Compact Microstrip Antennas

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Compact MSA

Size of the MSA is large at lower frequencies.

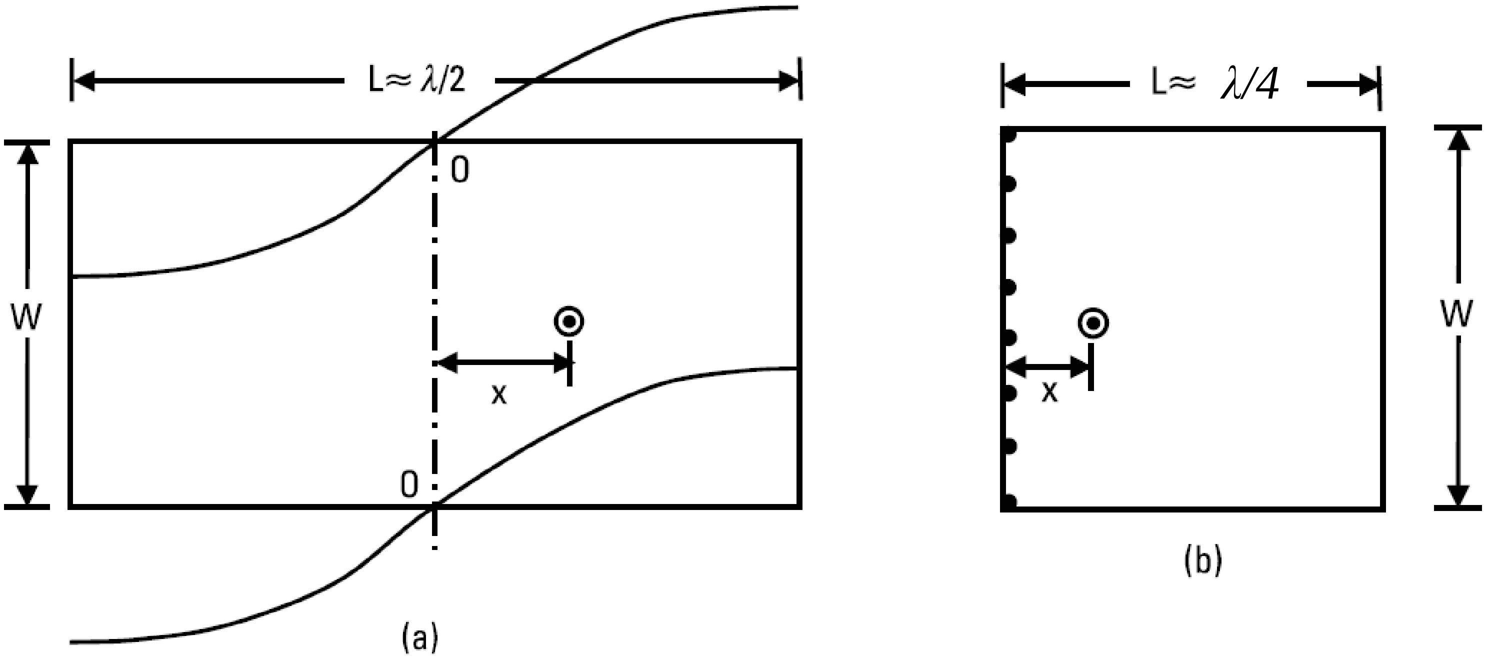
For RMSA, its effective length = λ/2.

- **At 900 MHz, λ/2 = 16.67 cm and**
- **At 300 MHz, λ/2 = 50.0 cm**

Size of the MSA can be reduced by using:

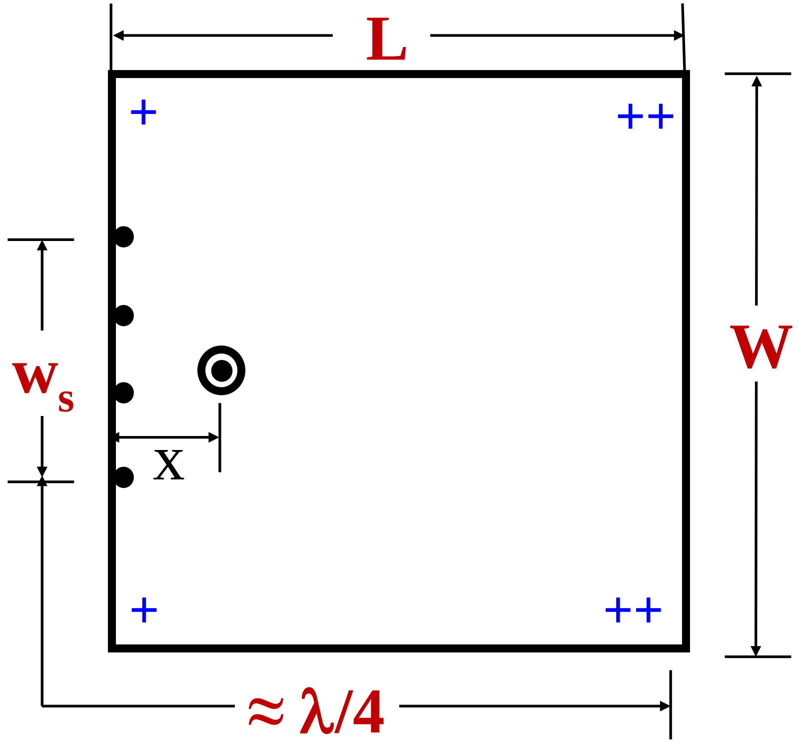
1. **Substrate with higher ε_r but BW and η reduce.**
2. **Shorting Post at appropriate location.**
3. **Cutting Slots at appropriate location**
4. **Any combination of the above techniques**

Compact Shorted Rectangular MSA



(a) Field distribution of the TM_{10} mode of RMSA of length ≈ λ/2 and (b) shorted λ/4 RMSA.

