Novel Low-Profile Surface-Conforming Leaky-Wave Antennas for Very High Peak Power Applications

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We report several new designs of low-profile sidewall-emitting forward traveling-wave continuous-aperture type leaky-wave antennas with geometries conformable to flat and curved surfaces. Support for up to multi-GW peak powers is realizable in a variety of aperture shapes, sizes, and aspect ratios. By application of both conventional design principles and iterative optimization via 3D full-wave numerical RF models, we are growing a catalog of representative geometries to aid those who wish to evaluate, design, or advance these types of low-profile antennas primarily, but not exclusively, for high power radiofrequency (HPRF) based directed energy applications. Among the important factors to consider are high gain (requiring high aperture efficiency), sufficient low-VSWR bandwidth, very high peak power (P_{pk}) handling, and shallow depth. For such cases, evacuated antennas built from multiple parallel leaky-waveguide channels are especially appropriate and remarkably adaptable. The leaky channels are typically driven in fundamental mode and integrated together into an evacuated array, with the leaky-sidewalls radiating through a single vacuum window that spans and seals the overall aperture. We have designed and documented specific flat-aperture designs using multiple waveguide channels with leaky wire-grill type sidewalls to yield overall aperture efficiencies up to ~80% and support P_{pk} close to limits imposed by exterior air breakdown. We have found that practical singly- and multiply-curved apertures are also realizable and can support comparable $P_{pk,}$ but are usually less aperture-efficient than flat ones, due to introduction of undesirable aperture phase error. Fortunately, part of the aperture efficiency that would otherwise be lost due to phase error can be recovered via introducing compensating path delays in the feeding waveguides of the different channels, or if appropriate, customization of individually-curved leaky-channels. Integration into especially-shallow packages is facilitated by judiciously bending/folding-over individual channels in a way that preserves the leaky-wave behavior. The overall antenna thickness of ~0.7 λ_0 for a simple (not bent) array can be reduced to ~0.45 λ_0 or even less, if bent/folded channels are employed. The resulting geometry is a bit more difficult to both fabricate and feed, and there are some minor (likely tolerable, in most cases) performance impacts. Note that the above thicknesses include the aperture vacuum window. For less extreme P_{pk} (i.e., with no aperture window) these antennas could be made even shallower. Finally, in addition to reviewing several geometric variants and their characteristics, we will discuss some non-fundamental mode driven leaky-wave antennas, beam steering options, and novel applications, such as the practical use of high-P_{pk} capable leaky-wave feeds to drive high-gain, non-paraboloidal reflectors.