SIR based Frequency Reconfigurable Antenna using Varactor Diodes

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Outline

- Introduction
- Antenna Geometry
- Results and Discussions
- Conclusion
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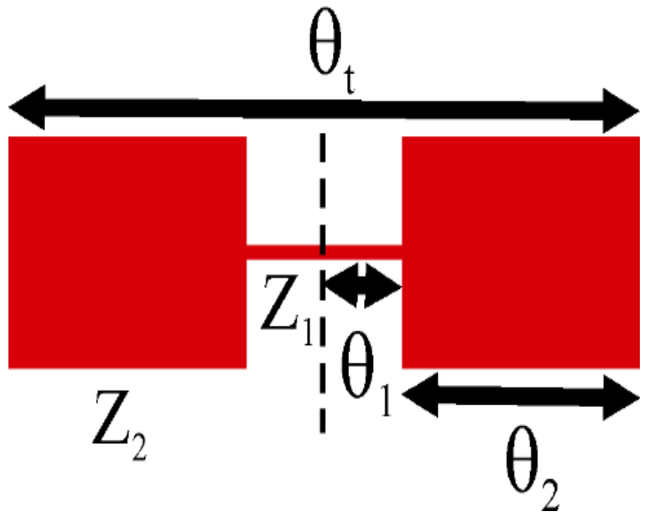
- References

Introduction

- Frequency reconfigurable antennas are useful for modern wireless communication
- Single antenna can cover several application bands
- Attractive features: reconfigurable capability, multipurpose function, low cost and miniaturized size
- By increasing the electrical length of the antenna or the current route on the antenna, the resonance frequency can be reconfigured [5], [6]
- Microelectromechanical systems (MEMS) , varactor diodes and PIN diodes

Stepped Impedance Resonators (SIR)

- *Half wavelength*



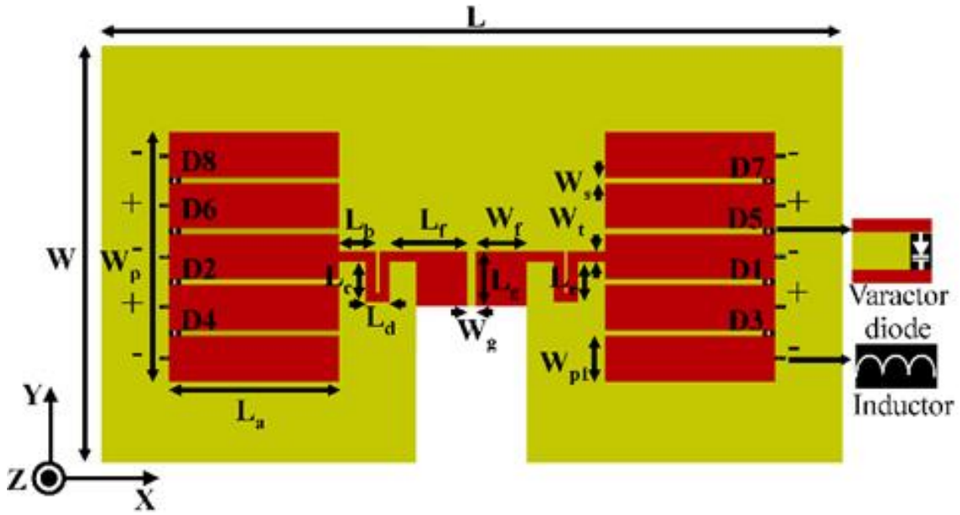
- *Impedance ratio*

$$K = \frac{Z_2}{Z_1}$$

- *Length ratio*

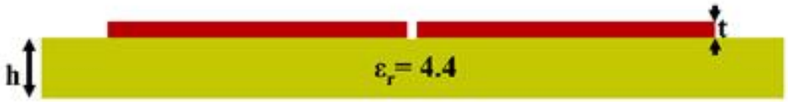
$$\alpha = \frac{\theta_2}{\theta_1 + \theta_2} = \frac{2\theta_2}{\theta_t}$$

Antenna Geometry

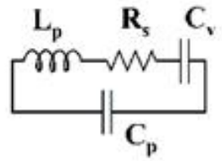


(a)

(b)



(c)



(d)

Geometry of the proposed antenna. (a) Top view (b) Fabricated prototype of the antenna operating at 2.45 GHz, ε_r= 4.4, tan δ = 0.02 and h = 1.6 mm. (c) Side view (d) Varactor diode equivalent circuit.

