Broadband Microstrip Antennas

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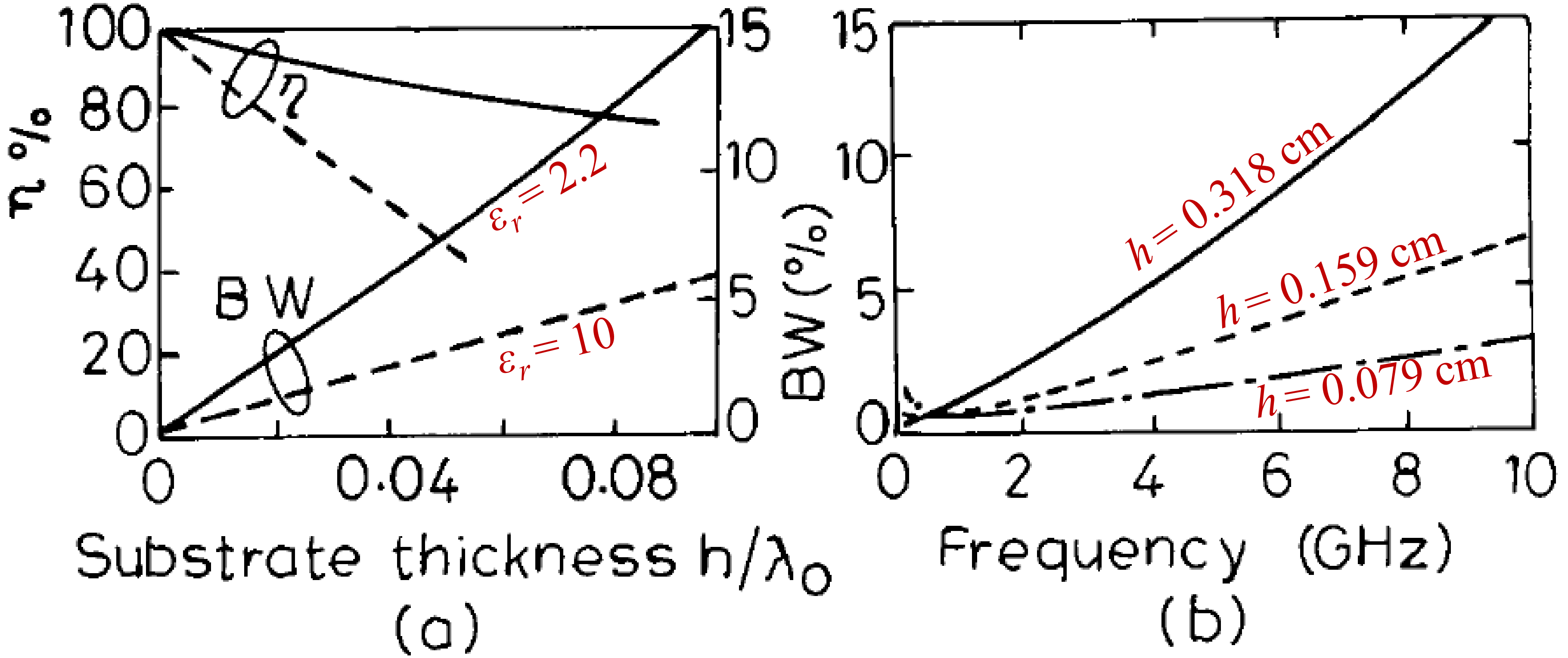
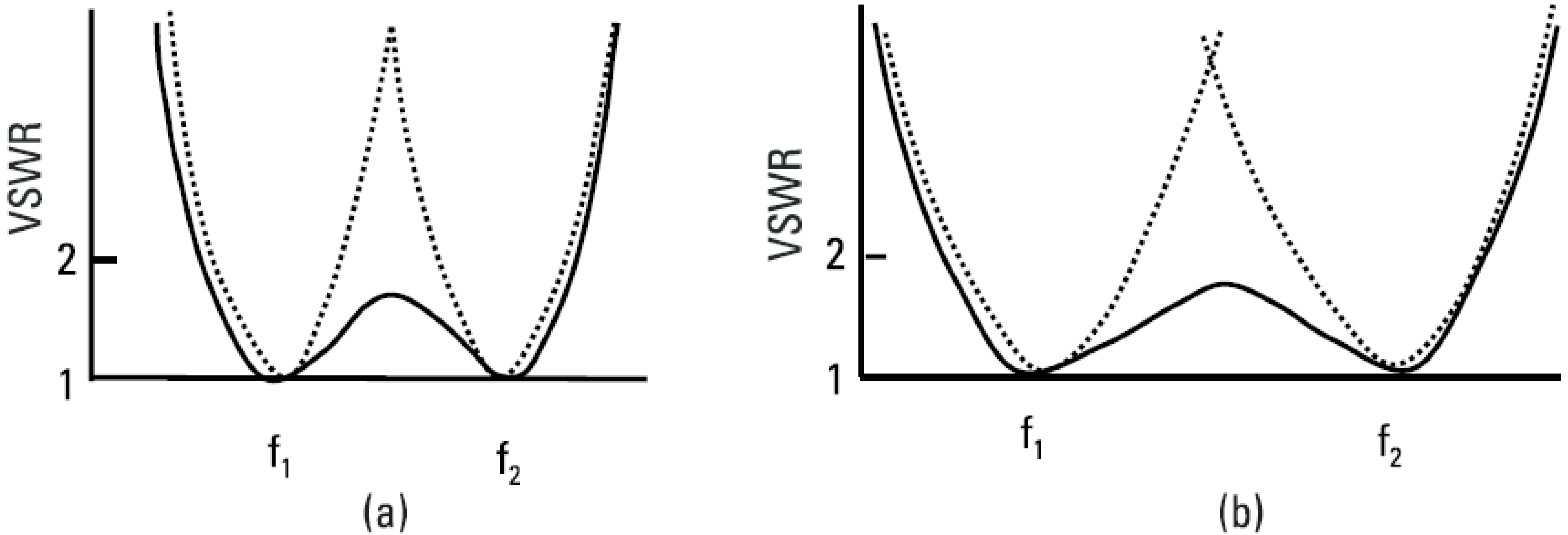
MSA – BW Variation with h and f