Partially Shorted RMSA



$$f_o = \frac{30}{4\left[L_e + \left(W_e - w_s\right)/2\right]\sqrt{\varepsilon_e}} \text{ GHz}$$

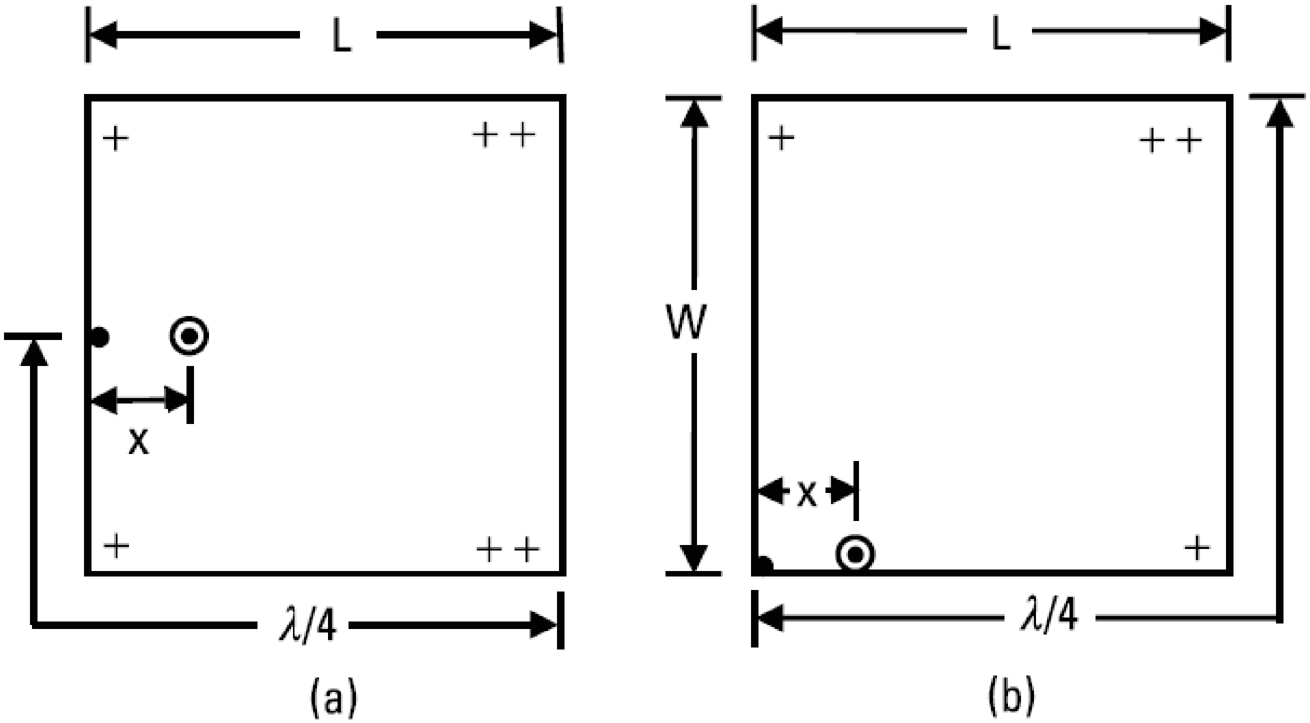
where, L_e and W_e are the effective length and width in cm

Variation of Resonance Frequency with Shorting Ratio for Partially Shorted RMSA

$L = W = 3.3$ cm, $\varepsilon_r = 2.33$, $h = 0.159$ cm, $tan\delta = 0.001$, and $x = 0.4$ cm

Shorting Ratio w_s/W	Experimental Results f_0 (GHz)	Z_{in} (Ω)	Theoretical Results f_0 (GHz)	Z_{in} (Ω)	Error in f_0 (%)
0.1	0.881	$528 + j2.8$	0.893	$535 - j5$	+1.24
0.2	1.028	$300 - j0.5$	1.025	$282 - j3$	−0.27
0.3	1.126	$212 + j1.3$	1.123	$179 - j1$	−0.25
0.4	1.206	$142 - j3.7$	1.203	$126 - j4$	−0.23
0.5	1.294	$95.5 - j0.7$	1.296	$81.2 - j2$	+0.12
0.6	1.345	$73.1 - j0.2$	1.348	$66.8 + j3$	+0.20
0.7	1.393	$59 + j0.3$	1.389	$59.6 + j2$	−0.25
0.8	1.420	$53.4 - j1.1$	1.419	$52.5 - j3$	−0.06
0.9	1.440	$51.9 - j1.7$	1.436	$50.9 - j.1$	−0.25
1.0	1.447	$50.7 - j0.0$	1.442	$50.1 + j0$	−0.31

RMSA with Single Shorting Post

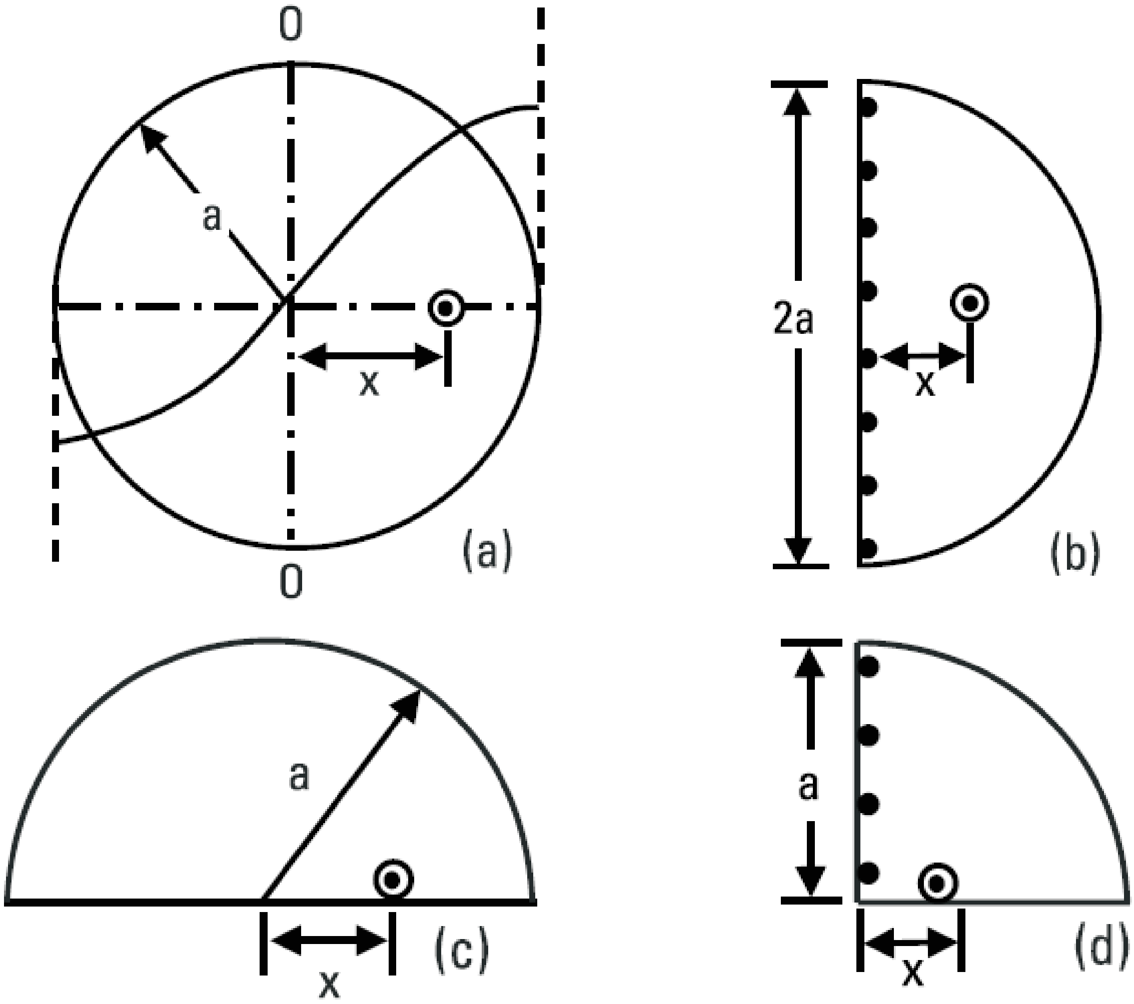


RMSA with a single shorting post at the (a) middle of the edge along the width (PIFA) and (b) corner

$$f_o = \frac{30}{4\left(L_e + W_e/2\right)\sqrt{\varepsilon_e}} \text{ GHz}$$

$$f_o = \frac{30}{4\left(L_e + W_e \quad\right)\sqrt{\varepsilon_e}} \text{ GHz}$$