- Optimized Dimensions of the Stepped Impedance (SI) reconfigurable dipole antenna

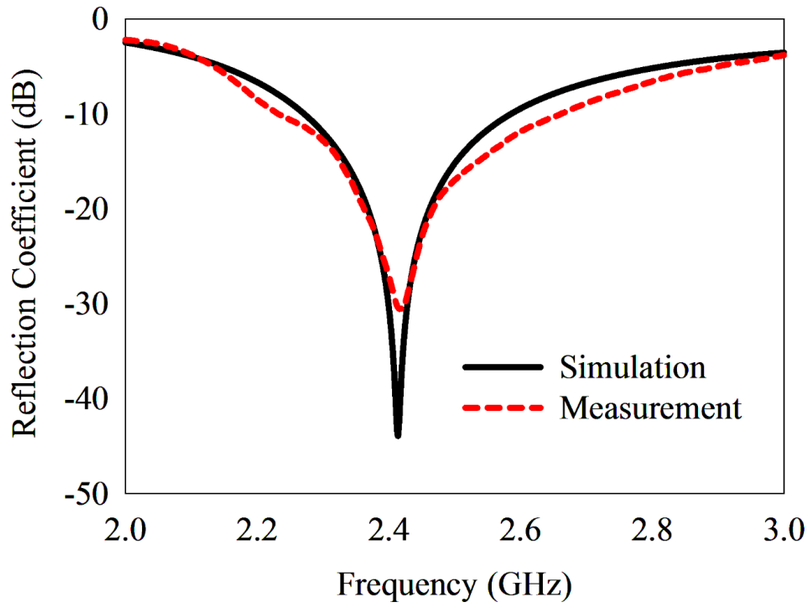
Parameter	Dimensions	Parameter	Dimensions
L	0.408 λ_0	W	0.245 λ_0
L_a	0.081 λ_0	W_g	0.00408 λ_0
L_b	0.0163 λ_0	W_p	0.12 λ_0
L_c, L_e	0.0179 λ_0	W_{pl}	0.022 λ_0
L_d	0.00163 λ_0	W_s	0.00245 λ_0
L_f	0.0408 λ_0	W_t	0.0049 λ_0
L_g, W_f	0.0245 λ_0	h	0.013 λ_0

- λ_0 represents the free-space wavelength at the frequency 2.45 GHz

- Z_1= 100 Ω and Z_2= 15 Ω, impedance ratio K=0.15
- θ_1=13.4 mm θ_2= 10 mm, Length ratio α= 0.43
- Fundamental resonance at 2.4 GHz and First spurious frequency at 7.5 GHz

Results and Discussions

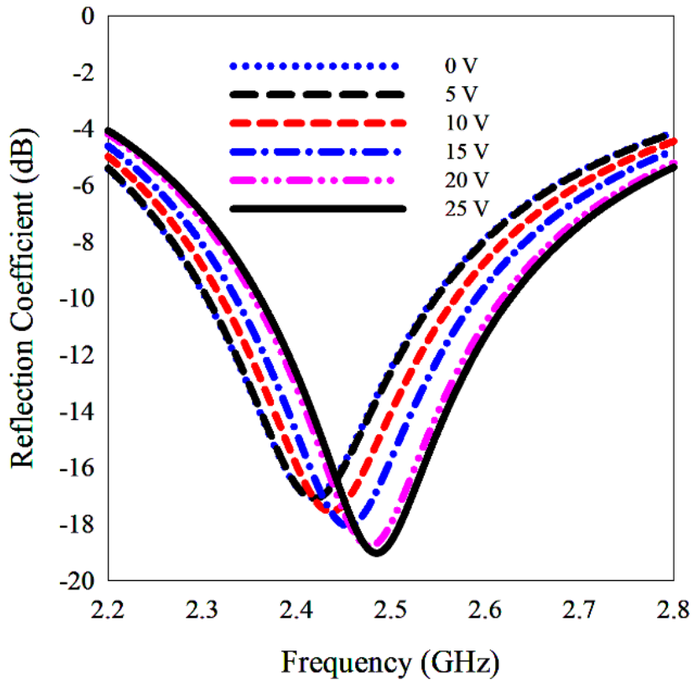
- Reflection Coefficient
- Impedance bandwidth: 2.24 - 2.66 GHz
- Varactor diode BB640 E6327
- Bias voltage : 0 to 25 V
- Chip inductors: 36 nH



