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Investigation of Parasitic Effects from Feed and Termination on the Far-Field Pattern of Leaky-Wave Antennas Based on HMSIW

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Abstract: Parasitic effects from the feed and termination on the far-field of two types of leaky-wave antenna (LWA) based on Half-Mode Substrate-Integrated Waveguide (HMSIW) are thoroughly investigated.

It is shown that ripples observed in the radiation patterns originate from discontinuities in the aperture field distribution, which typically appear at the feed and termination.

The paper firstly focuses on explaining the ripples on the pattern of a wideband omni-directional antenna based on a tapered HMSIW. In the second part, the ripples in the highly directive pattern of a uniform LWA are analyzed and compared.

Keywords: Investigation, Parasitic Effects, Feed and Termination, Far-Field Pattern, Leaky-Wave Antennas, HMSIW

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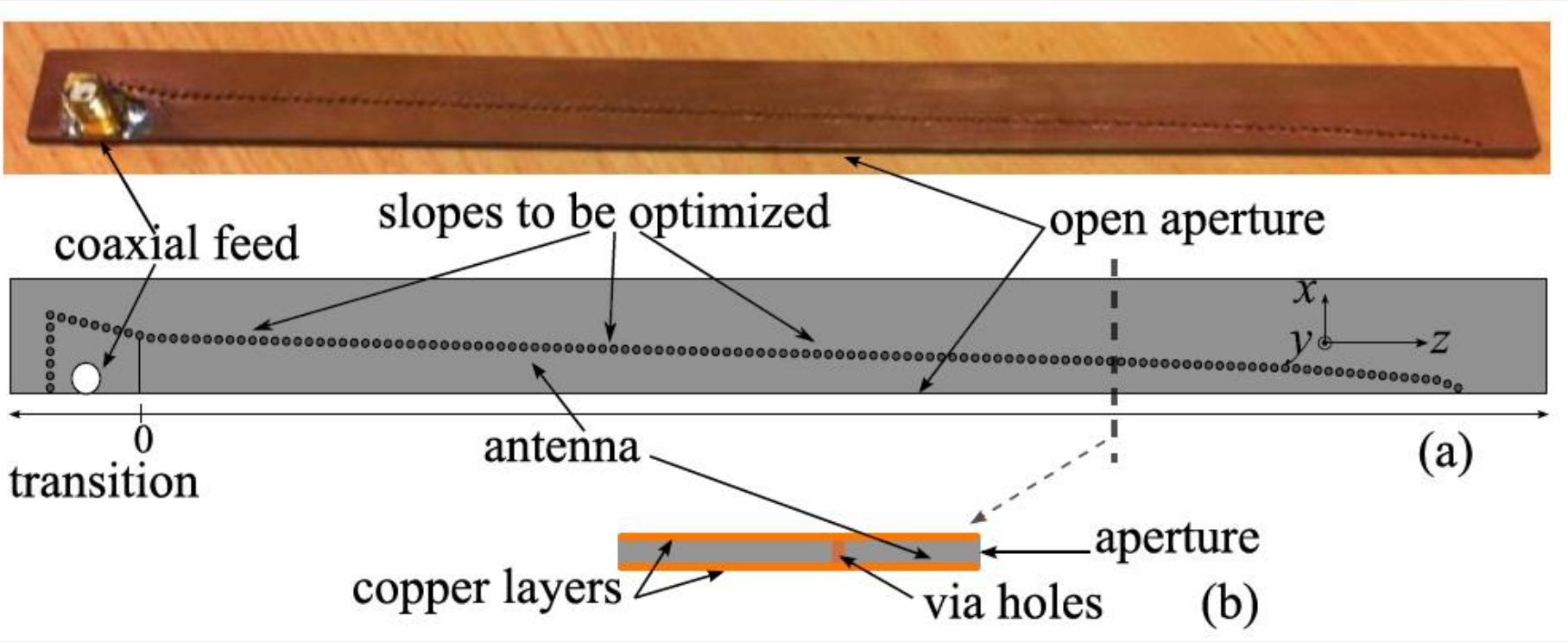
Tapered HMSIW LWA