Compact Shorted CMSA



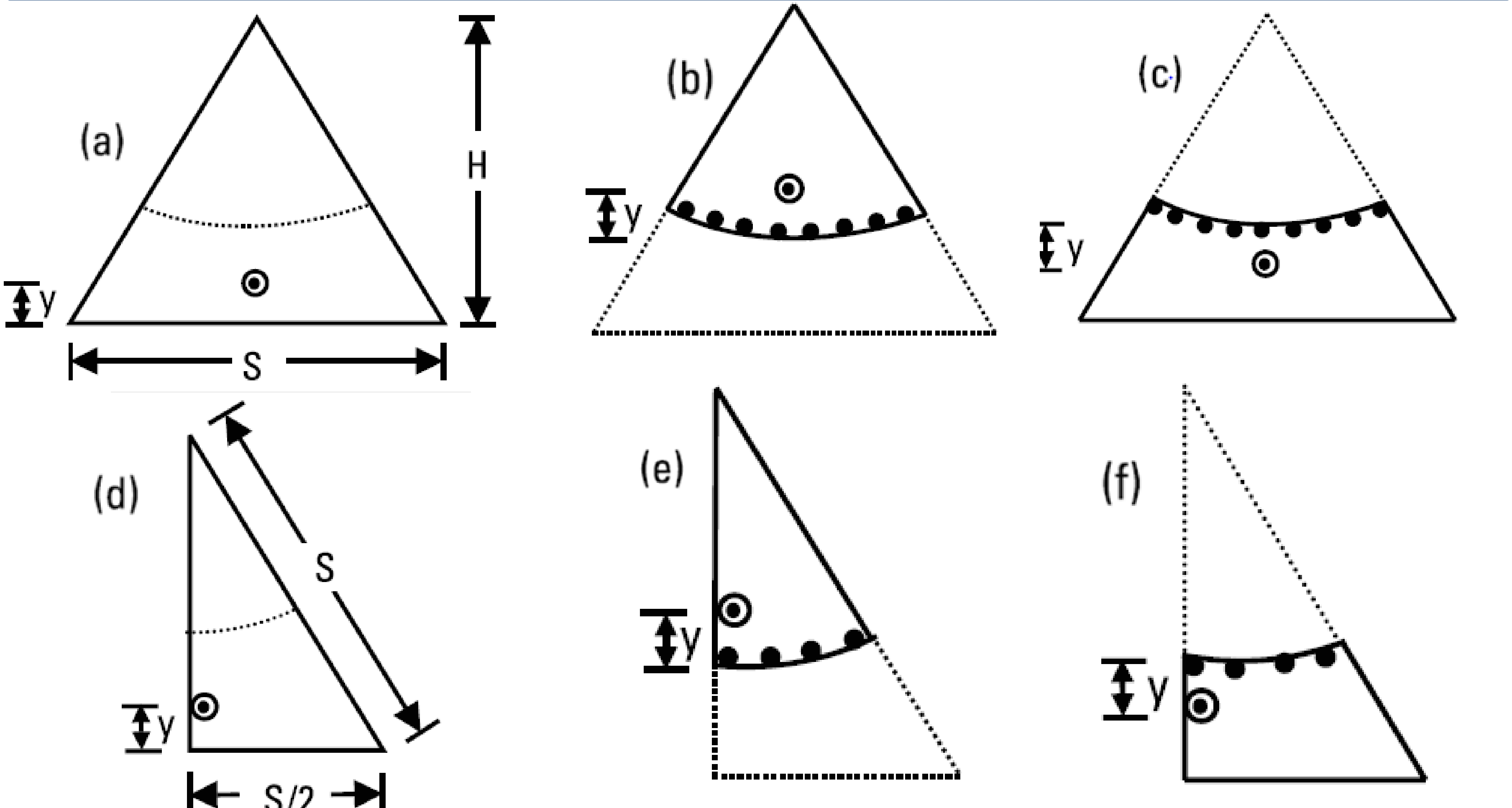
(a) CMSA - voltage distribution for the fundamental TM_{11} mode, (b) shorted semi-circular MSA, (c) semi-circular MSA and (d) shorted 90° sectoral MSA.

Comparison of Different CMSA Configurations

Comparison of Different Variations of CMSA
(a = 3.0 cm, ε_r = 2.33, h = 0.159 cm and $tan\delta$ = 0.002)

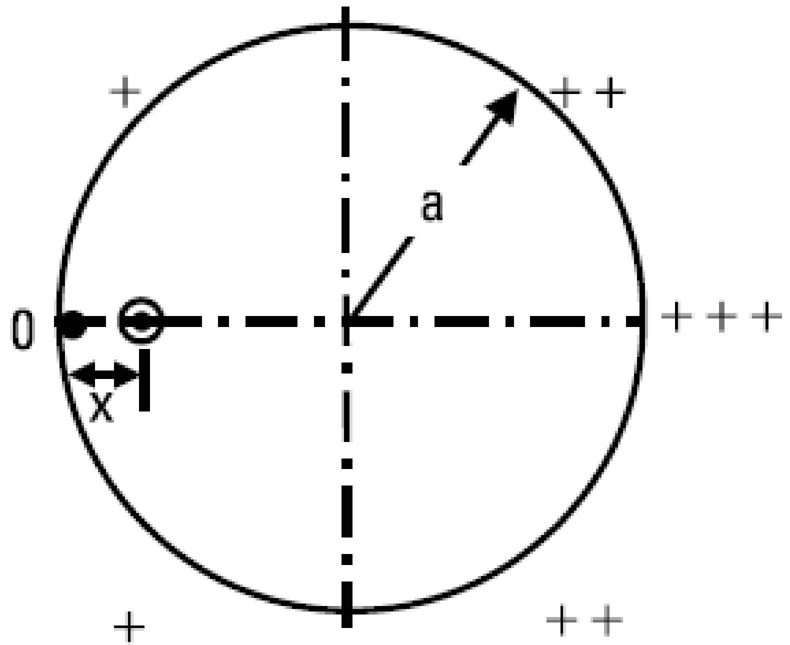
Variations of CMSA	x (cm)	f_o (GHz)	BW (MHz)	% BW	Area (cm^2)
CMSA	0.9	1.866	25	1.3	28.27
SCMSA	0.7	1.863	18	0.9	14.13
Shorted SCMSA	0.65	1.788	22	1.2	14.13
Shorted 90°-sectoral MSA	0.3	1.761	14	0.8	7.06

TMSA and its Variations



TMSA and its variations (a)Equilateral TMSA, (b) shorted 60°-sector, (c) complement of shorted 60°-sector, (d) 30°-60°-90° TMSA, (e) shorted 30°-sector and (f) complement of shorted 30°-sector.