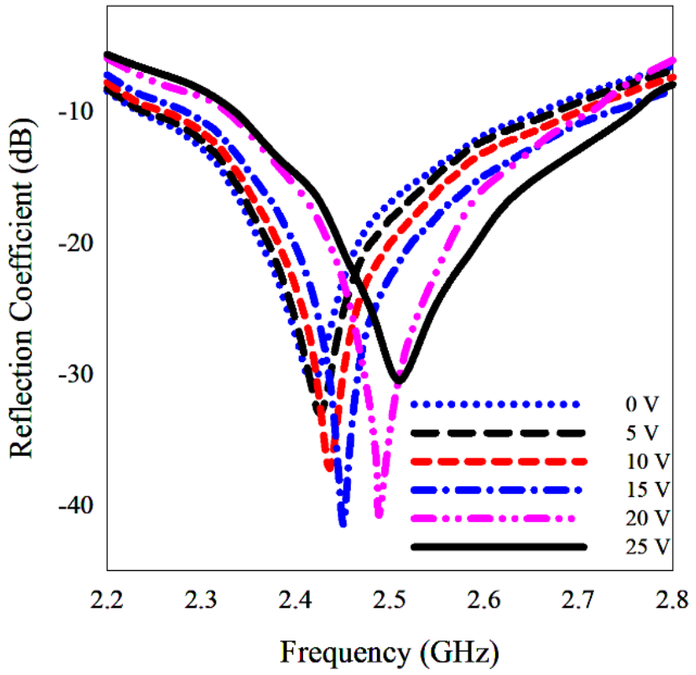
Reverse bias voltage (V)	Capacitance (pF)
0	77
5	55
10	13
15	7
20	4.2
25	3.7