(a) Variation of percentage BW and efficiency of a square MSA versus h/λ_0. (——) ϵ_r = 2.2, (- - -) ϵ_r = 10 and (b) variation of percentage BW with frequency for three values of h and ϵ_r = 2.32: (——) 0.318, (- - -) 0.159, (– - –) 0.079 cm.

MSA – Broadband Using Multi-Resonators

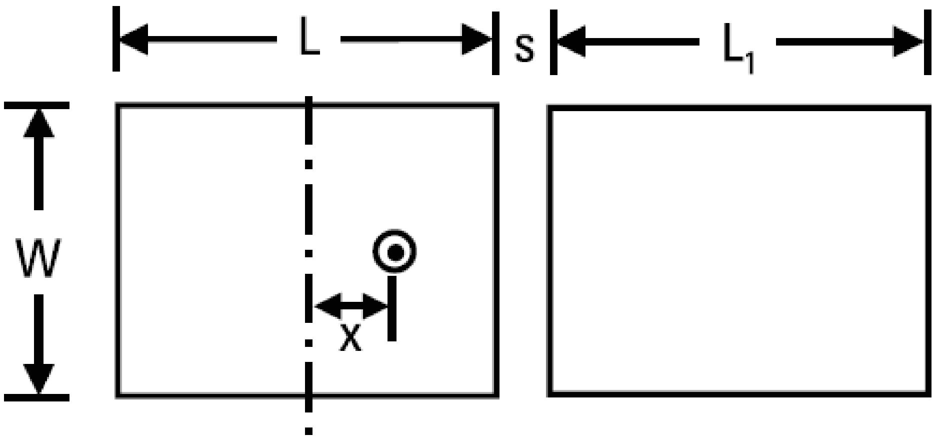


VSWR plots of two coupled resonators having (a) narrow and (b) wide BW: (· · ·) individual resonators and (——) overall response.

