

# A Comparative Analysis between Pillbox Systems using Reflecting Mirrors and Virtual Optics.

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Controlling an antenna's pointing direction is important for a multitude of applications, from wireless communications to radar systems and high-power microwave (HPM) applications. For HPM systems mechanical steering is an appealing solution to orient the radiating beam of the antenna to the desired location (Y. Sun, F. Dang, C. Yuan, J. He, Q. Zhang and X. Zhao, "A Beam-Steerable Lens Antenna for Ku-Band High-Power Microwave Applications," *IEEE Transactions on Antennas and Propagation*, vol. 68, no. 11, pp. 7580-7583, Nov. 2020). Mechanically steering solutions based on optical concepts such as Risley scanners or quasi-optical systems (QOS) can reduce the complexity of the moving systems. In this abstract, we discuss the capability of QOSs to shape in phase and amplitude the energy of HPM antennas for mechanical steering. QOSs are typically implemented in parallel plate waveguides (PPW); they utilize a parabolic vertical metallic mirror or dielectric/discrete lens to control the propagation of the transverse electromagnetic (TEM) mode of the PPW. A classical example of a QOS is the pillbox beamformer which uses a parabolic vertical mirror to couple the layers of two-stacked PPWs as shown in Fig. 1(a) (M. Ettore, R. Sauleau, and L. Le Coq, "Multi-Beam Multi-Layer Leaky-Wave SIW Pillbox Antenna for Millimeter-Wave Applications," *IEEE Transactions on Antennas and Propagation*, vol. 59, no. 4, pp. 1093-1100, April 2011). The vertical parabolic mirror can make multi-layered stack ups difficult to implement. Perfect magnetic conductors (PMC) are introduced here to operate as virtual optics to replace the vertical mirrors. Their implementation with bed of nails configuration is also discussed.

The performance of three unique QOSs is presented. The first system is a classical pillbox with a vertical metallic parabolic mirror (Fig.1 (a)). The second QOS replaces the parabolic mirror with a virtual mirror implemented by two planar parabolic PMCs (Fig.1 (b)). The final QOS realizes the virtual mirror using a bed of nails, which introduces an electromagnetic bandgap in the band of interest. The electromagnetic bandgap is engineered through dispersion analysis of the bed of nails unit cell. All three QOSs are designed with the same geometric dimensions and illuminating horn. An elongated horn is utilized as the radiating aperture. The amplitude and phase profile of the TEM mode within the structure, matching and radiation patterns of the three QOSs are compared. This work was sponsored by the Office of Naval Research (ONR), under grant/contract number N00014-24-1-2201. The views and conclusions contained herein are those of the authors only and should not be interpreted as representing those of ONR, the U.S. Navy or the U.S. Government.

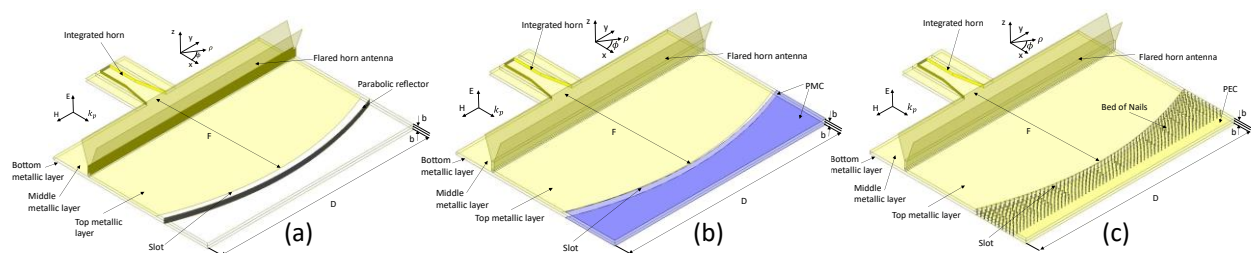


Figure 1. Compared pillbox systems. (a) Classical solution with a vertical metallic wall. (b) Implementation of the virtual mirror with planar PMCs. (c) Bed of nails implementation of the PMCs.