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Hat-Fed Reflector Antenna for Satellite Communication

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Abstract

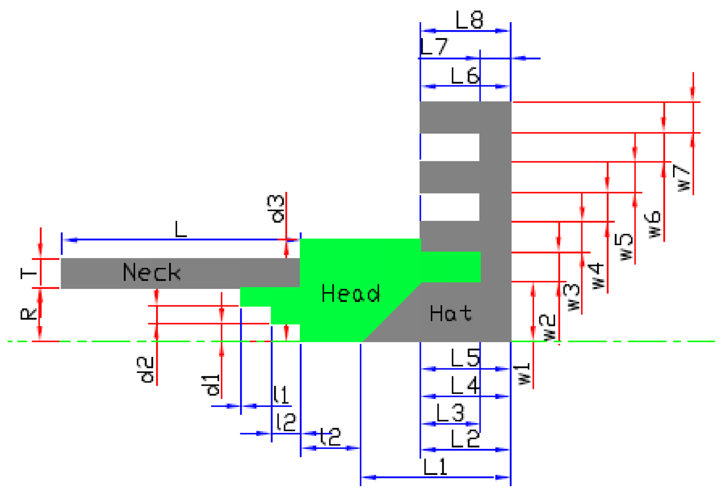
We present a new design of the hat-fed reflector antenna for satellite communications in the Ku-band (10.75-14.50 GHz), where a low reflection coefficient, high gain, low sidelobes and low cross polar level are required. The hat feed has been optimized by using the Genetic Algorithm (GA) through a commercial FDTD solver, QuickWave V2D, together with an own-developed optimization code. The Gaussian vertex plate has been applied at the center of the reflector in order to improve the reflection coefficient and reduce the far-out sidelobes. A parabolic reflector with a ring-shaped focus has been designed for obtaining nearly 100% phase efficiency. The antenna's reflection coefficient is below -17 dB and the radiation patterns satisfy the M-x standard of sidelobe level envelope for earth stations over a bandwidth of 30%.

Hat feed antenna optimization

- QuickWave V2D was called by the GA to optimize the hat feed.
- The optimization goals are minimized reflection coefficient and maximized aperture efficiency (which can be divided into the relevant sub efficiencies):

$$e_{opt} = e_{spill} e_{ill} e_{pol}$$

- The F/D ratio was chosen to 0.255 corresponding to a subtended half angle of $\Theta_0 = 89^\circ$.
- The hat-feed is presented as a chromosome consisting of genes representing the dimensions to be optimized.
- Each solution from an optimization is given a fitness value based on its characteristics and the fittest solutions are forming a pareto front.



Parameters of the hat feed to be determined by the optimization.

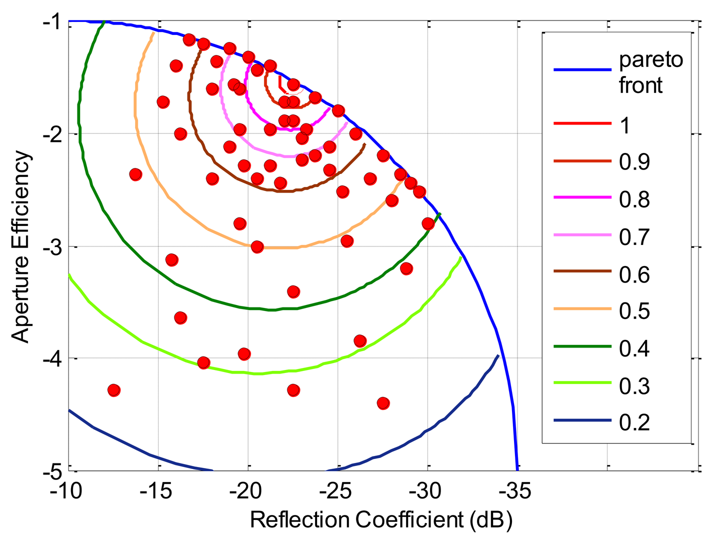
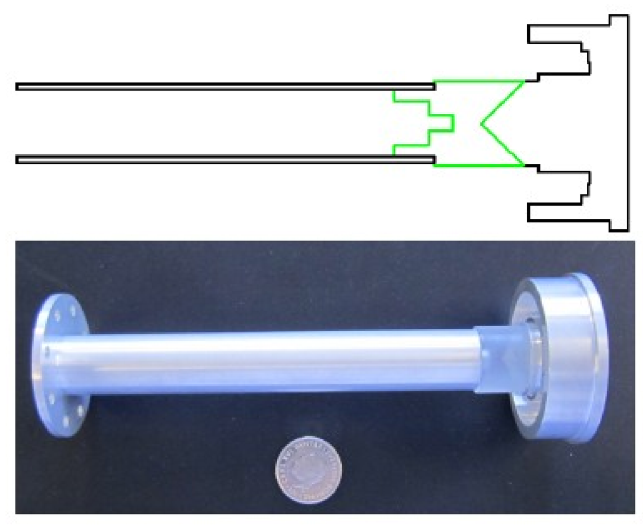


