Ku-Band Traveling Wave Slot Array Using Simple Scanning Control

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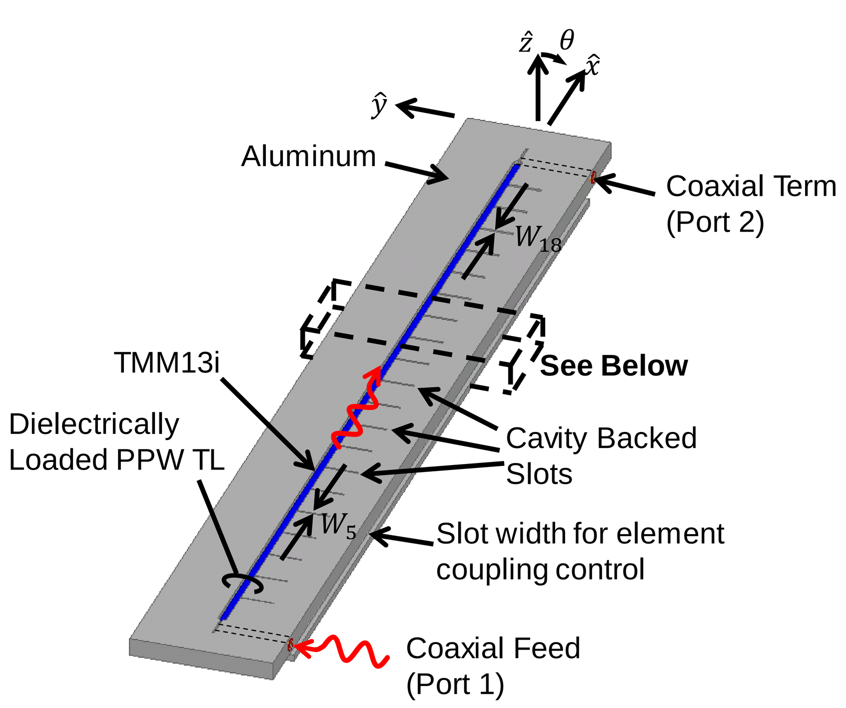
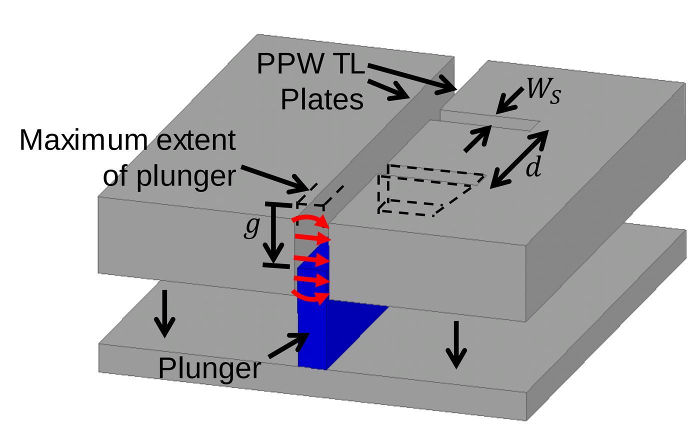
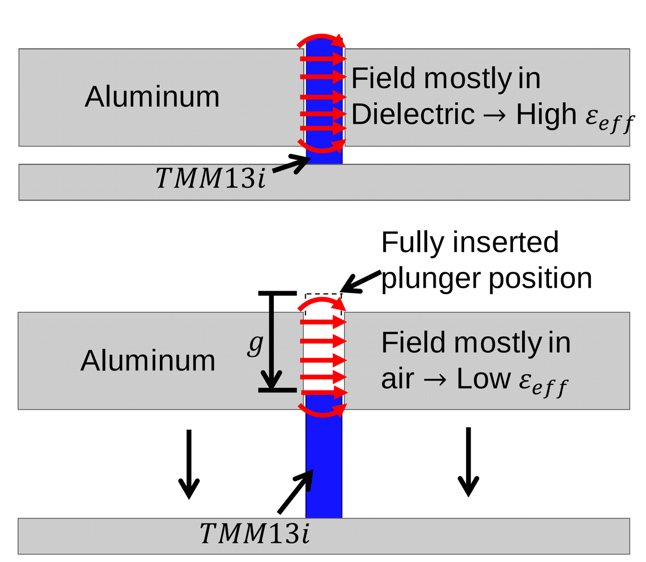
Abstract: This poster introduces a feeding concept aimed at simplifying the backend (phase shifters) of traditional phased arrays. As an alternative to traditional phased arrays, we employ a traveling wave array (TWA) using a single feedline whose propagation constant is controlled via a single, small mechanical movement without a need for phase shifters to enable scanning. Specifically, a dielectric plunger is positioned within a parallel plate waveguide (PPW) transmission line (TL) that feeds the TWA. By adjusting the position of the dielectric plunger within the PPW feeding the TWA, beam steering is achieved. A 20 element array is designed at 13GHz shown to give stable realized gain across the angular range of $-25° \leq \theta \leq 25°$. A proof of concept array is fabricated and measured to demonstrate and validate the concept's operation.