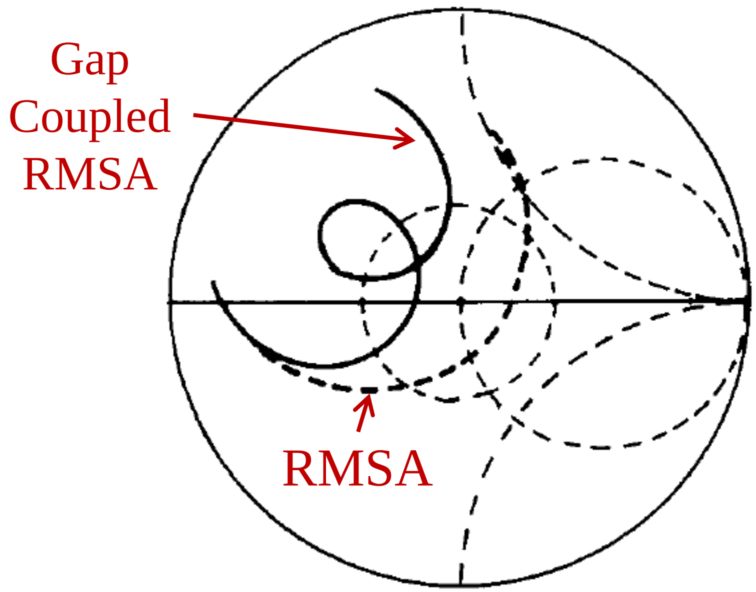
Broad bandwidth using multi-resonator concept.

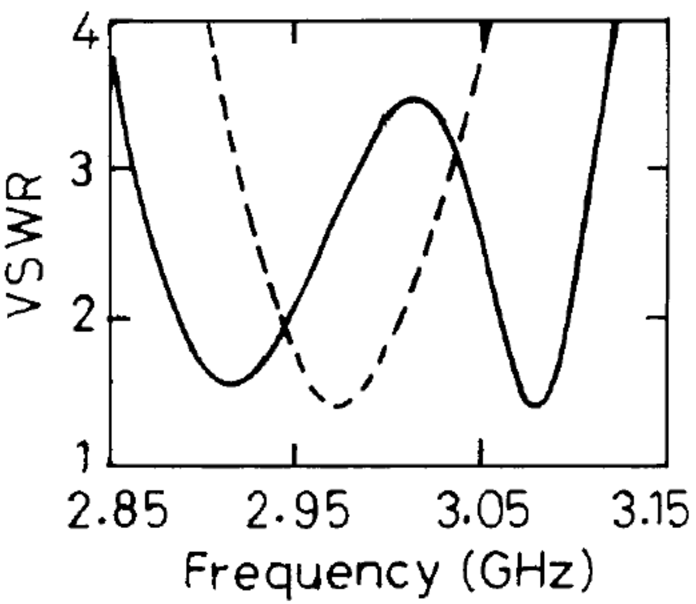
Two resonators are optimally coupled to obtain broad bandwidth