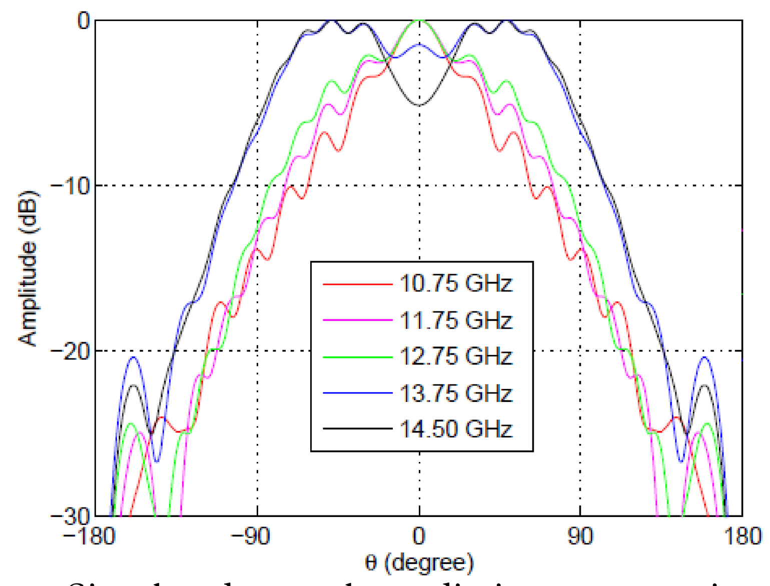
Illustration of pareto front with individuals represented by red dots. The curved lines marks different fitness values in the GA optimization.

Optimization results

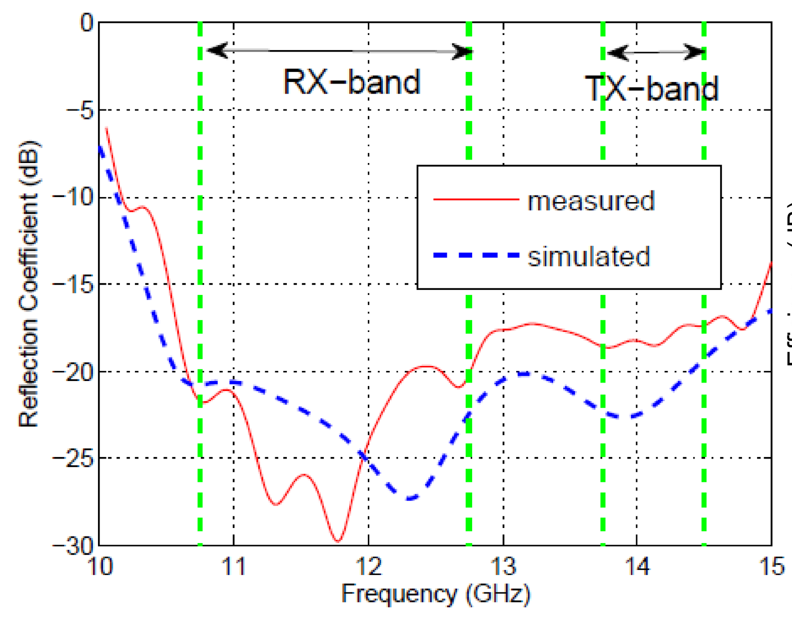
- The reflection coefficient is <-17 dB in the band.
- The efficiency is <2.5 dB in the band.