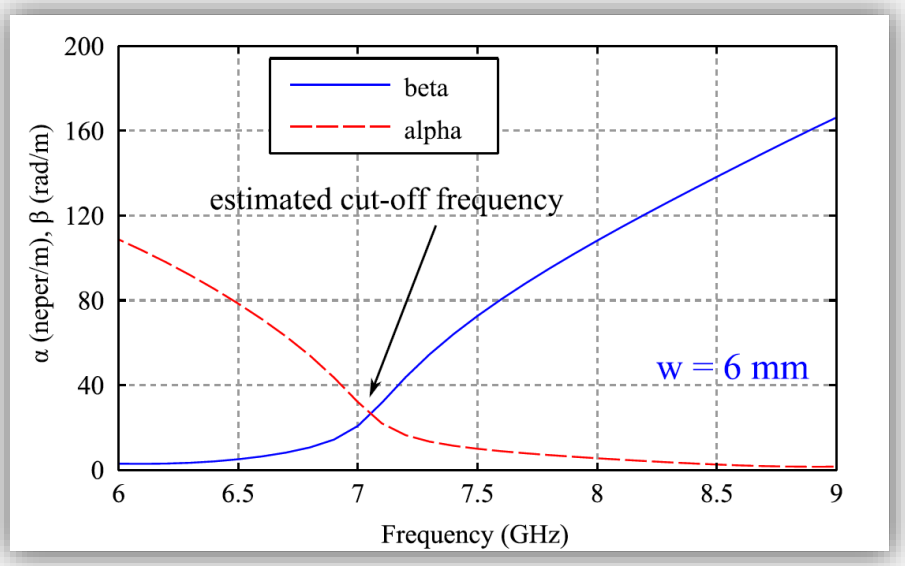
A wideband LWA based on a tapered HMSIW fed by a coaxial line:

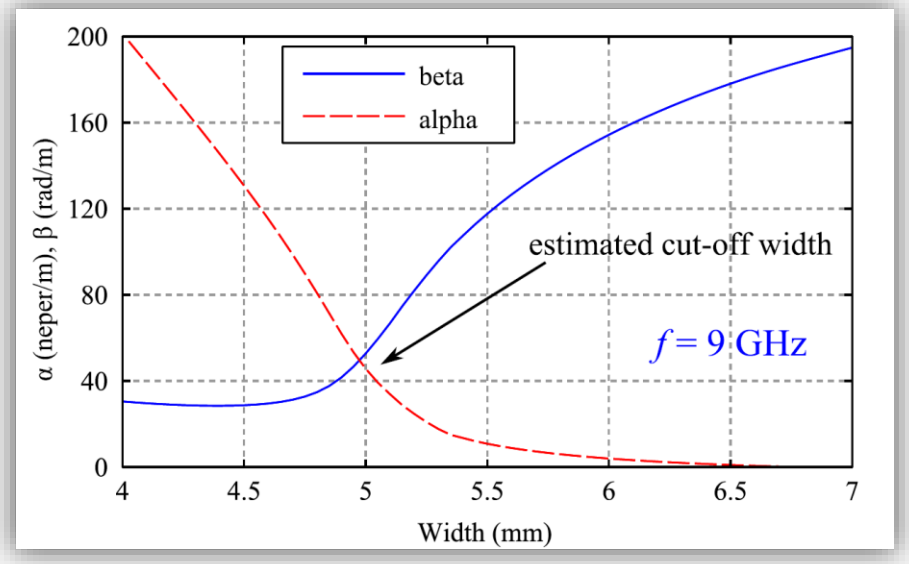
(a) Top view,

(b) Cross section.

Radiation Mechanism of Tapered HMSIW LWA

✓ The antenna exploits the radiation loss of the HMSIW close to its cut-off frequency.

