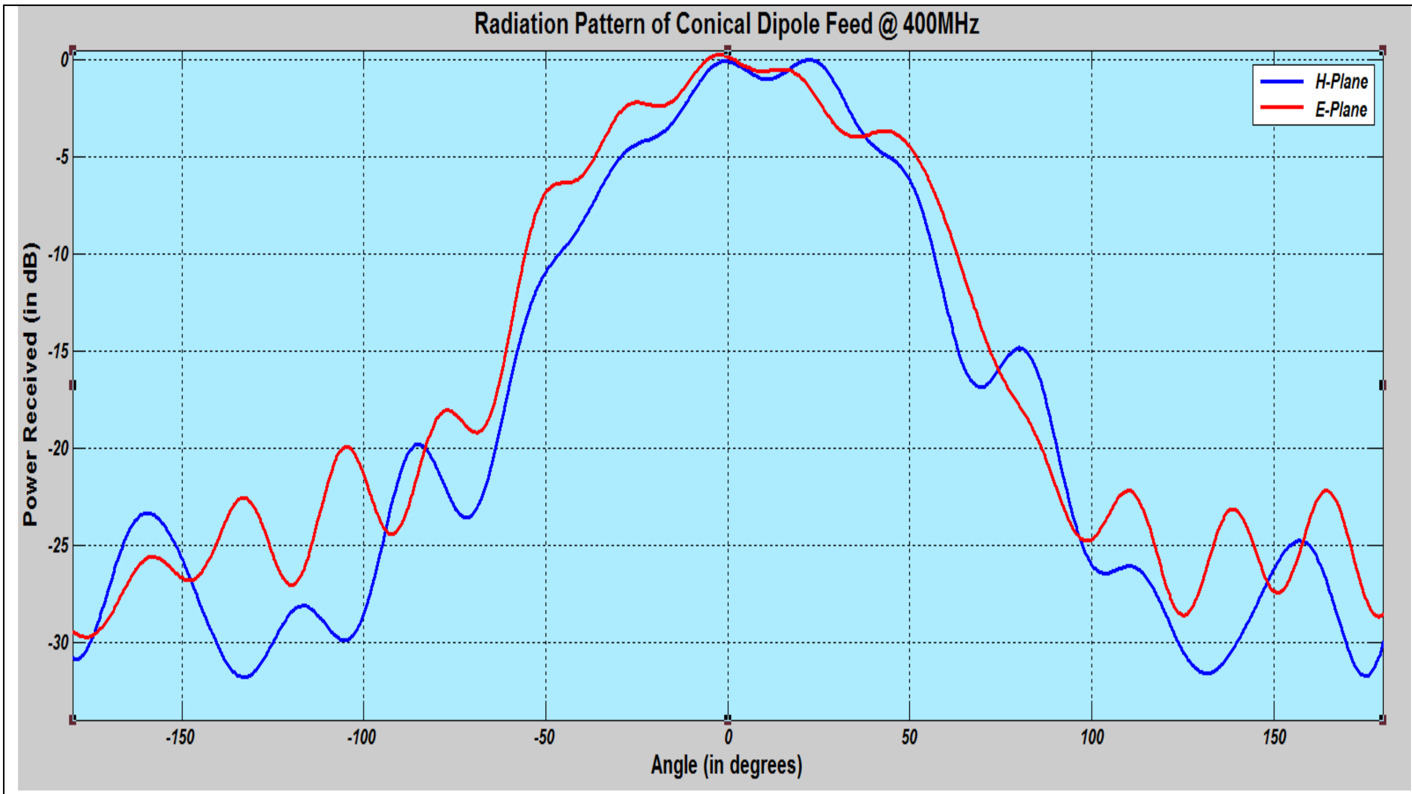

Figure 11: E- & H-Plane pattern @ 400 MHz

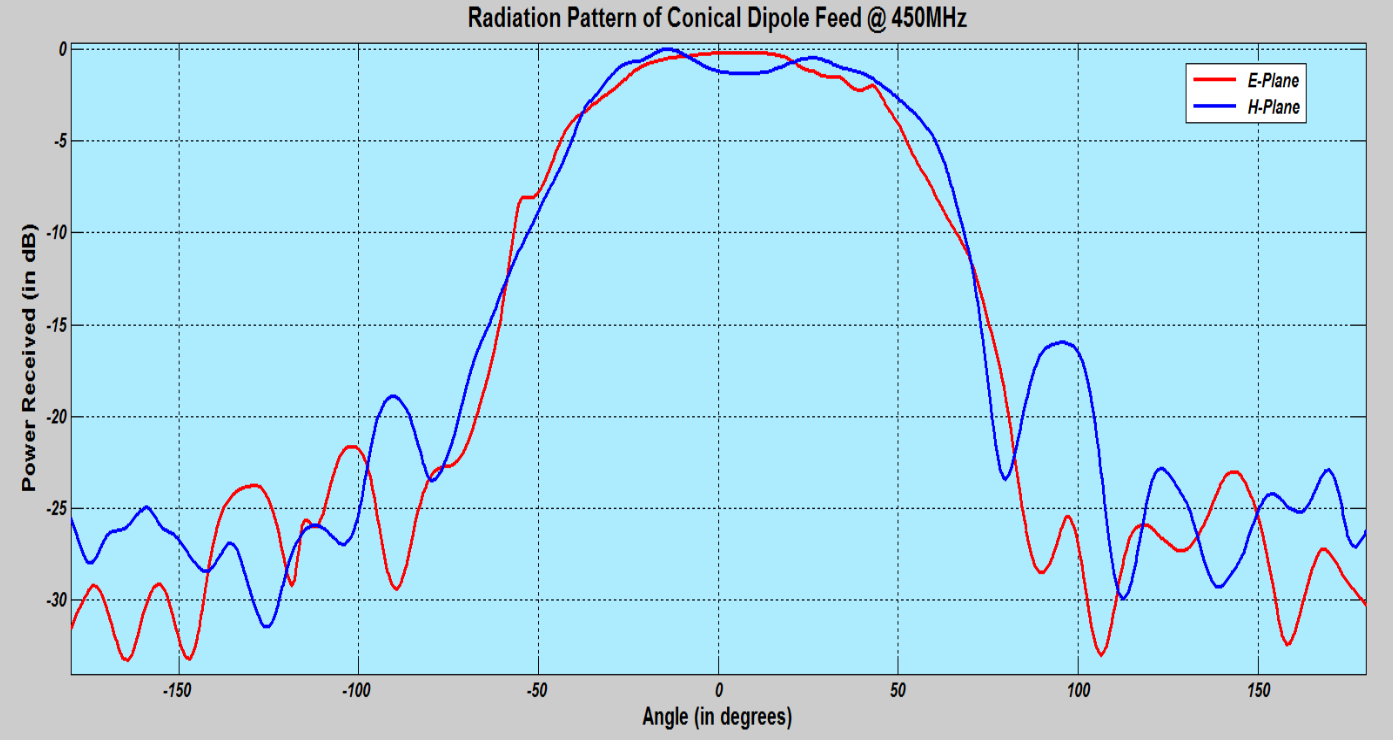

Figure 12: E- & H-Plane pattern @ 450 MHz

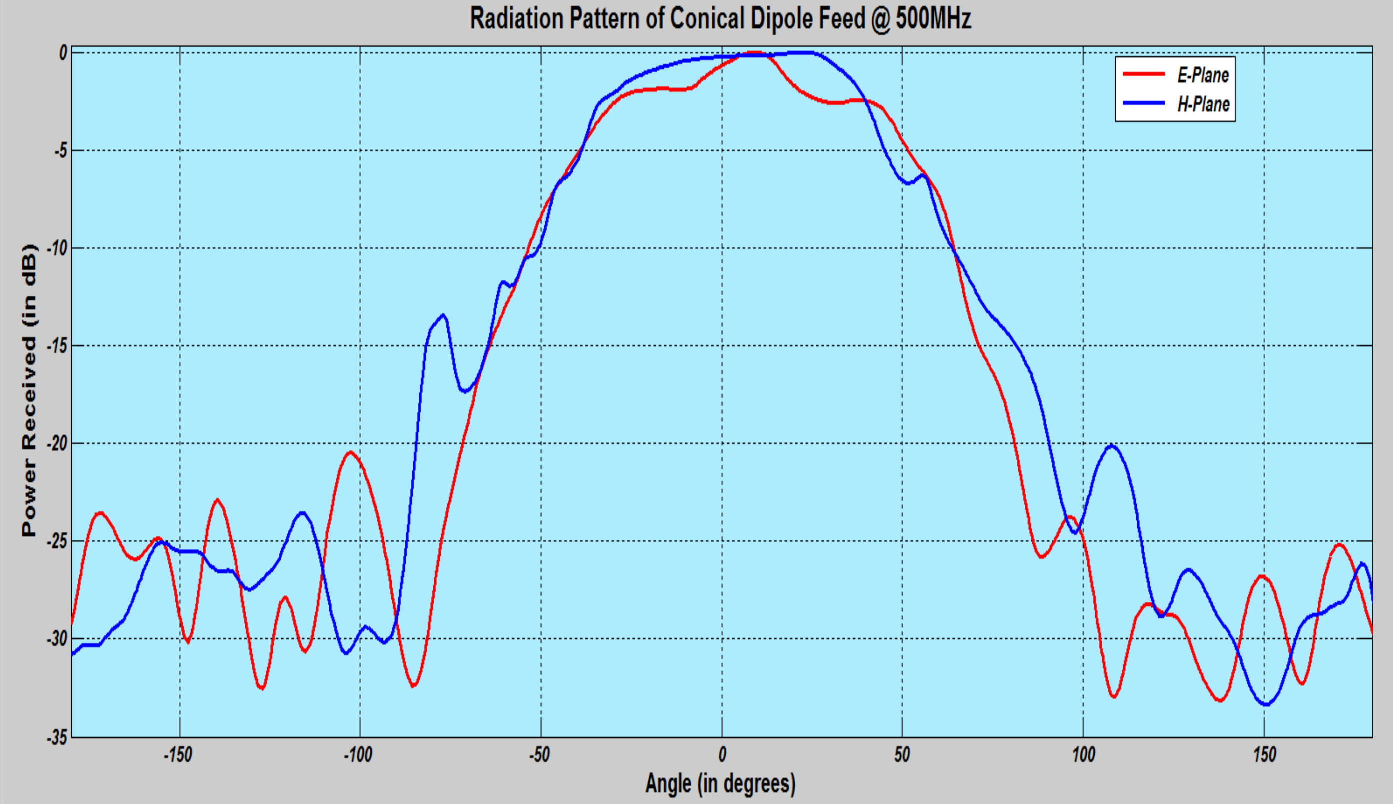

Figure 13: E- & H-Plane pattern @ 500 MHz