Frequency switching

- Using single varactor diode on each arm of the SI dipole

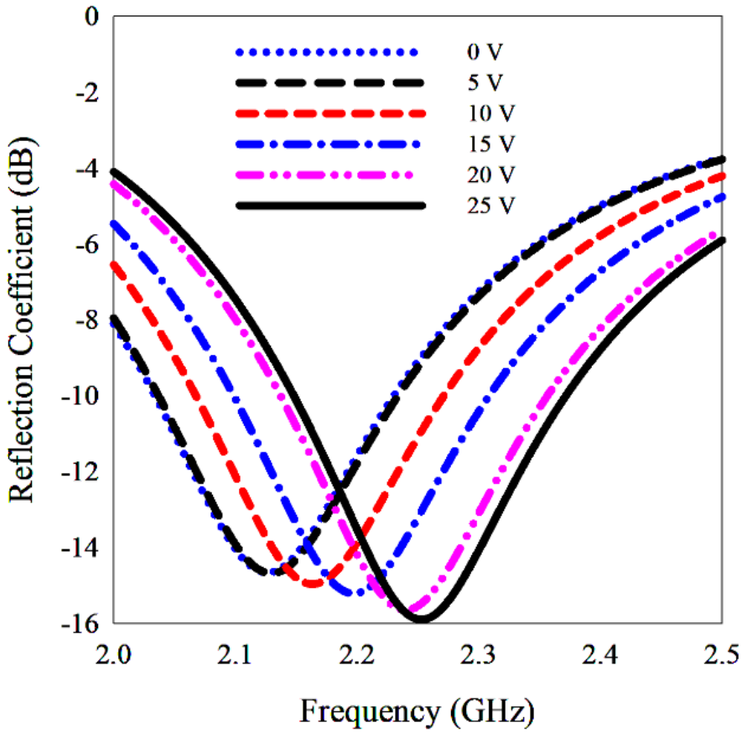


Simulation

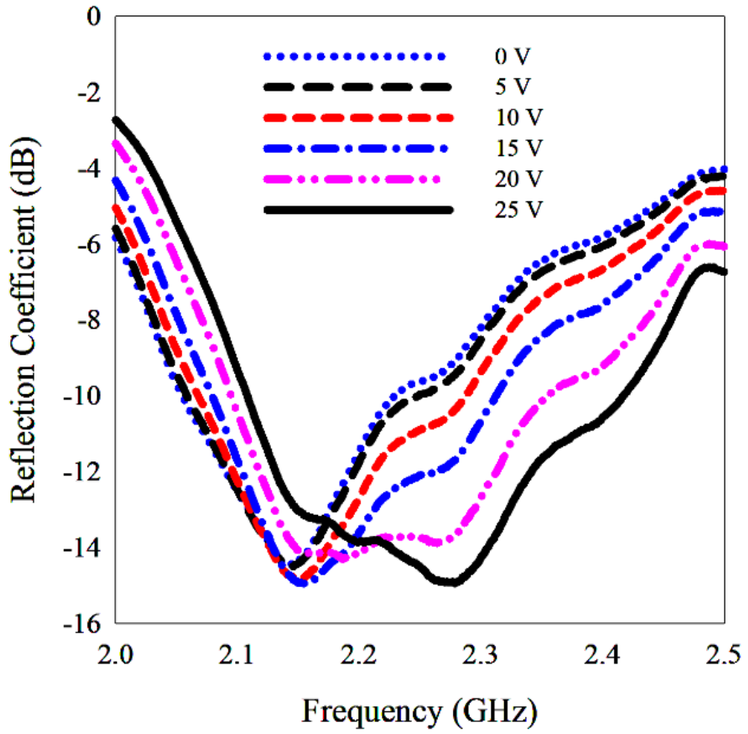


Measurement

- Pair of varactor diodes on each arm of the SI dipole

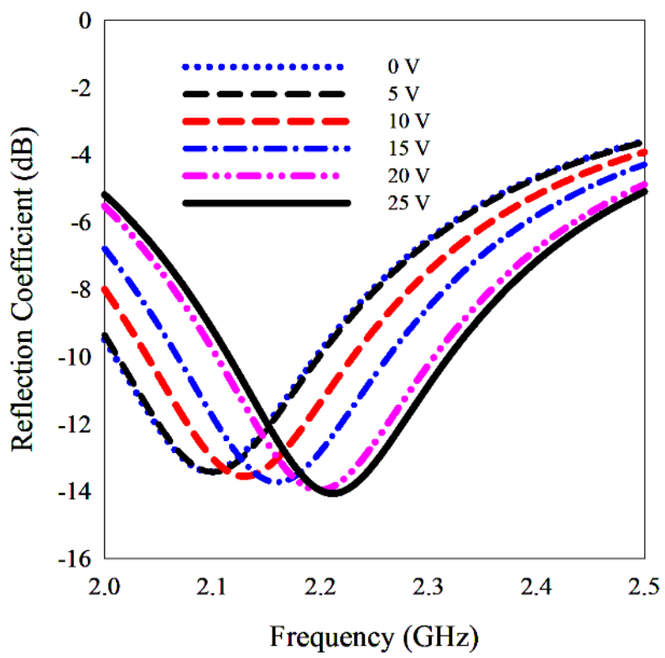


Simulation

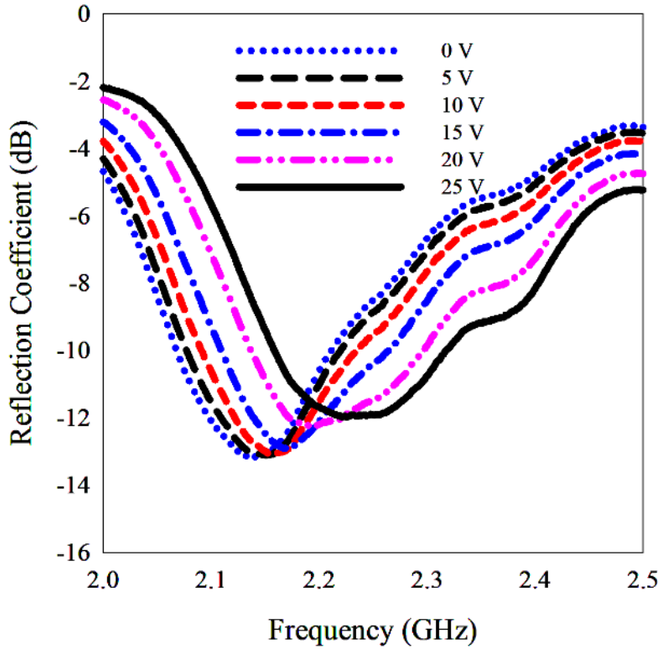


Measurement