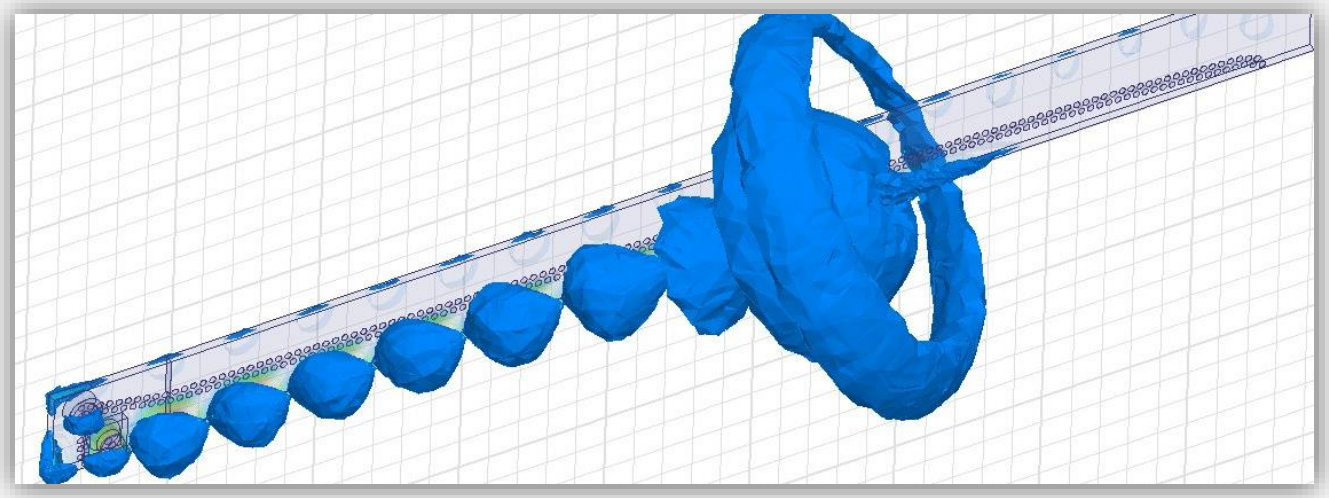




✓ The excited wave travels along the tapered HMSIW until it reaches the position where the corresponding cut-off frequency is close to the operating frequency.

✓ In the vicinity of this position the power is radiated intensively due to the high radiation loss from the open aperture.