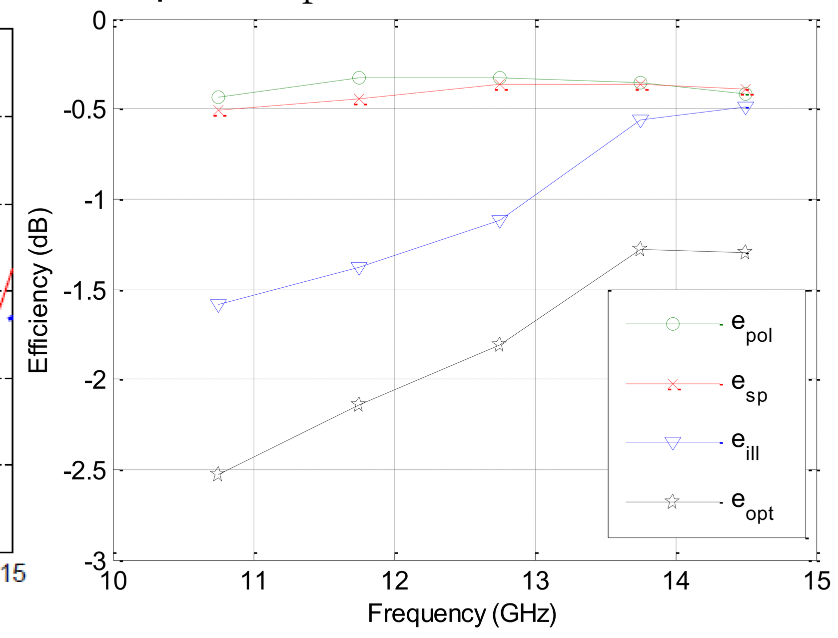
Cross section of the optimized hat feed and the manufactured prototype



Simulated co-polar radiation patterns in the $\phi = 45^\circ$ plane



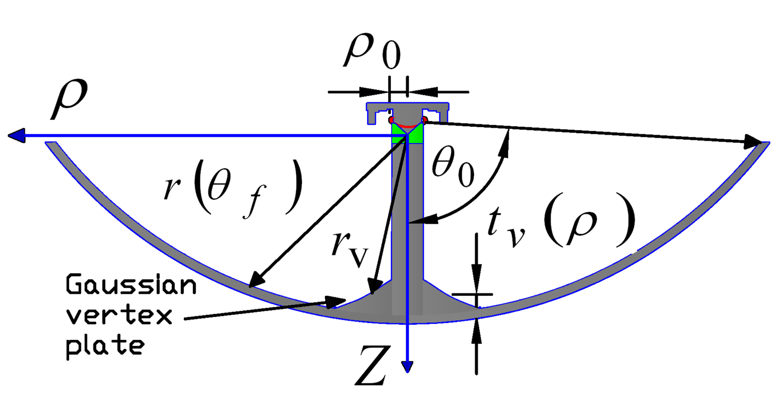
Measured and simulated reflection coefficient of the hat feed.