- Switching using 3 varactor diodes on each arm of the SI dipole

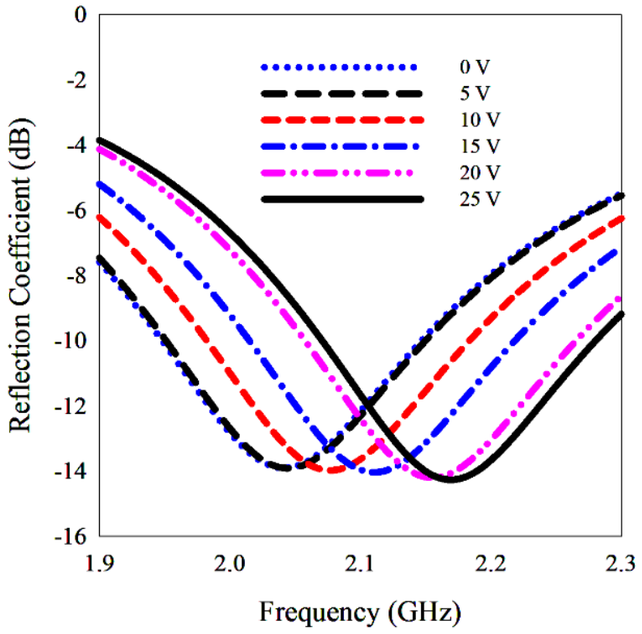


Simulation

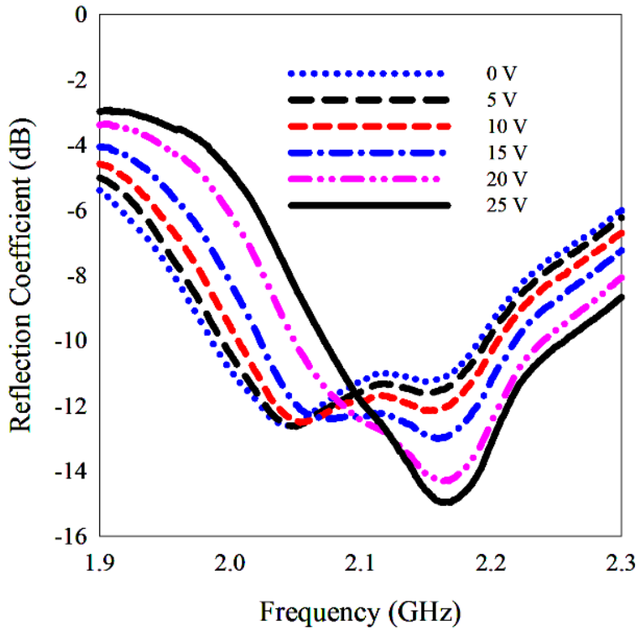


Measurement

- Four varactor diodes are used in each arm of the SI dipole

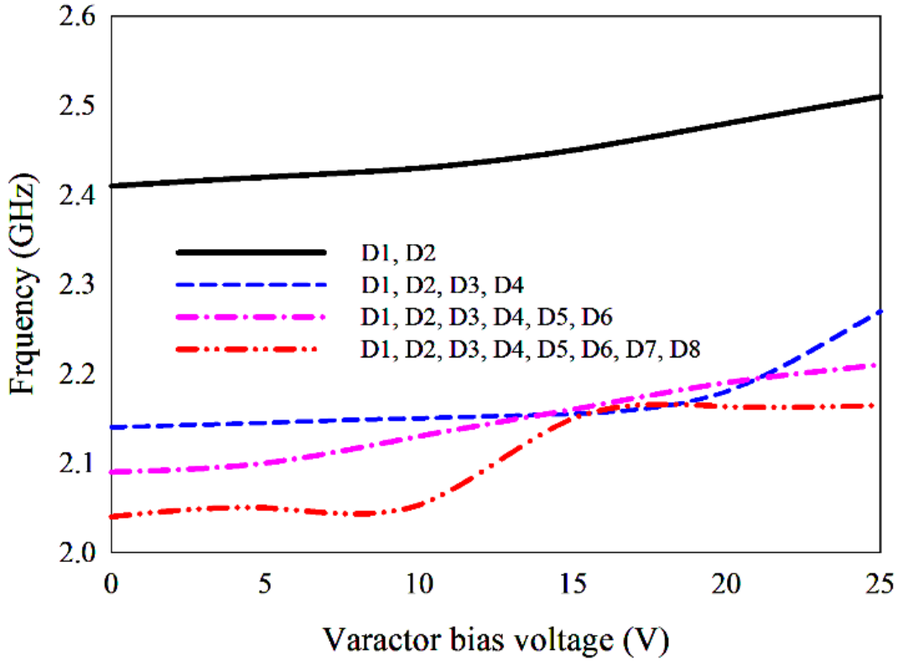


Simulation



Measurement

- Measured variation of resonant frequency against different reverse bias voltages