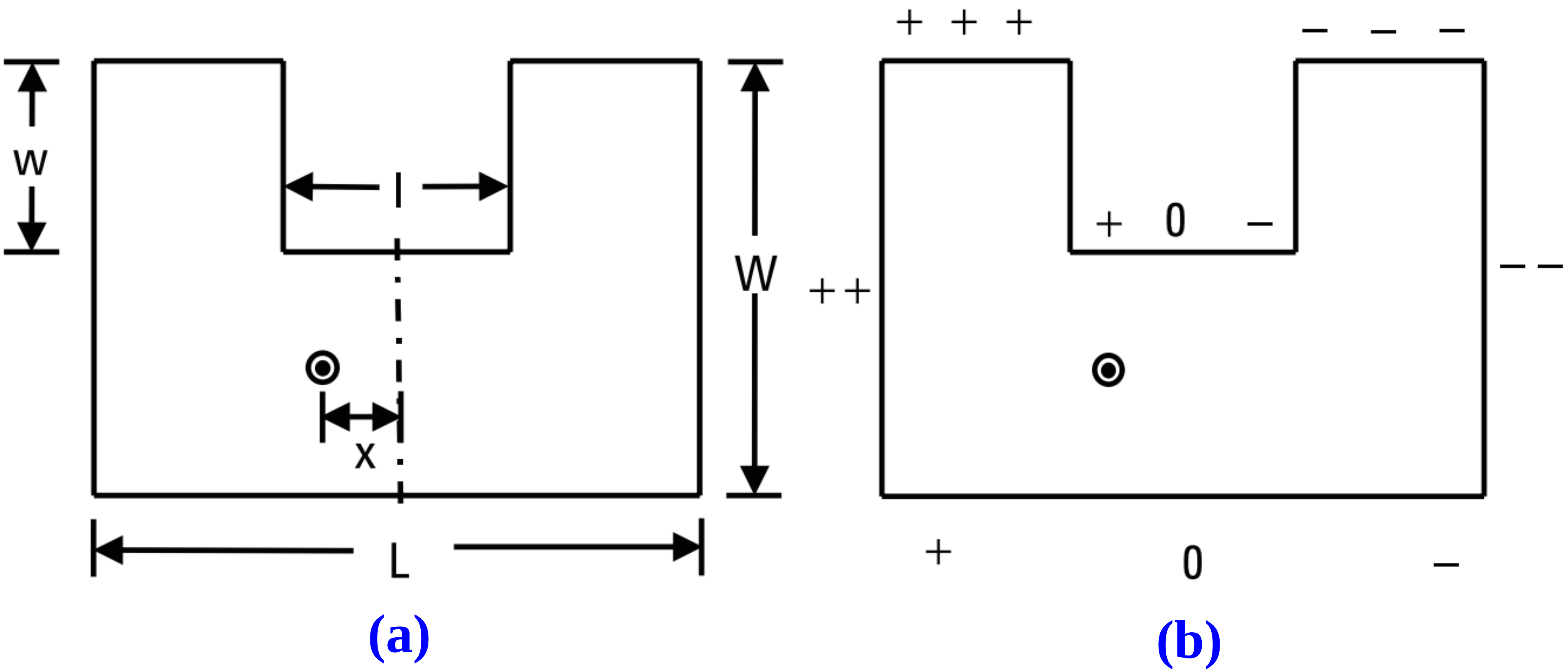
CMSA with Single Shorting Post



$$f_o = \frac{8.791}{a_{e1}\sqrt{\varepsilon_e}} \text{ GHz}$$

where, $a_{e1} = \pi a_e$ in cm and a_e is the effective radius of the CMSA.

C- Shaped MSA



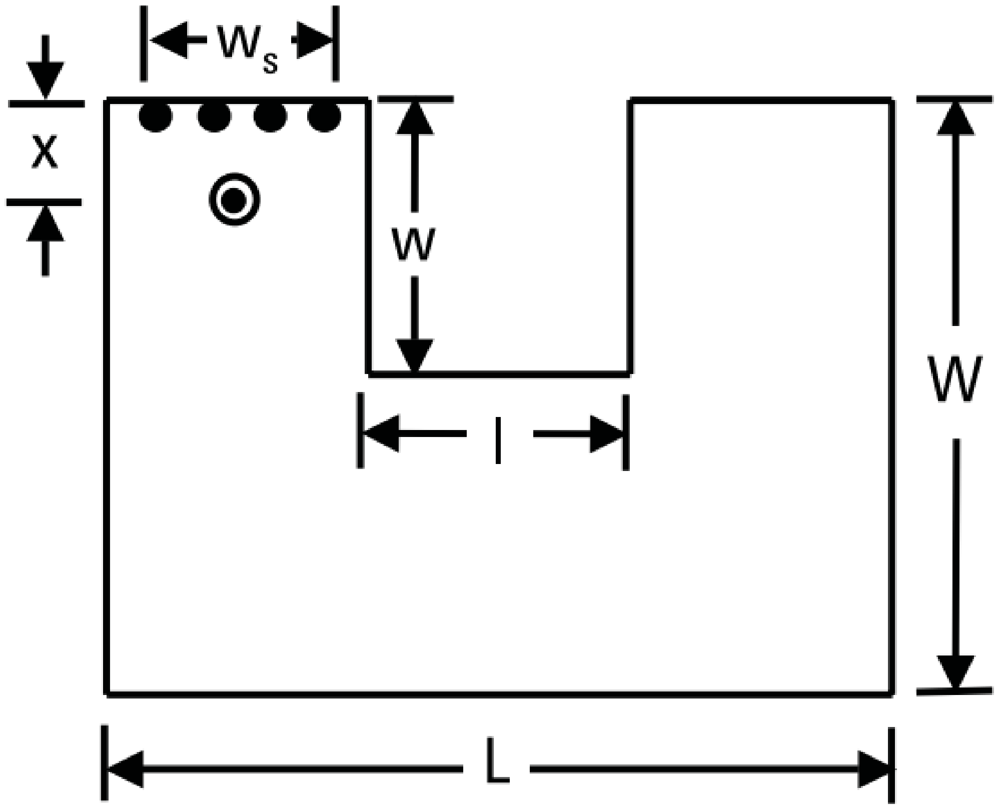
(a) C-shaped MSA and its (b) Voltage Distribution