1 Operation Principle

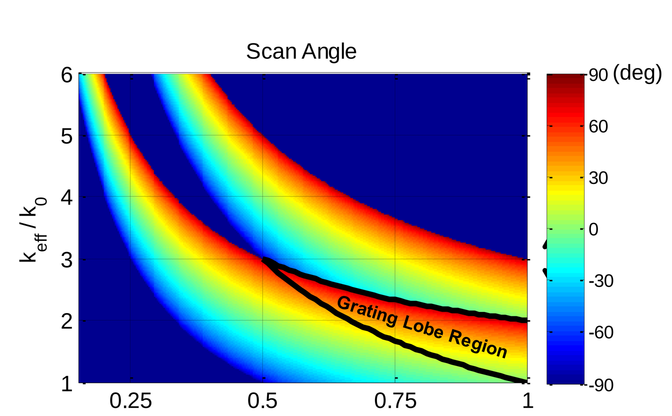


- Array elements fed via propagation reconfigurable transmission line
- k_{eff} reconfigured via small mechanical movement
- Phase delivered to each element a function of k_{eff}
- Array scanned with only the small mechanical movement

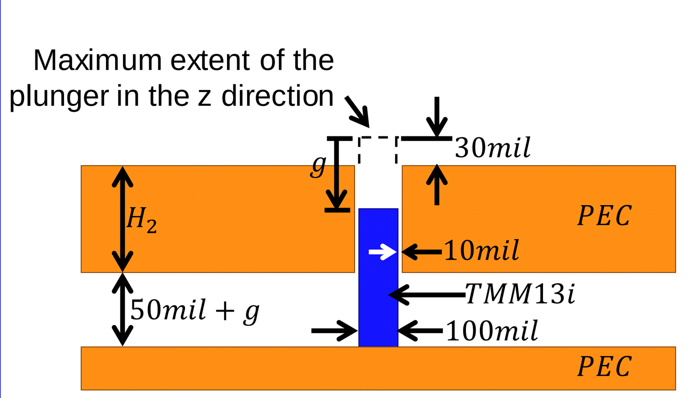


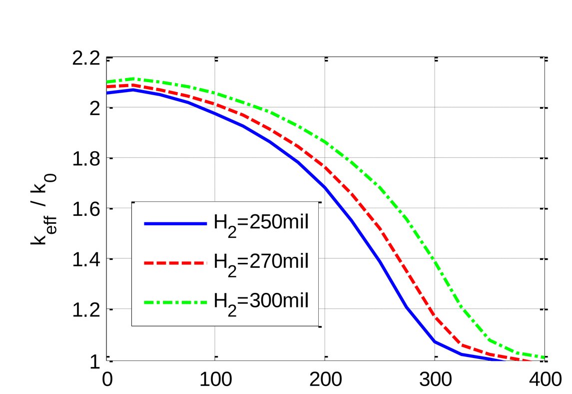


2 Transmission Line Design

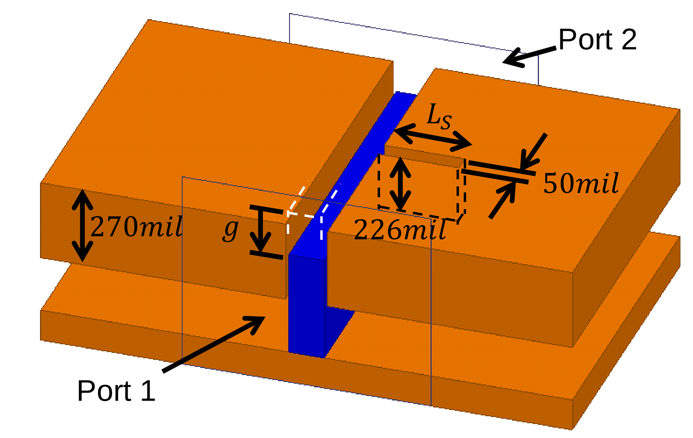


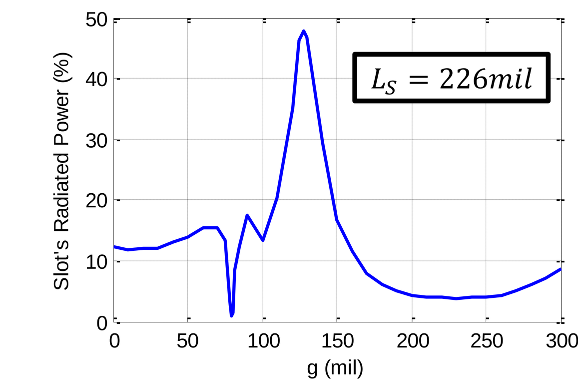
- Scan range a function of element spacing and TL k_{eff}
- $-30° \leq \theta \leq 30°$ scanning is achieved with $1.04 \leq \frac{k_{eff}}{k_0} \leq 2.04$ for and element spacing of 0.65λ
- Line achieves the necessary k_{eff} agility at $H_2 = 270mil$