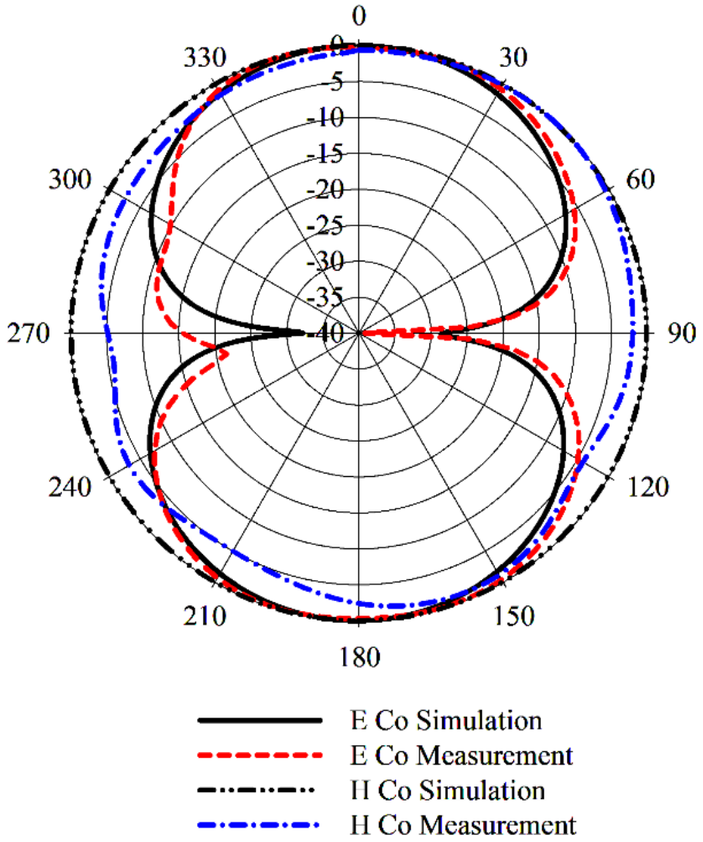


• Simulated and measured resonant frequencies

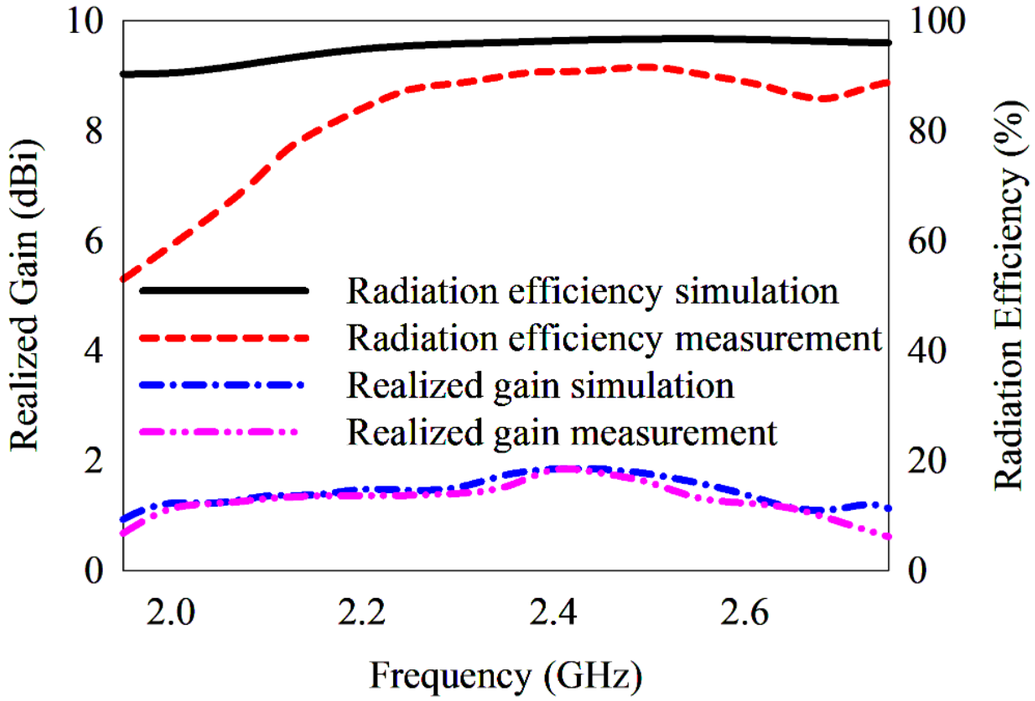
Diodes enabled	Reverse voltage applied (V)	Switching resonant frequency fo (GHz), Reflection coefficient (dB)		Operation Band (GHz), Percentage of bandwidth (%)	
		Simulation	Measurement	Simulation	Measurement
D1, D2	0	2.41, -43	2.41, -30.5	2.27-2.57, 12.44	2.24-2.66, 17.42
	5	2.418, -17	2.42, -33	2.30-2.54, 9.9	2.23-2.65, 17.36
	10	2.43, -18	2.43, -37	2.31-2.56, 10.2	2.27-2.68, 16.87
	15	2.45, -18	2.45, -41	2.33-2.59, 10.61	2.29-2.70, 16.73
	20	2.495, -28	2.48, -40.5	2.35-2.61, 10.42	2.33-2.71, 15.32
	25	2.485, -20	2.51, -30.5	2.36-2.62, 10.46	2.34-2.76, 16.73
D1, D2, D3, D4	0	2.12, -14.6	2.14, -14	2.02-2.2, 8.4	2.04-2.22, 8.41
	5	2.13, -14.6	2.145, -14	2.05-2.21, 7.5	2.05-2.25, 9.32
	10	2.16, -15	2.15, -14	2.08-2.25, 7.87	2.06-2.28, 10.2
	15	2.19, -15	2.155, -15	2.11-2.29, 8.2	2.08-2.31, 10.6
	20	2.24, -15	2.18, -14	2.15-2.34, 8.48	2.09-2.35, 11.9
	25	2.25, -15	2.27, -15	2.16-2.36, 8.88	2.1-2.42, 14.09
D1, D2, D3, D4, D5, D6	0	2.09, -13.4	2.137, -13	2-2.19, 9	2.05-2.20, 7.01
	5	2.1, -13.4	2.1513, -13	2.01-2.19, 8.57	2.07-2.21, 6.5