Effect of Slot Dimensions on the Performance of C-Shaped MSA

Effect of Slot Dimensions on the Performance of C-Shaped MSA
(L = 6 cm, W = 4 cm, ε_r = 2.33, h = 0.159 cm and tanδ = 0.002)

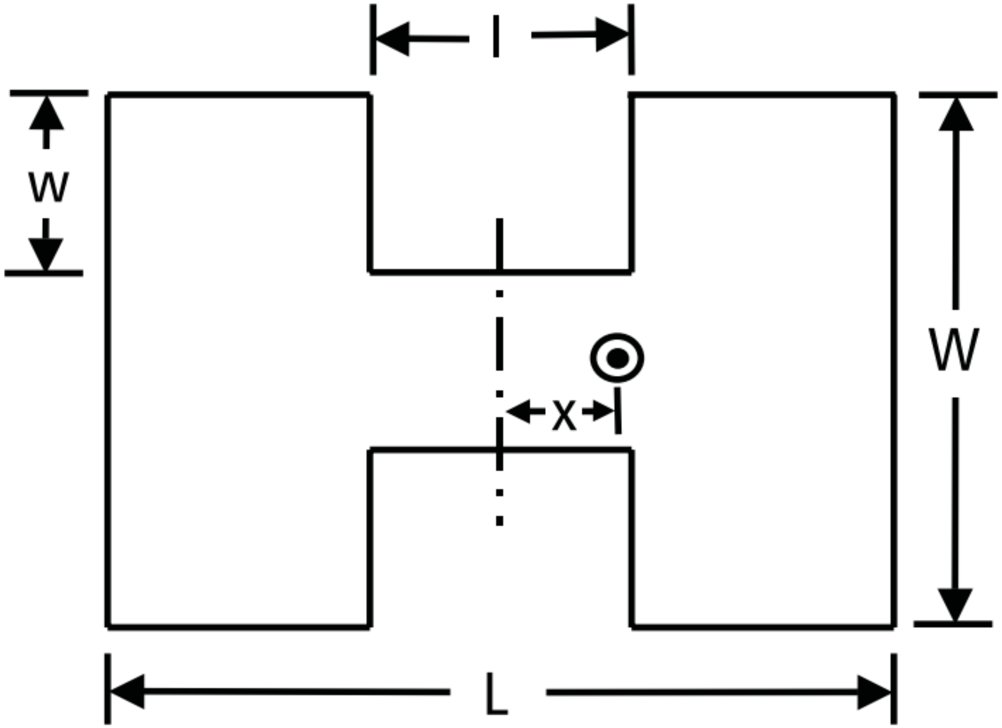
w x *l* (cm, cm)	*x* (cm)	f_o (GHz)	BW (MHz)	D (dB)	η (%)
0 x 0	0.70	1.606	12	7.2	79
1 x 1	0.55	1.448	8	7.1	70
2 x 2	0.40	1.142	3	6.9	42
3 x 1	0.30	0.900	2	6.8	16
3 x 4	0.30	0.904	2	6.8	15

Shorted C- Shaped MSA

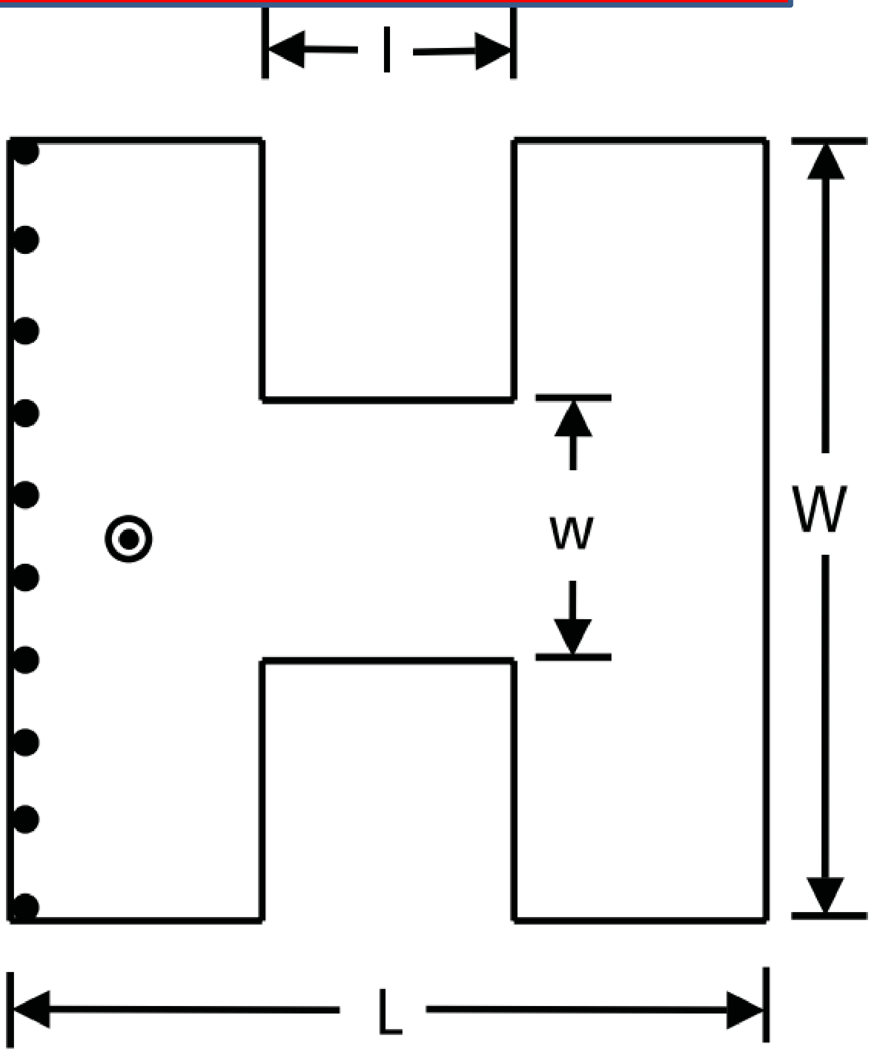


Resonance frequency of the C-shaped MSA is reduced by approximately half, when edge is fully shorted