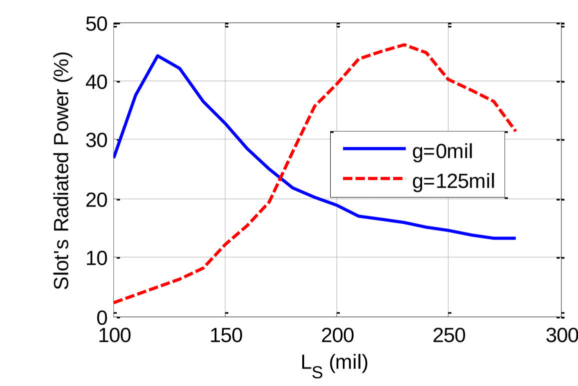




3 Rectangular Cavity Backed Slot

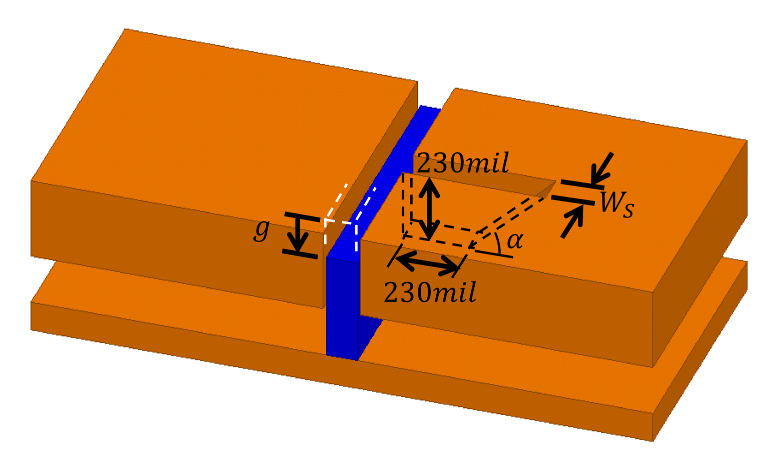


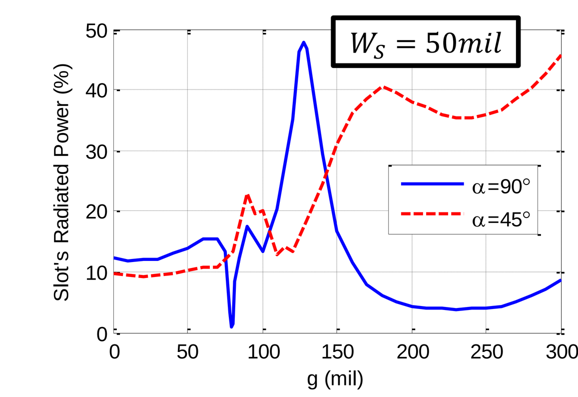


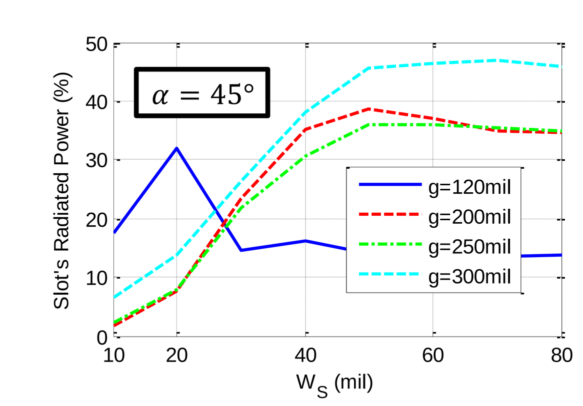


- Cavity backed slot becomes detuned as the plunger is adjusted
- Resonant length of the cavity backed slot varies with plunger position