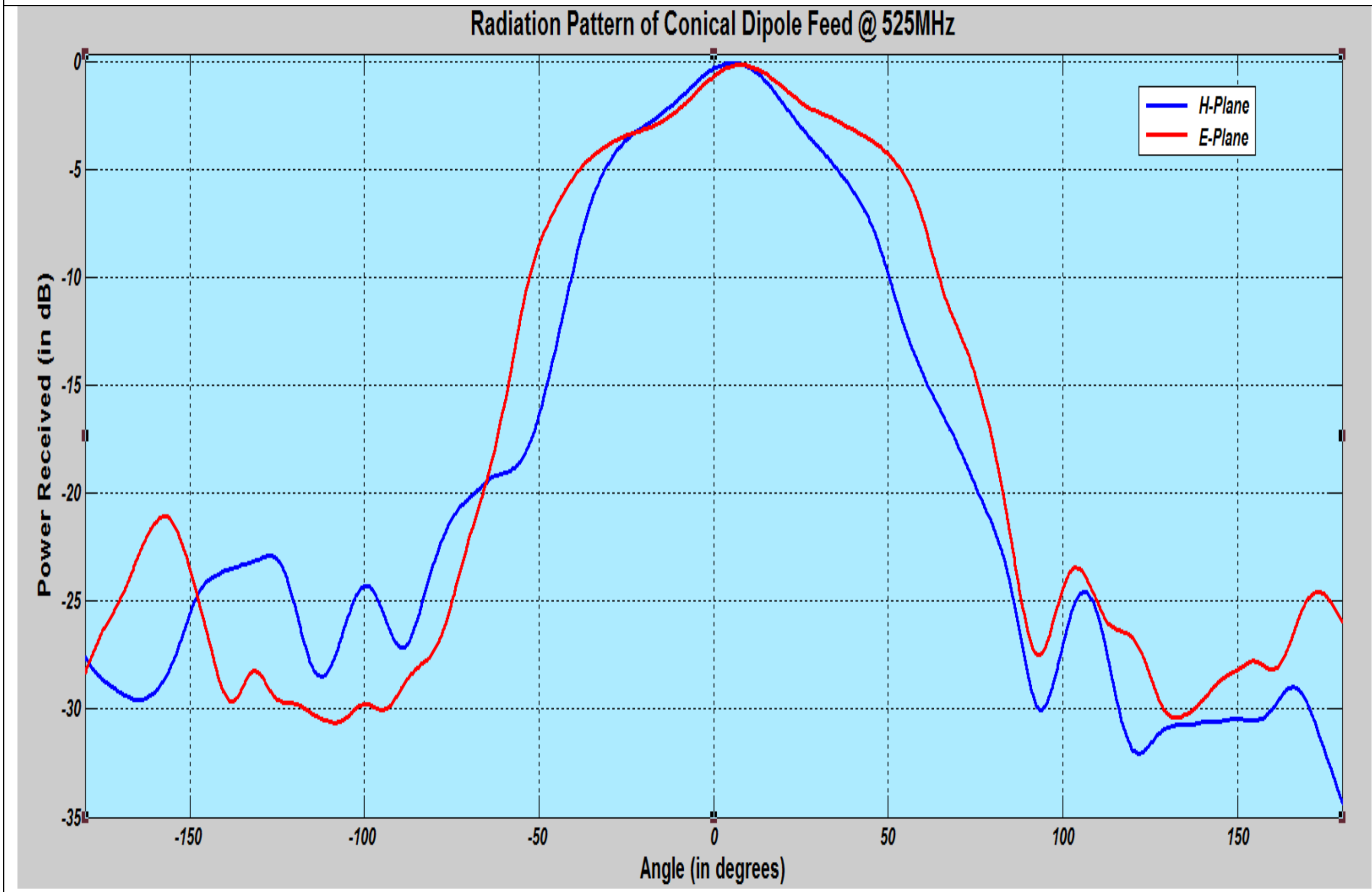

Figure 14: E- & H-Plane pattern @ 525 MHz

Annexure-B

The cross-polar patterns were measured as per IEEE standard 149-1979 procedures: The transmitting antenna was positioned 45 deg. to the horizontal and the test ant. was positioned at 135 deg. to the horizontal and scanned w.r.to the vertical axis. The measured power is with respect to the co-polar maximum measured as the first data point (: when both the trans. and test antennas are at 45 deg.). These are repeated for different frequencies (250 to 500 MHz.).