H-Shaped MSA

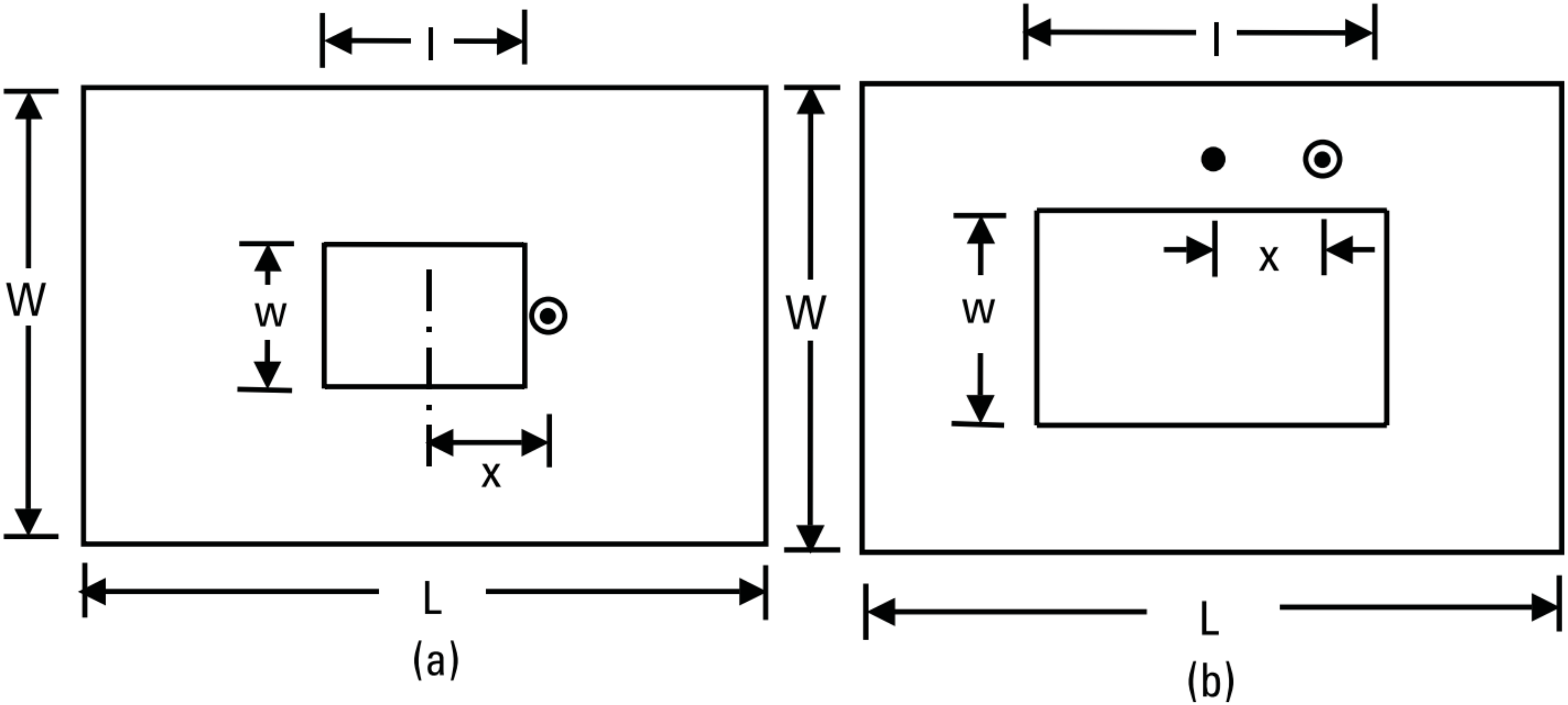


H-shaped MSA



Shorted H-shaped MSA

Rectangular Ring MSA (RRMSA)



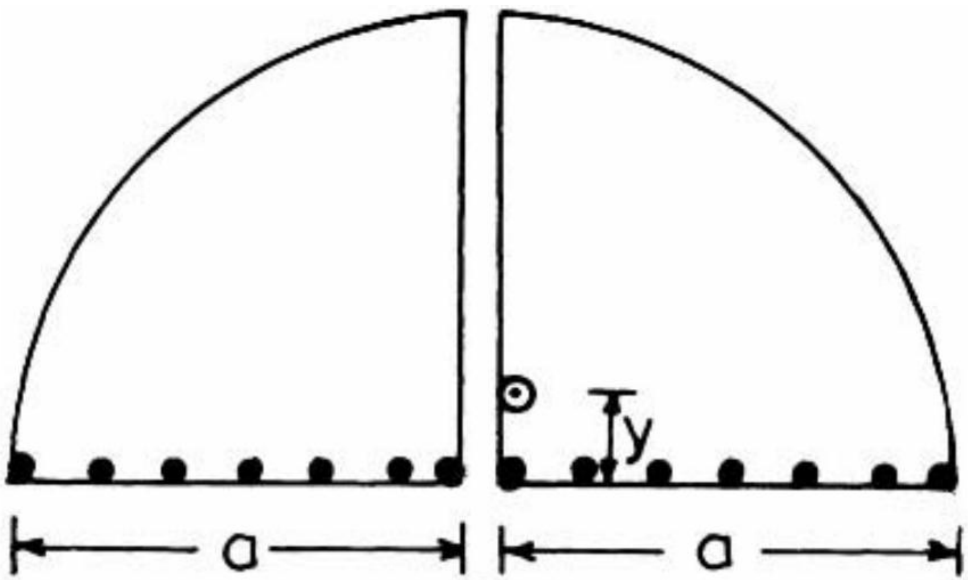
(a) RRMSA and (b) RRMSA with short.

Comparison of Various MSA Configurations with and without Slot

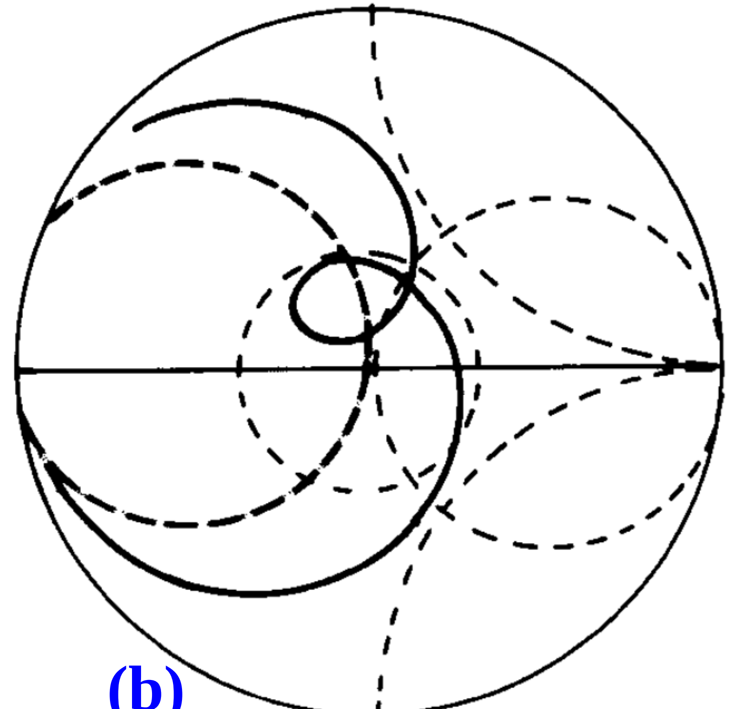
Comparison of Various MSA Configurations with and Without Slot
(L = 6 cm, W = 4 cm, ϵ_r = 2.33, h = 0.159 cm, and tan δ = 0.002)