Radiation Mechanism of Tapered HMSIW LWA

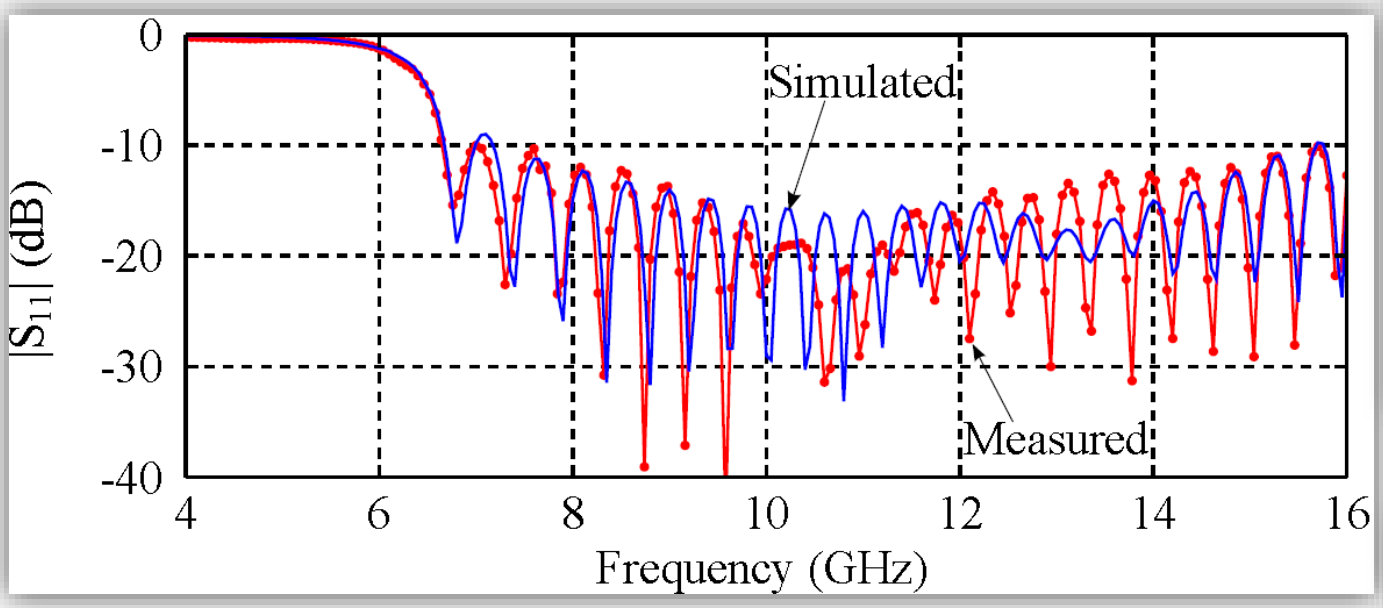


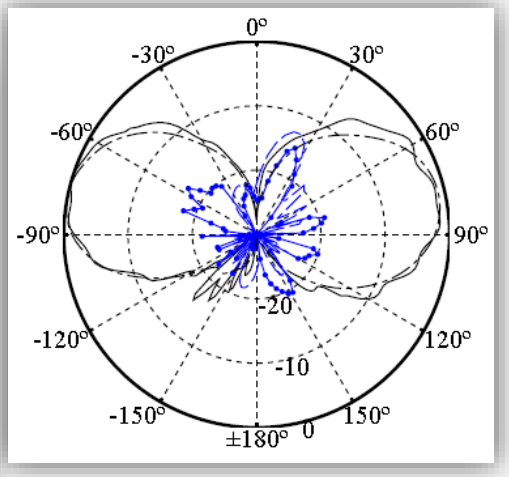
✓After the cut-off position, the wave transforms from a travelling to an evanescent mode and decays very quickly with strong radiation loss.

7 GHz

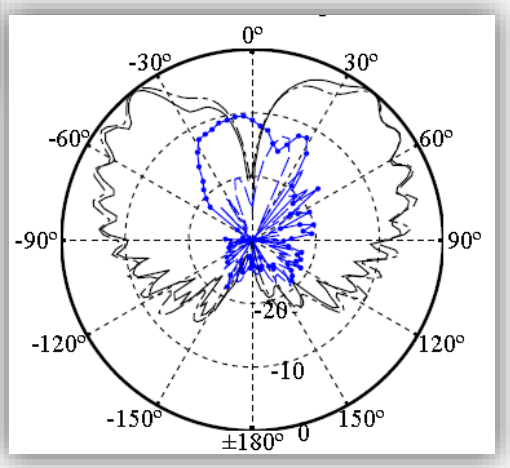
11.5 GHz

Tapered HMSIW LWA Results





f = 7GHz

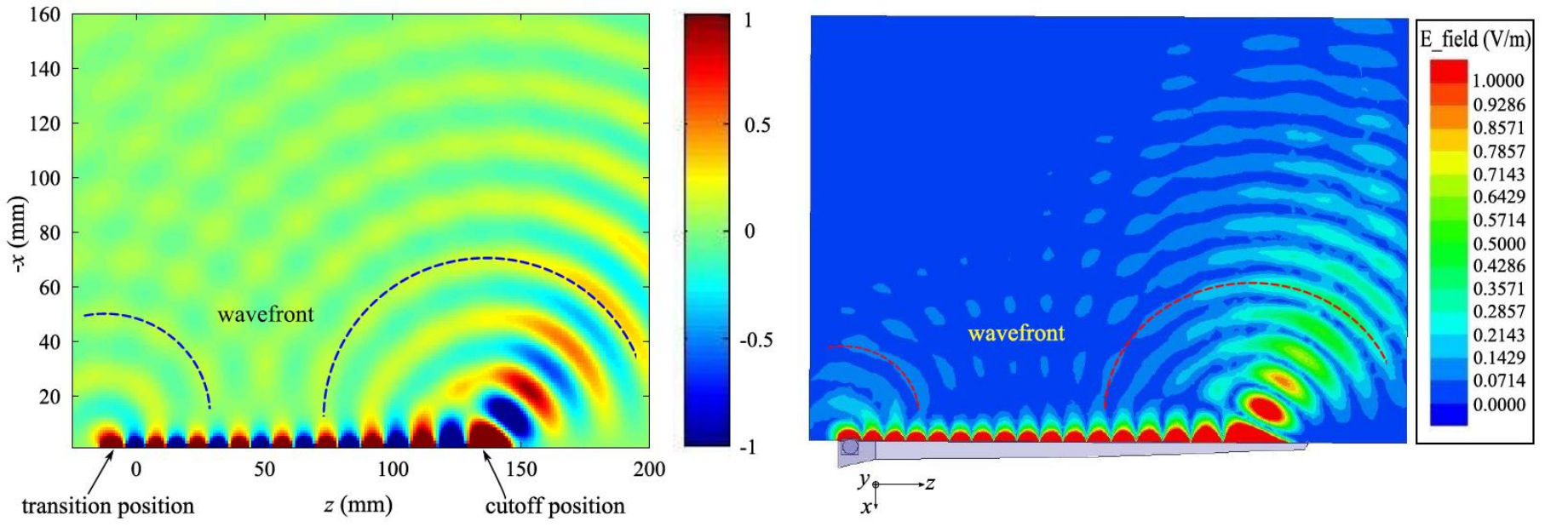


f = 11.5GHz

Reflection coefficient (left) and radiation patterns of the antenna at two selected frequencies (right).