4 Non-Rectangular Cavity Backed Slot

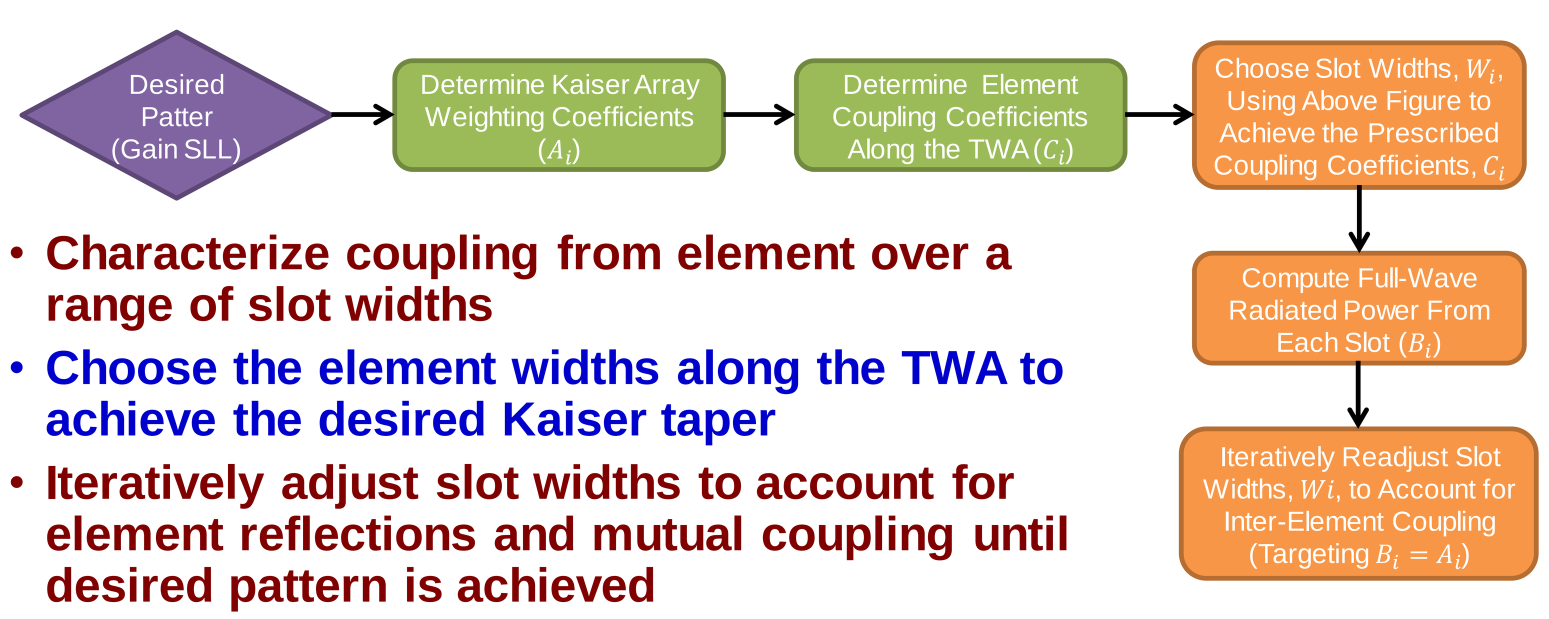






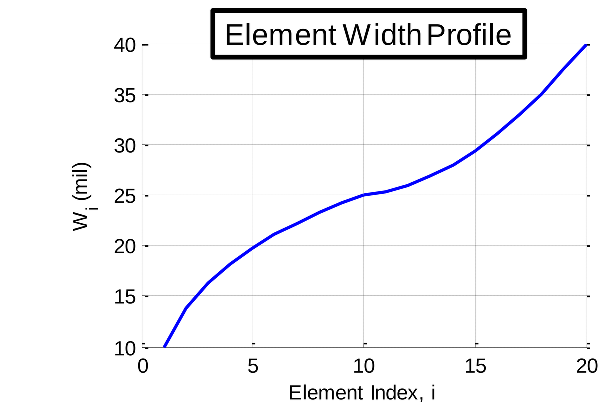
- By angling the back of the cavity we lower the Q value
- W_S is used to control the coupling to each element
- A large range of coupling achievable is desired

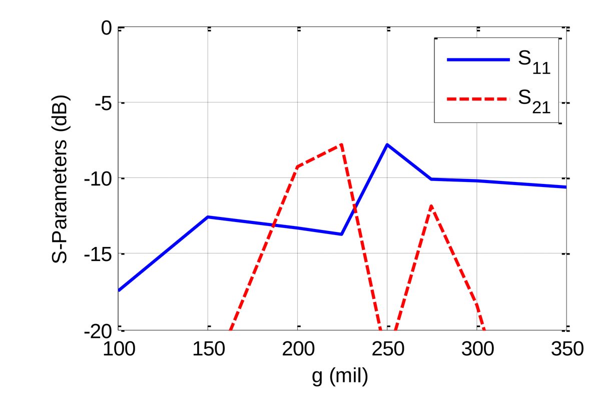
5 Array Design Procedure

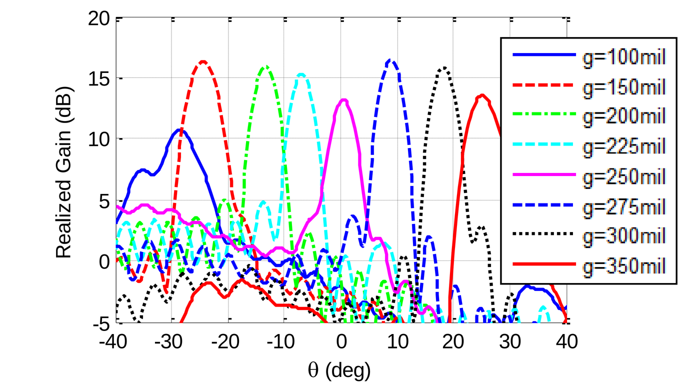


- Characterize coupling from element over a range of slot widths
- Choose the element widths along the TWA to achieve the desired Kaiser taper
- Iteratively adjust slot widths to account for element reflections and mutual coupling until desired pattern is achieved