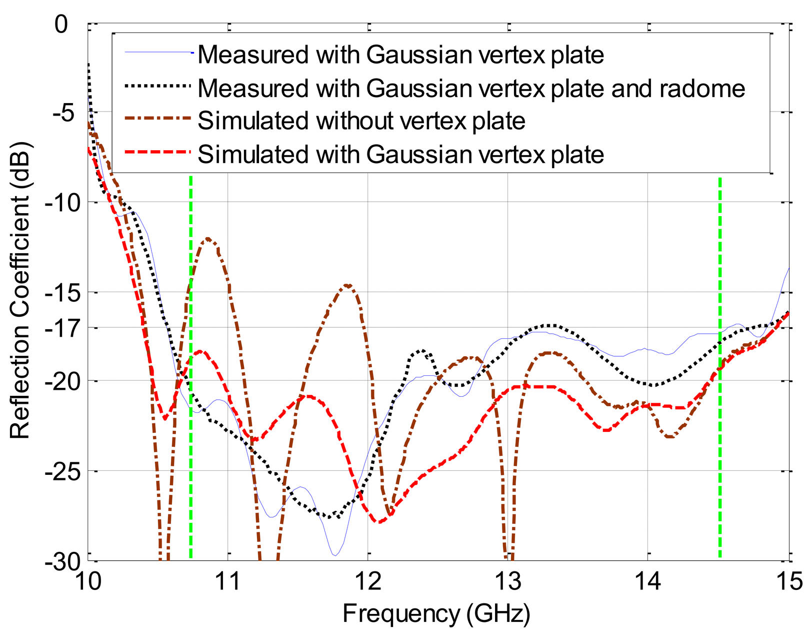
Calculated efficiencies based on simulated far field functions of the hat feed with subtended angle $\Theta = 2*89^\circ$.

Gaussian vertex plate

- Reduces multiple reflections between reflector and feed.
- Improves the reflection coefficient.
- Less diffraction at the hat edge reduces the sidelobe levels.



Gaussian vertex plate on hat-fed ring focus reflector.

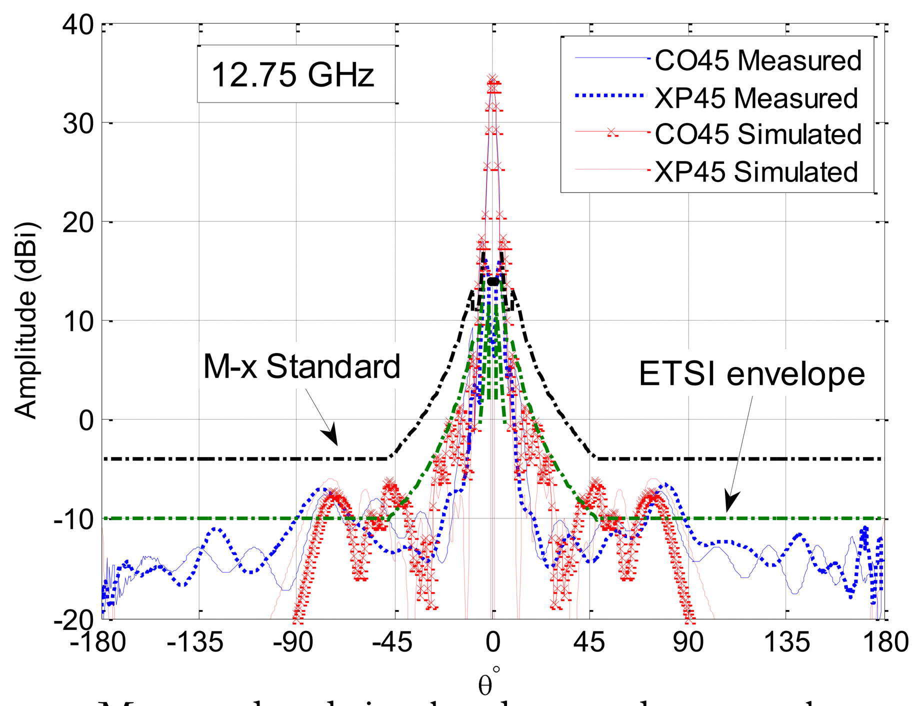


Simulated and measured reflection coefficient of hat-fed reflector antenna with and without Gaussian vertex plate.

Reflector radiation pattern measurement

- The hat feed was measured in anechoic chamber. with a 53 cm diameter ring focus reflector antenna ($\rho_0 = 6.8$ mm).
- The co- and cross polarization in the 45 degree plane is presented with the sidelobe envelope requirements for earth stations according to the ETSI EN 301 standard and the M-x nomenclature defined by Eutelsat.

Hat-fed reflector antenna under test.



Measured and simulated co- and cross polar radiation patterns in the $\phi = 45^\circ$ plane.

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Background design by Jan-Olof Yxell