Type of MSA	**Slot Dimensions $w \times l$ (cm)**	**f_0 (GHz)**	**BW (MHz)**	**D (dB)**	**η (%)**
Rectangular	0×0	1.606	12	7.2	79
C-shaped	3×1	0.900	2	6.8	16
H-shaped	1.5×1	1.061	2	6.9	32
Rectangular Ring	1.8×1.7	1.378	6	7.1	64

Broadband Gap Coupled Shorted 90°-Sectoral MSA



(a)

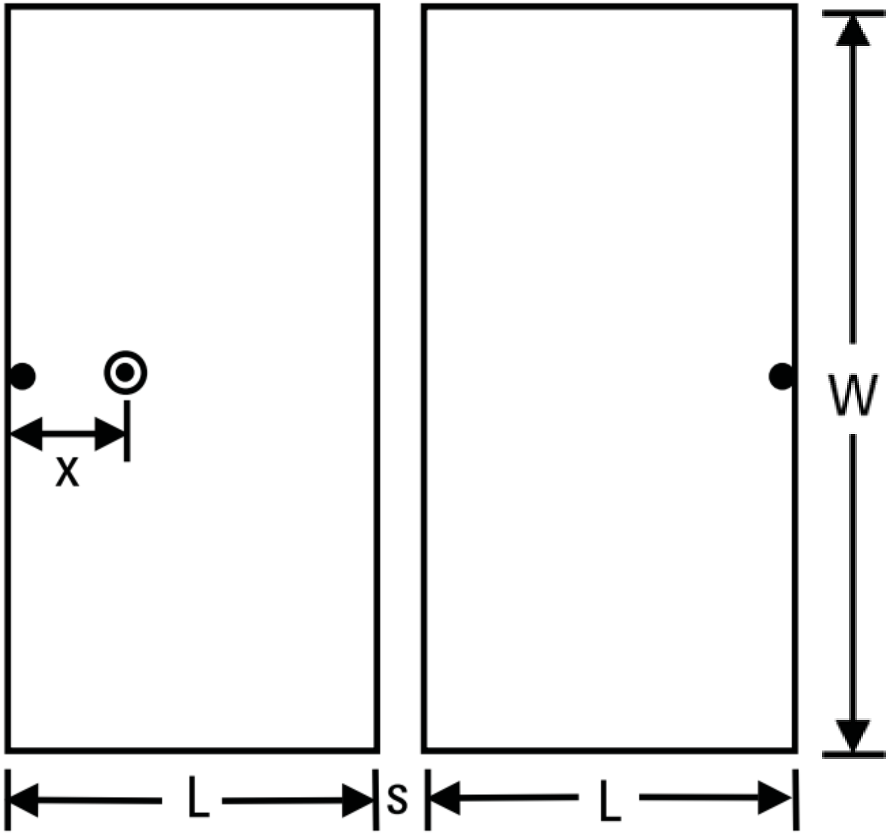


(b)

(a) Broadband gap-coupled shorted 90^0 sectoral MSA, and (b) Measured input impedance of (—) Gap-coupled shorted 90^0-sector, and (– – –) CMSA

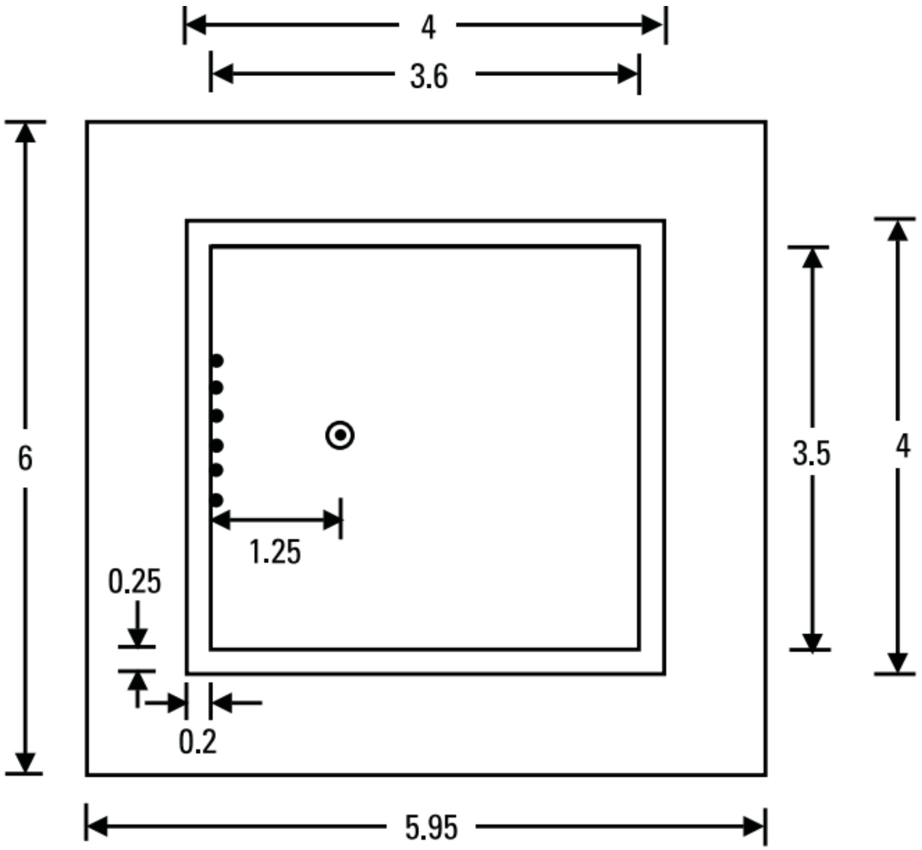
BW of gap-coupled shorted 90^0 sectoral MSA is 69 MHz at 1.358 GHz, whereas the BW of CMSA is 28 MHz at 1.375 GHz.