Near-Field Distribution

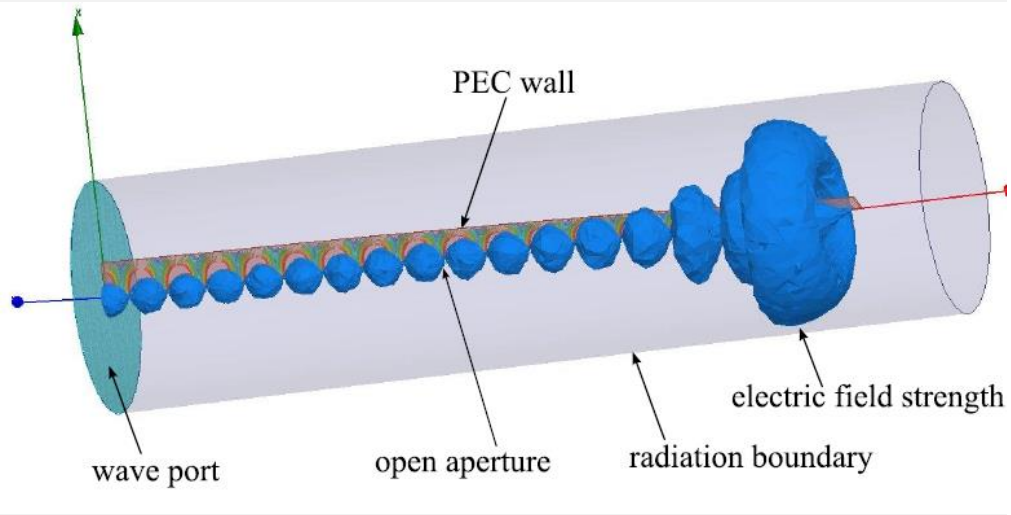
✓ Near-field is calculated utilizing a semi-analytical solution of the field distribution at the open aperture (N. Nguyen Trong et. al. [3])

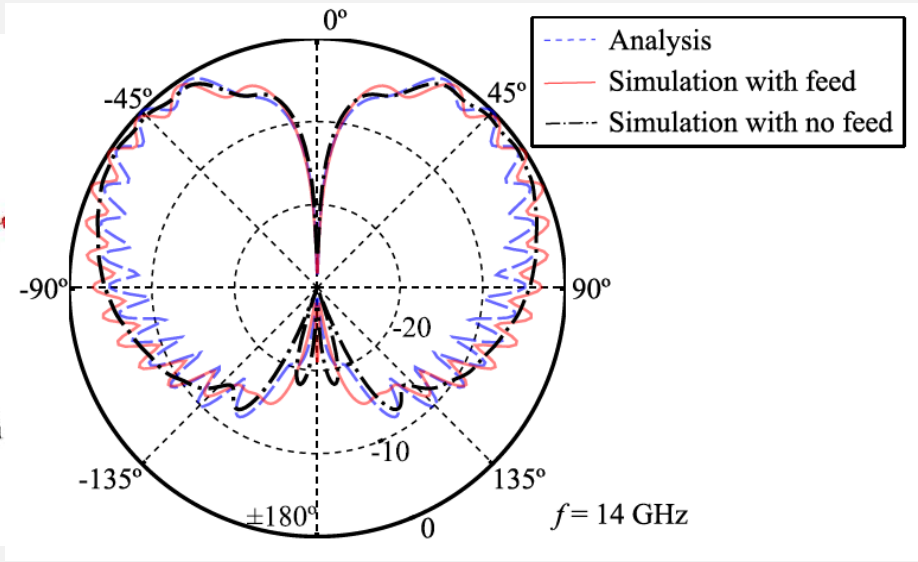


Calculated (left) and simulated (right) electric field at f = 14 GHz.

✓ A weaker secondary source of radiation located **at transition** is observed. This radiation interferes with main radiation and causes ripples in the pattern.

