Active Reflectarray Element with Large Reconfigurability Frequency Range

S. Costanzo[1], F. Venneri[1], A. Raffo[1], G. Di Massa[1], P. Corsonello[1]
DIMES - University of Calabria, 87036 Rende (CS) Italy, email: costanzo@deis.unical.it

Abstract— A varactor-loaded radial phasing line is proposed in this work to actively tuning the phase of an aperture-coupled reflectarray cell, thus allowing to enlarge the reconfigurability frequency range. The proposed approach is applied to design an X-band 0.45 $\lambda \times 0.45\lambda$ reflectarray cell giving a 320° phase agility within a measured frequency range of about 8.5%, significantly greater with respect to that achievable by a simple linear phasing line.

***Index Terms*—reflectarray, reconfigurable antennas.**

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Sandra Costanzo, Francesca Venneri, Antonio Raffo, Giuseppe Di Massa, Pasquale Corsonello
DIMES - University of Calabria, Rende (CS), Italy – costanzo@deis.unical.it

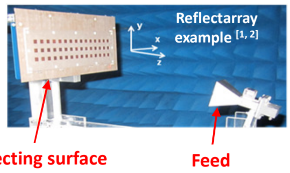
Abstract

The development of reconfigurable antenna systems is gaining increasing interest in last decades to satisfy the multi-functionality and adaptability demands of modern RF systems for radar applications, mobile and satellite communications, cognitive radio, etc. Reconfigurable antennas offer many advantages, such as: ability to support multiple standards and adaptability to different coverage requirements. A very interesting alternative to standard mechanically moved reflectors or conventional phased arrays is given by ***reconfigurable reflectarray antennas****.* ***A novel aperture-coupled reflectarray unit cell*** *is proposed in this work having a large reconfigurability frequency range.* ***A phasing line composed by a couple of broadband radial stubs loaded by a single varactor diode*** *is adopted to realize the dynamic phase shift mechanism, extending the unit cell beam-scanning and/or reshaping pattern capabilities within a broader frequency range. The radiating structure is properly optimized at 10 GHz, obtaining a full phase tuning range within a large frequency span of about 1.3 GHz.*

Why use a Reconfigurable Reflectarray ?

Electronic Reconfigurable Reflectarray Antennas

Usually based on the use of tunable components or materials, such as MEMS switches, PIN/varactor diodes and liquid crystal substrates.



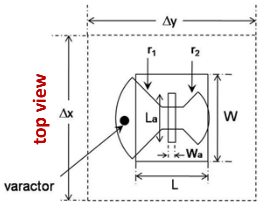
Reflectarrays ***VS*** **Parabolic Reflectors & Phased Arrays**

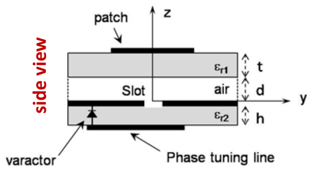
Reconfigurable Reflectarrays Advantages over conventional reconfigurable antennas

- ✓ **Low profile and scalability**
- ✓ **Instantaneous radar beam positioning , without time delays and vibration of mechanical systems**
- ✓ **Increased data rates**
- ✓ **Simpler architectures** due to the absence of complicated beam-forming networks
- ✓ **Increased efficiencies** thanks to the use of spatial feeding

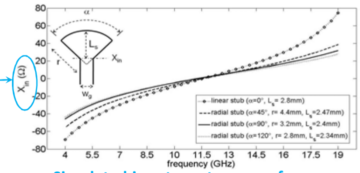
Proposed Reflectarray Unit Cell with Large Reconfigurability Frequency Range

The **unit cell** consists of **a rectangular patch aperture-coupled to a microstrip line**, which is composed by **a couple of radial stubs**. One end of the line is loaded by a **varactor diode**, that allows a dynamical tuning of the phase reflected by the cell.



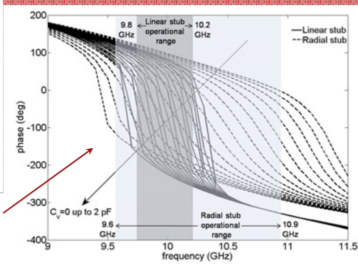


This novel phasing line geometry **improves the reconfigurability frequency range of the cell** due to the fact that the **input impedance of a radial stub** has a **smoother behavior** with respect to an equivalent linear stub.



Simulated input reactance vs. frequency for different stubs

Simulated reflectarray unit cell operating at 10 GHz



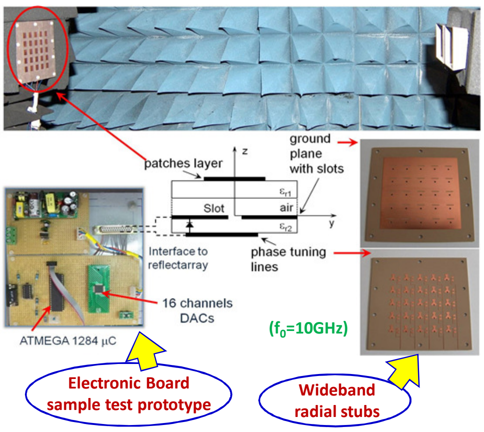
Simulated phase curves vs. frequency for different diode capacitance values
(Comparison between two cells respectively driven by a radial and a linear phasing line)

Element sizes: $L=8.9mm$, $W=6.8mm$ ← (patch)
$L_a=6.7mm$, $W_a=0.7mm$ ← (slot)
$r_1=4.3mm$, $r_2=2.7mm$ ← (radial stubs)

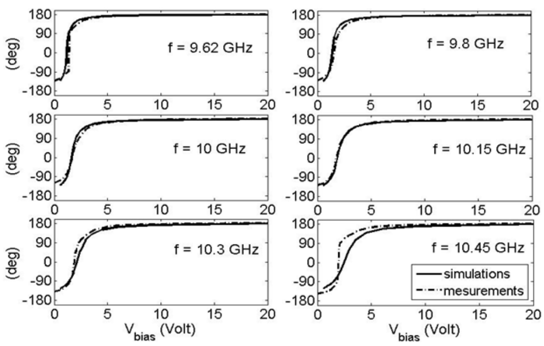
Element stratification

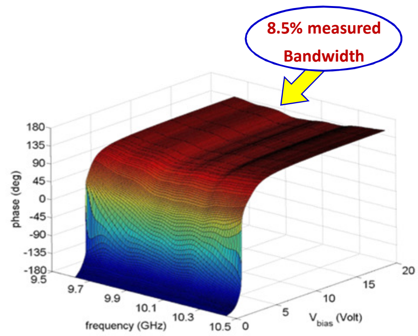
Layer	*Material*	*Thickness*
Patch	Copper	35 µm
Antenna substrate	Diclad870 (ε_{r1}=2.33)	t= 0.762 mm
	Air	d= 1.524mm
Ground plane with slot	Copper	35 µm
Phasing line substrate	AR600 (ε_{r2}=6.15)	h= 0.762 mm
Phasing line	Copper	35 µm

Preliminary Experimental Results



Comparison between simulated and measured phase curves at different frequencies





Measured phase curves vs. frequency and varactor bias voltage

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