Figure 15 : Cross-Polar pattern @ 250 MHz

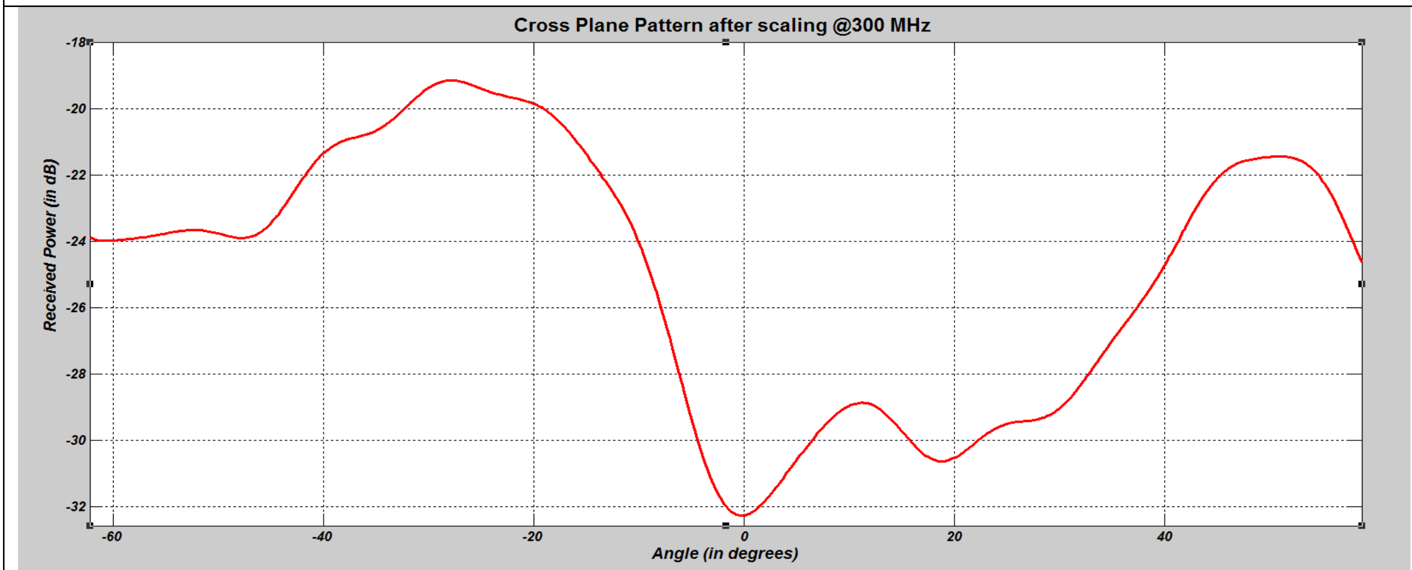

Figure 16: Cross-Polar pattern @ 300 MHz