6 Initial Design Performance

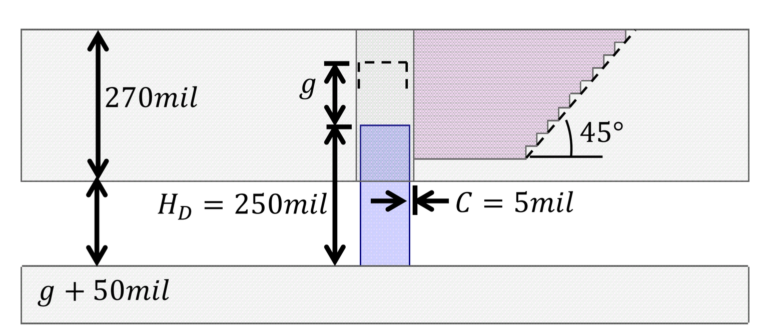


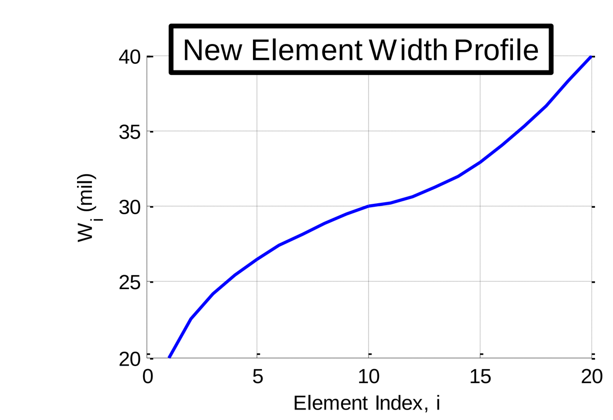




- S-Parameters generally less than $-10dB$ except around boresight scan as expected
- Scanning of $-25° \leq \theta \leq 25°$
- Consistent realized gain level across scan range

7 Increased Manufacturability

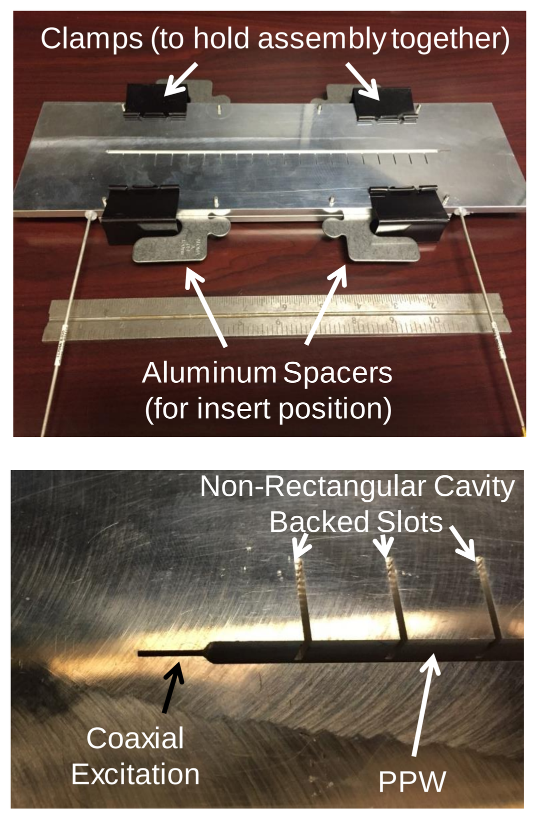


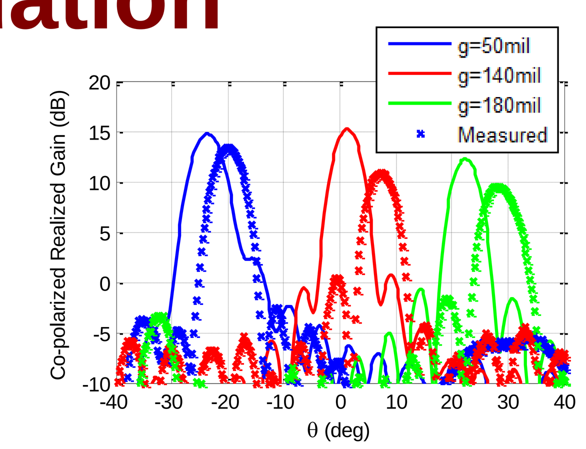


Reduce fabrication complexity
- 10 Steps to approximate cavity back
- Reduced plunger height
- Alter TL geometry and element spacing to achieve desired scan range

Variable	Initial Design	Final Design
Cavity Back	Straight	Stepped
H_D	350mil	250mil
C	10mil	5mil
Element Spacing	0.65λ	0.54λ

8 Prototype Validation





- Measurements generally agree with simulation
- Realized gain is down compared to simulated due to differences in TL geometry
- Measured scan angle is more positive, also due to differences in TL geometry