Industrial Workshop

Company/Organization: CADFEM

Title: Physics based workflow for the design of THz lens antennas

Abstract: In the never-ending quest for faster wireless communication, scientists and engineers continuously progress to higher frequencies and less utilized portions of the electromagnetic spectrum. In recent years this has led to the intense interest in the terahertz regime, nominally defined as frequencies between 300 GHz and 10 THz. One significant challenge at these frequencies is that the pathloss is very high, thereby necessitating the use of extremely high gain antennas to enable practical communication schemes. A traditional method for achieving high gain antennas is through the use of phased arrays; however, in the THz regime, the use of phase array systems is challenging to design and expensive to manufacture, thereby hindering phased-arrays as a viable strategy. An alternative approach that offers significant benefits in both cost and performance, is to leverage dielectric lenses in front of a low-gain antenna to improve the emitter/receiver coupling efficiency.

At present, the workflow for designing these THz lensing systems is entirely based on HFSS, a full-wave solver, which is extremely accurate but suffers from long calculation times which consequently increases the design loop time. Since the terahertz regime corresponds to wavelengths from 30μm to 1mm, and typical terahertz lenses would have physical dimensions on the order of several centimetres, this physical regime is approaching the region where “ray-based” simulation can effectively be leveraged to greatly improve the design speed.

Here we propose an alternative workflow that leverages the powerful ray-tracing from OpticStudio for fast design iterations and then utilizes HFSS for confirmation of the performance to greatly expedite the design of these THz lensing systems. This approach also has the added benefit of helping the designer to build an intuition of the system based on the ray-based visualization provided by OpticStuidio.

The workflow starts with an antenna source designed in HFSS on an appropriate substrate that will be used as the first refractive lens (e.g. Silicon). The system is then optimized in OpticStudio using a point source approximation for the antenna, and the substrate refractive index & dispersion as the material properties of the first lens. OpticStudio then designs a “first pass” lens system that incorporates the initial lens (e.g. silicon) as well as potentially subsequent additional lenses (e.g. Teflon) to improve the performance/gain. The lens system designed by OpticStudio can furthermore be optimized with respect to any other criteria such as material cost, volume, etc. This system is then exported back into HFSS to confirm the performance using the full-wave simulation capability. This process can be further extended into an iterative/multi-cycle process such as by extracting the antenna emission profile under a “far-field”

approximation and using this as the basis for a ray-set that is evaluated in OpticStudio non-sequential mode.

The proposed workflow is expected to bring significant advantages to engineers working on THz systems by greatly reducing the design loop time via OpticStudio optimization speed, building intuition through the ray-based approximation, and leveraging the extensive library of design forms that have been developed over the years for optical refractive lens systems – all while maintaining the confidence that comes from confirming the design with the extreme accuracy offered by HFSS.

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