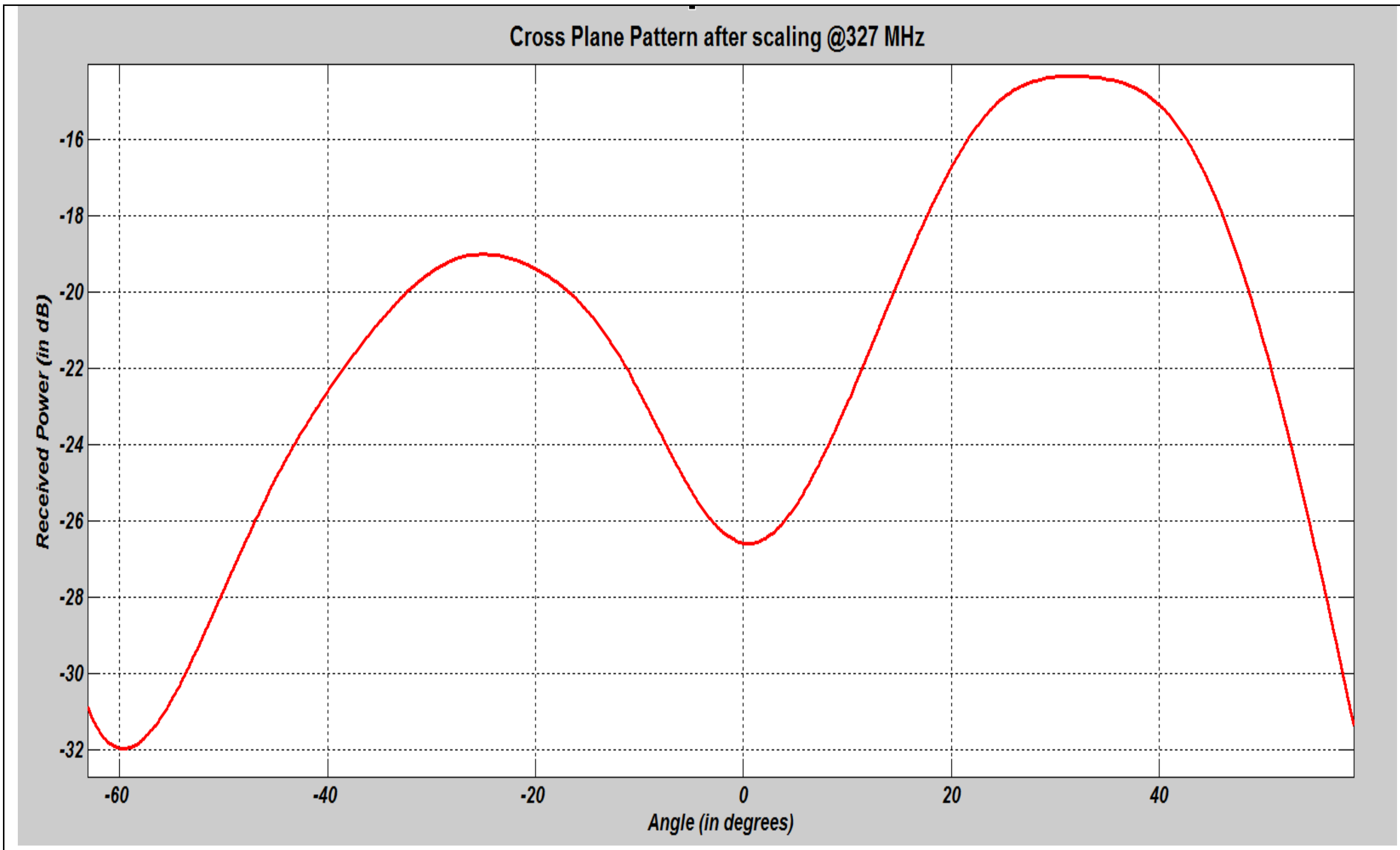

Figure 17: Cross-Polar pattern @ 327 MHz

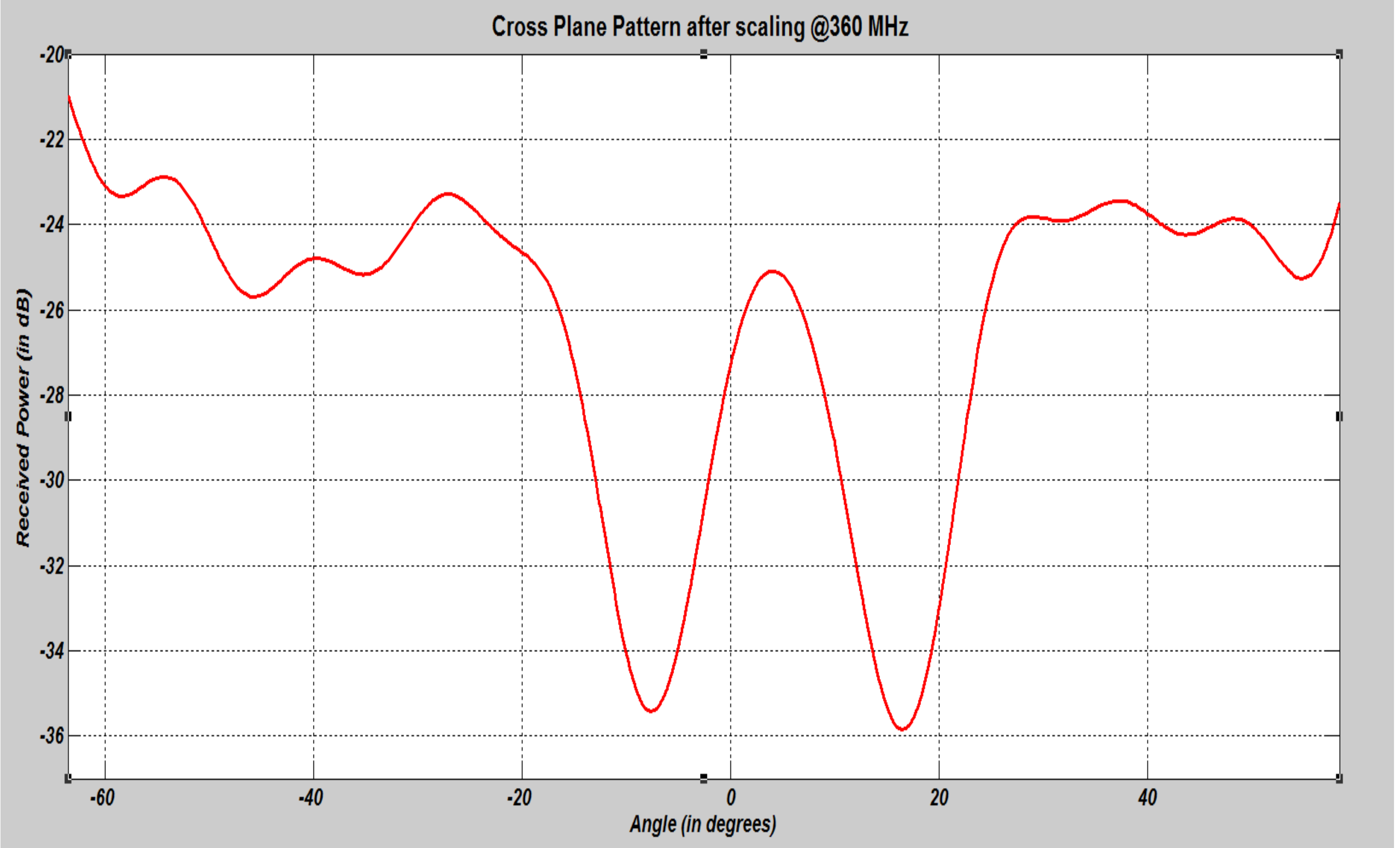