Broadband Gap Coupled Shorted RMSA

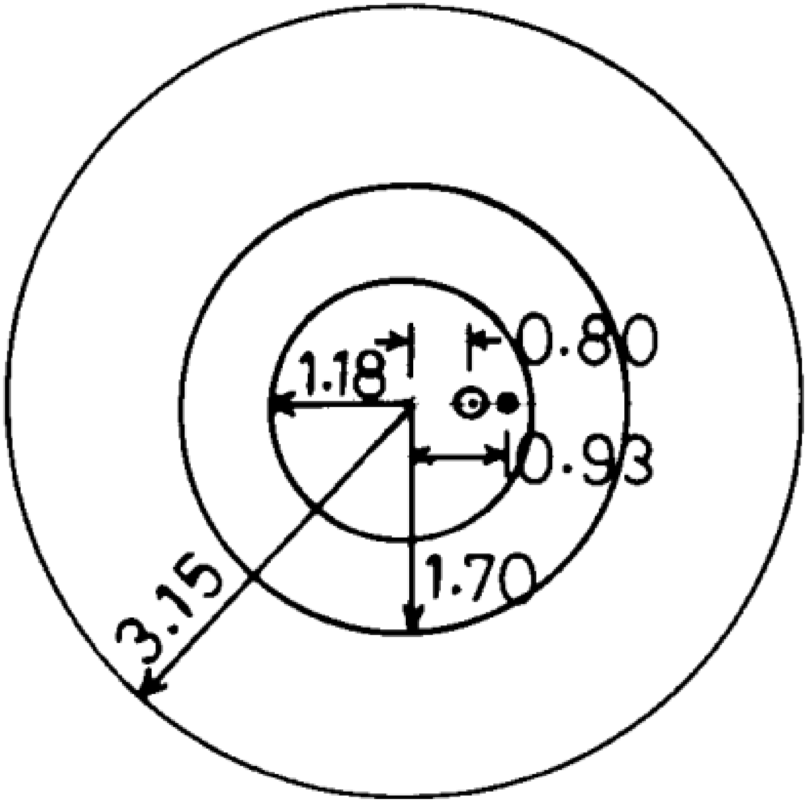


Radiating Edge Gap-Coupled Shorted RMSA

Ring Gap Coupled with Shorted MSA

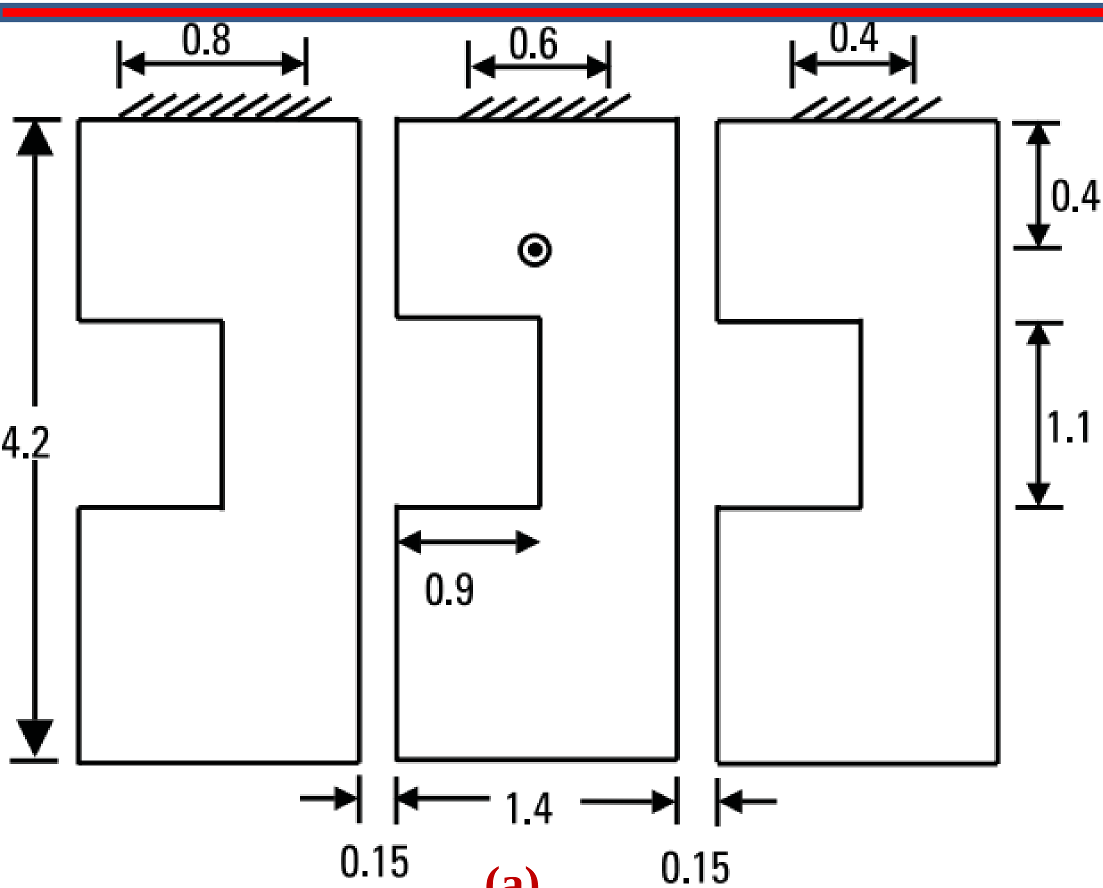


Rectangular Ring Gap-Coupled to a Shorted RMSA

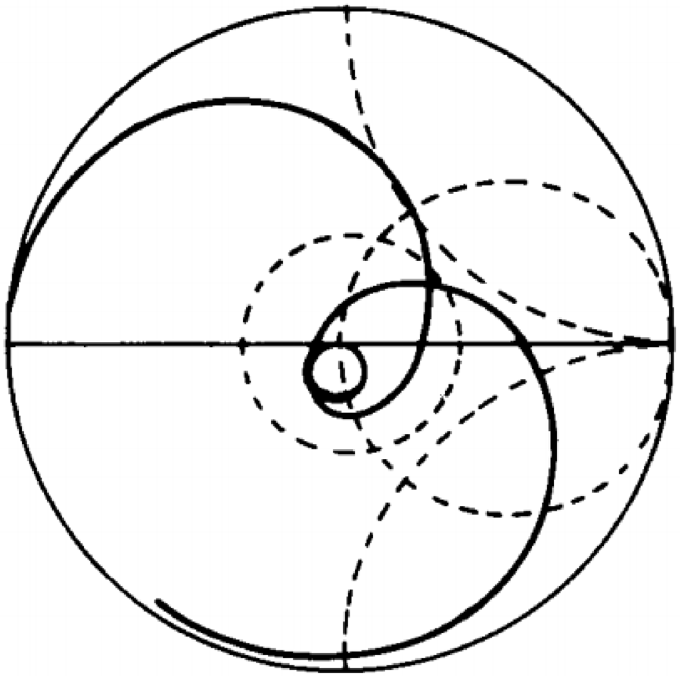


Circular Ring Containing a Shorted CMSA

Gap Coupled Shorted C-Shaped MSA



(a)



(b)

(a) Three gap-coupled shorted C-shaped MSA and its (b) input impedance