	10	2.13, -13.4	2.1575, -13	2.04-2.23, 8.9	2.09-2.23, 6.4
	15	2.16, -13.7	2.1713, -13	2.06-2.26, 9.2	2.10-2.26, 7.36
	20	2.19, -14	2.195, -12	2.1-2.3, 9.1	2.13-2.29, 7.28
	25	2.21, -14	2.2213, -12	2.11-2.31, 9	2.16-2.31, 6.75
D1, D2, D3, D4, D5, D6, D7, D8	0	2.04, -14	2.04, -12.5	1.94-2.14, 9.8	1.98-2.18, 9.78
	5	2.05, -14	2.05, -12.5	1.95-2.15, 9.7	1.99-2.19, 9.75
	10	2.07,-14	2.053, -12.5	1.98-2.18, 9.6	2-2.22, 10.71
	15	2.11, -14	2.15, -13	2.01-2.21, 9.4	2.02-2.22, 9.3
	20	2.15, -14	2.163, -14	2.05-2.26, 9.7	2.04-2.24, 9.24
	25	2.169, -14	2.1645, -15	2.07-2.28, 9.6	2.07-2.26, 8.77

Radiation patterns

- Normalized omnidirectional radiation pattern of the antenna at 2.45 GHz



Realized gain and efficiency



Conclusions

- A stepped impedance based frequency reconfigurable antenna for WLAN (2.4- 2.48 GHz)/ bluetooth (2.4-2.48 GHz)/ LTE (2.4-2.7 GHz)/ WiMAX (2.5-2.7 GHz) has been presented
- The simulation and experiments are well matched and offer a 2:1 VSWR (S11‹ -10 dB) bandwidth of 780 MHz
- The proposed antenna offers the omni directional radiation characteristic

Acknowledgements

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Thank You