Figure 18: Cross-Polar pattern @ 360 MHz

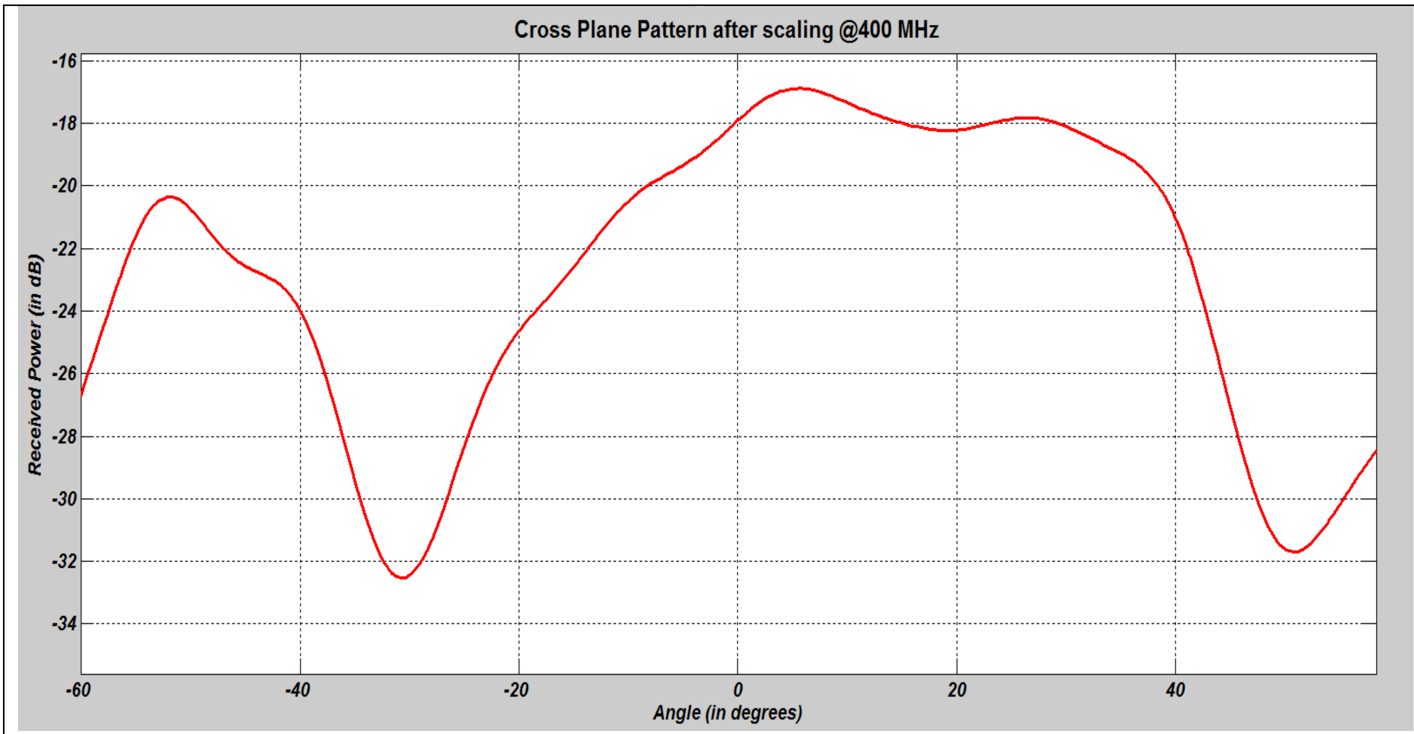

Figure 19: Cross-Polar pattern @ 400 MHz