Simulation Results without Transition Discontinuity

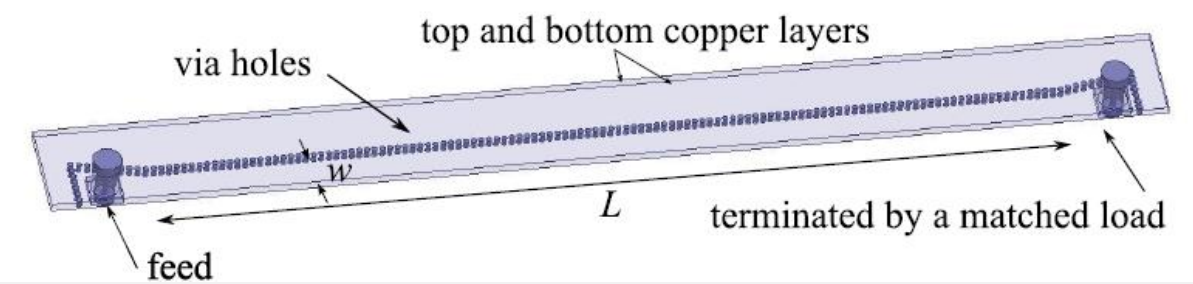




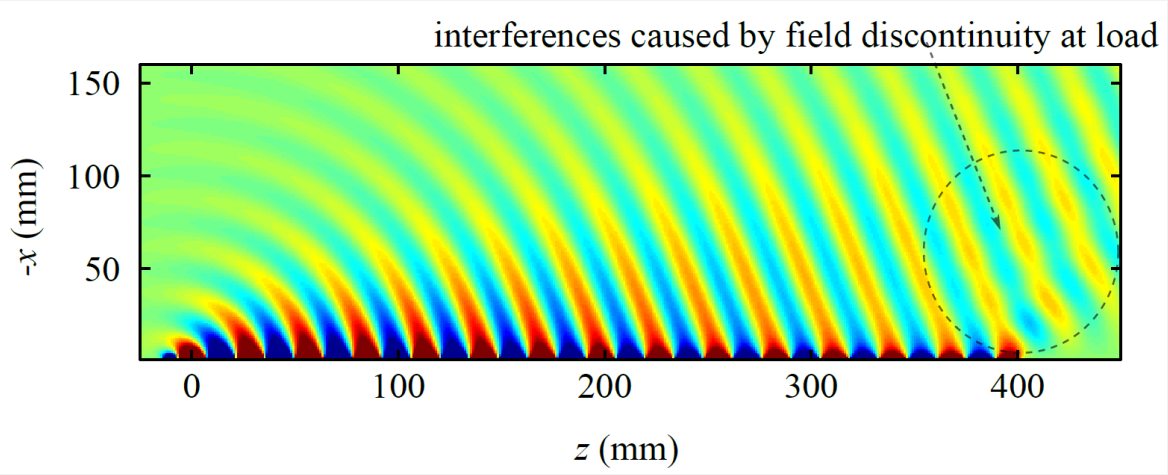
✓ Identical antenna with large feeding waveport is simulated.

✓ Radiation of this conceptual antenna exhibits a broad beam with almost no ripples → confirming that the discontinuity at the transition is the dominant source of ripples in this type of antenna

Comparison with Uniform HMSIW LWA



A uniform HMSIW LWA similar to the one proposed by J. Xu, 2008 [2]



Calculated field distribution along the uniform LWA.

✓ For the uniform LWA, ripples can be due to parasitic radiation at the load where a discontinuity in the field distribution appears because of antenna termination.

✓ This result also confirms that ripples are due to the finite antenna length.

Conclusion

✓ The electric field distribution in the near-field region of a wideband LWA based on a tapered HMSW has been calculated and compared with simulation.

✓ Compared to a uniform LWA where the ripples can be interpreted as originating from the field discontinuity at load, the ripples in a highly tapered HMSIW come from the discontinuity at the feeding section.

✓ This insight of the impact of the feed will be utilized to design similar antenna with minimized ripples in the radiation pattern.

References

[1] N. Nguyen-Trong, T. Kaufmann, and C. Fumeaux, “A wideband omni-directional horizontally polarized traveling-wave antenna based on half-mode substrate integrated waveguide,” IEEE Antennas Wireless Propag. Lett., vol. 12, pp. 682–685, 2013.

[2] J. Xu, W. Hong, H. Tang, Z. Kuai, and K. Wu, “Half-mode substrate integrated waveguide (HMSIW) leaky-wave antenna for millimeter-wave applications,” IEEE Antennas Wireless Propag. Lett., vol. 7, pp. 85 –88, 2008.

[3] N. Nguyen-Trong, T. Kaufmann, and C. Fumeaux, “A Semi-Analytical Solution of a Tapered Half-Mode Substrate-Integrated Waveguide with Application to Rapid Antenna Optimization,” IEEE Transactions on Antennas and Propagation, AP-62(6), 3189-3200 (June 2014)