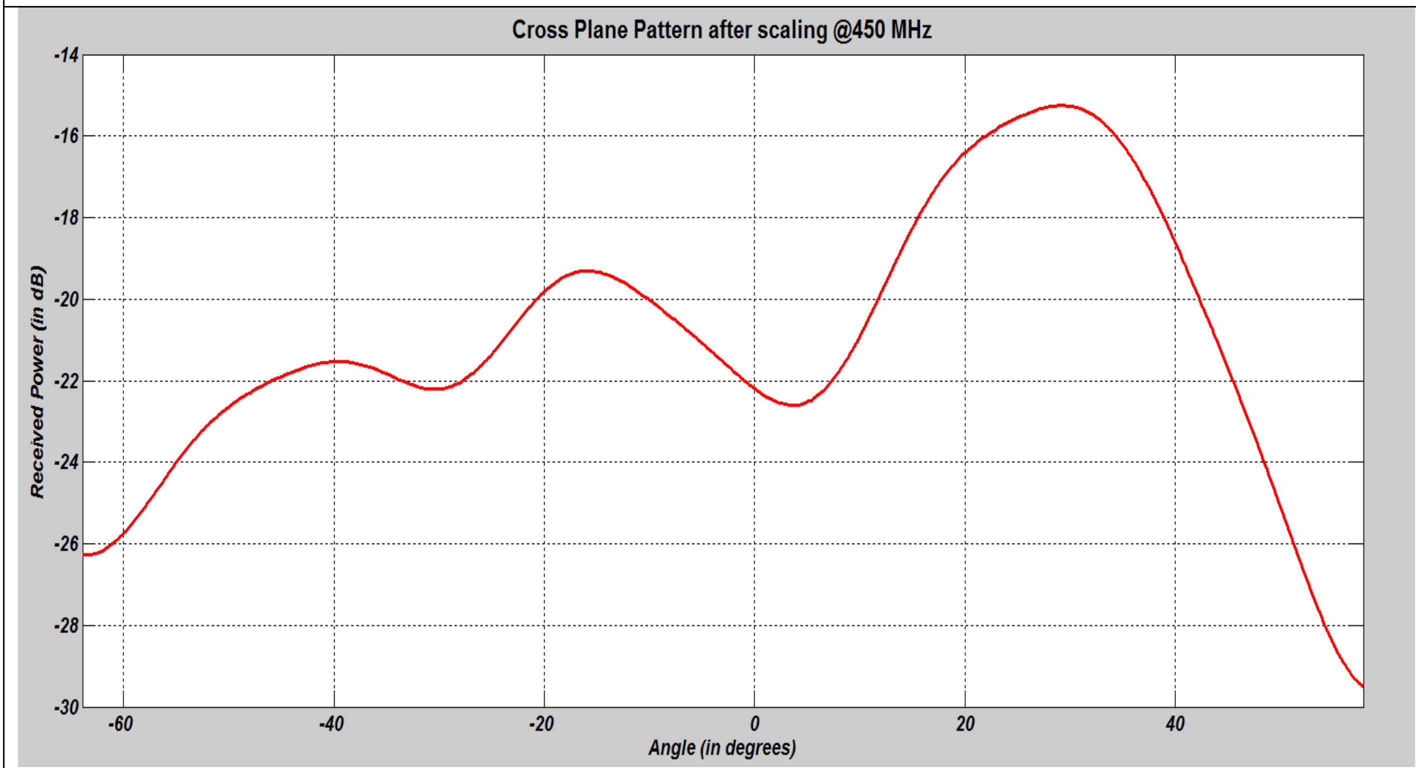

Figure 20: Cross-Polar pattern @ 450 MHz

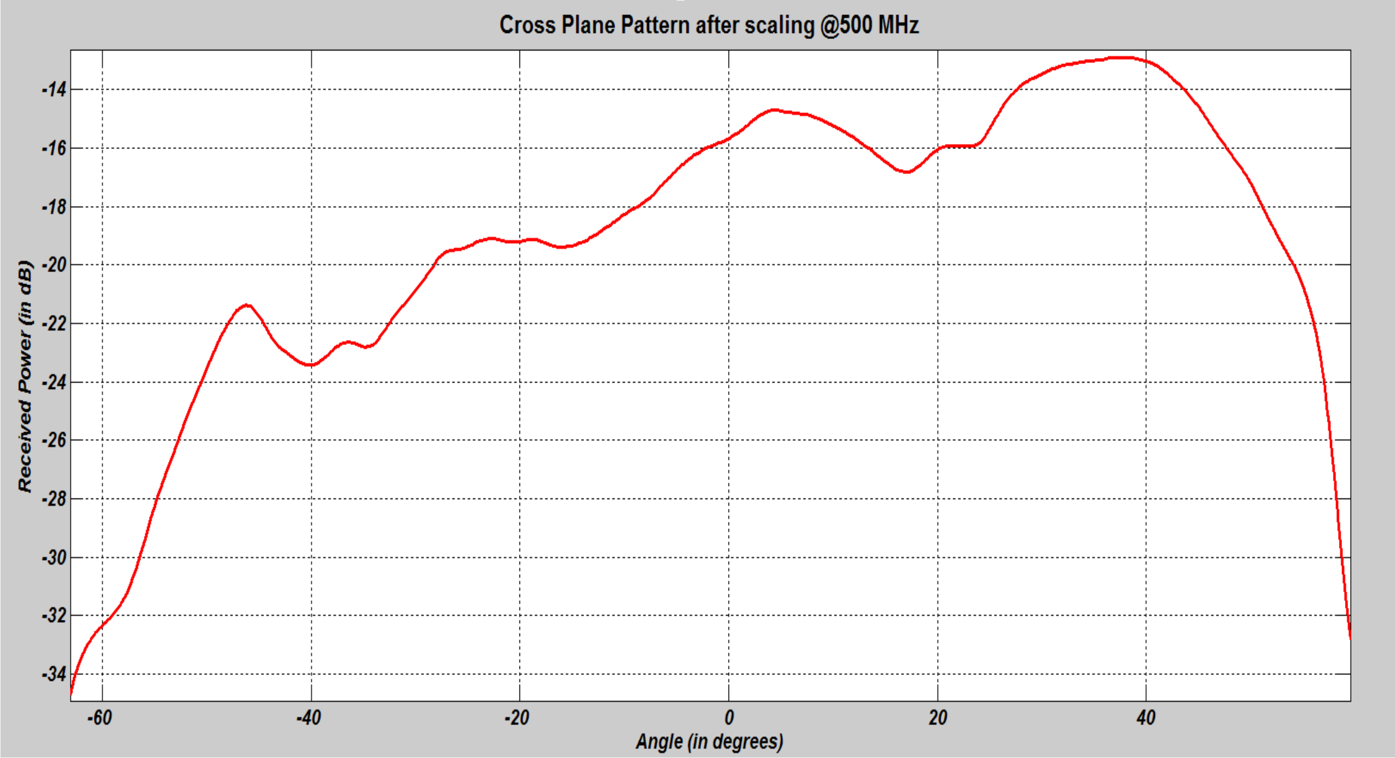

Figure 21: Cross-Polar pattern @ 500 MHz

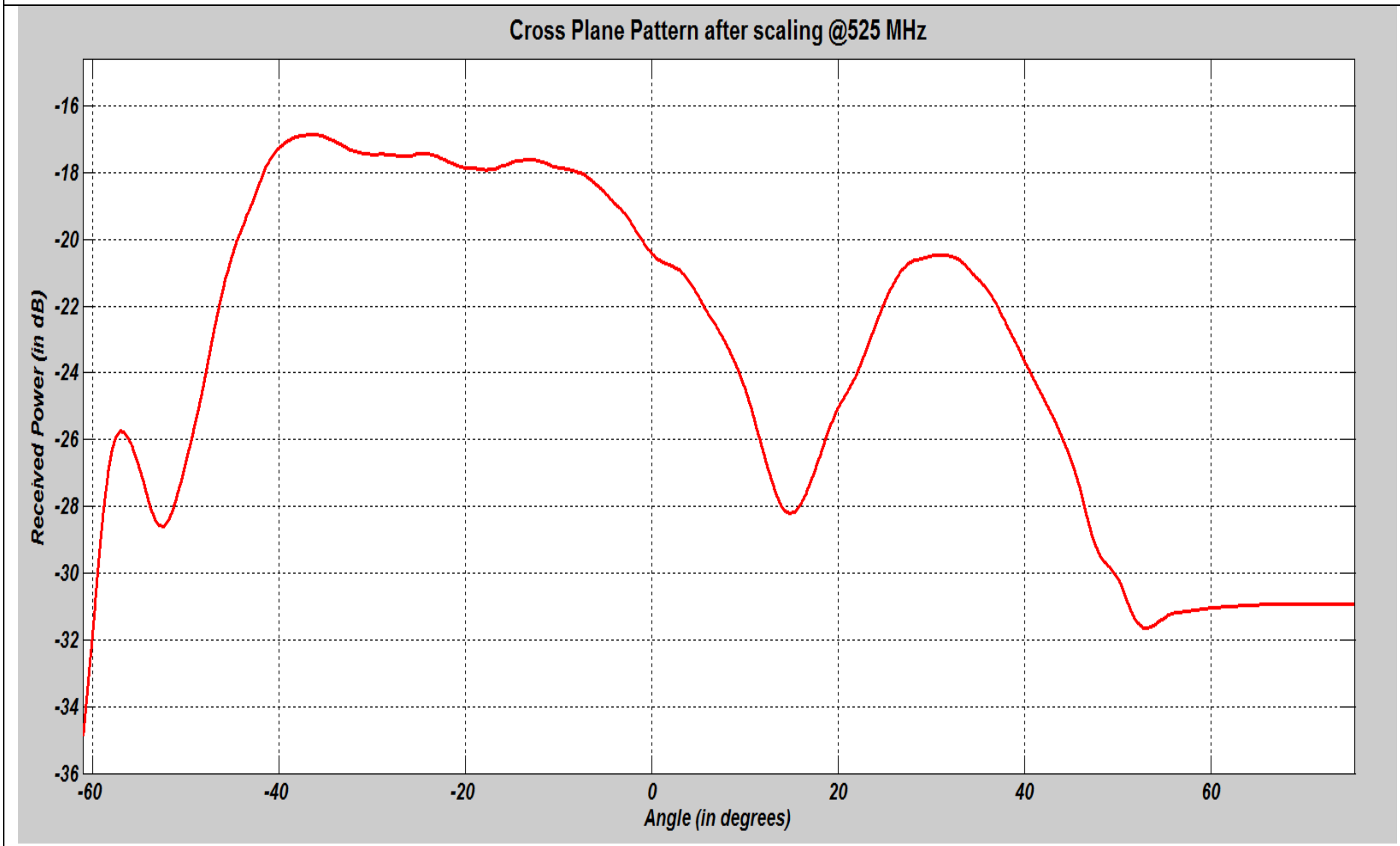

Figure 22: Cross-Polar pattern @ 525 MHz