Two Gap Coupled RMSA

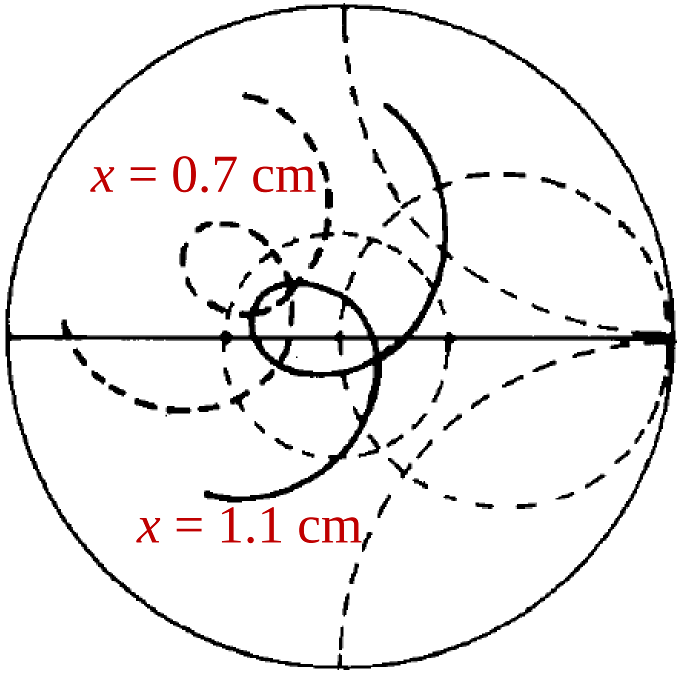


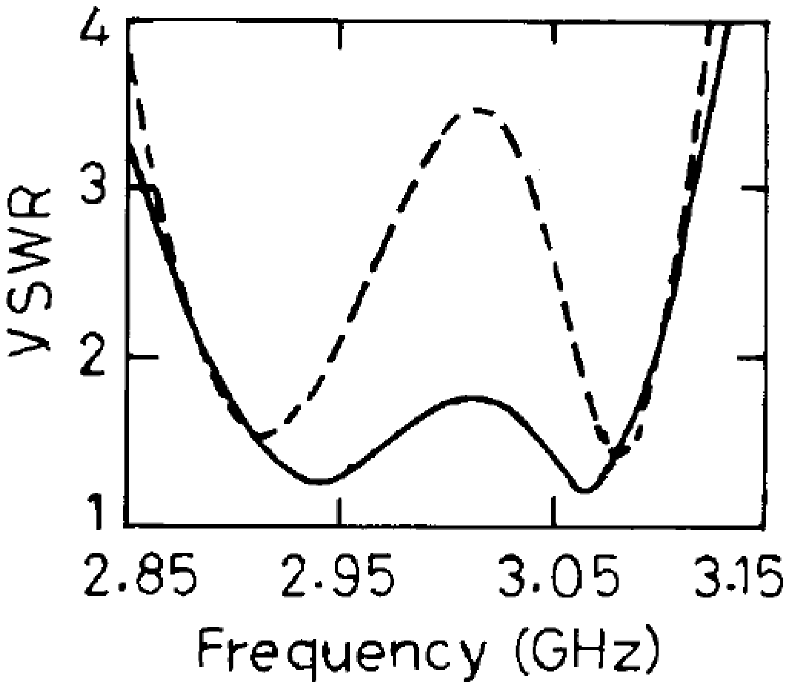
L = 3 cm and W = 4 cm,
ε_r = 2.55 and h = 0.159 cm,
L_1 = 2.9 cm, W = 4 cm,
s = 0.1 cm and x = 0.7 cm.





Effect of Feed-Point - Two Gap Coupled RMSA

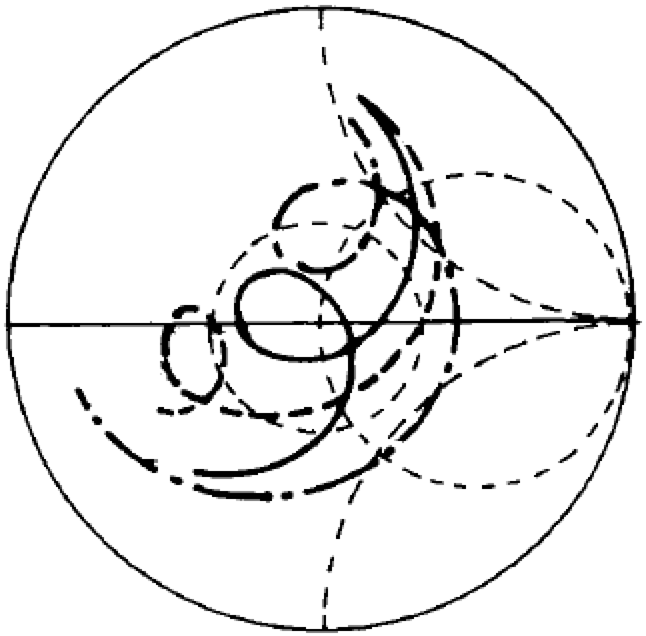


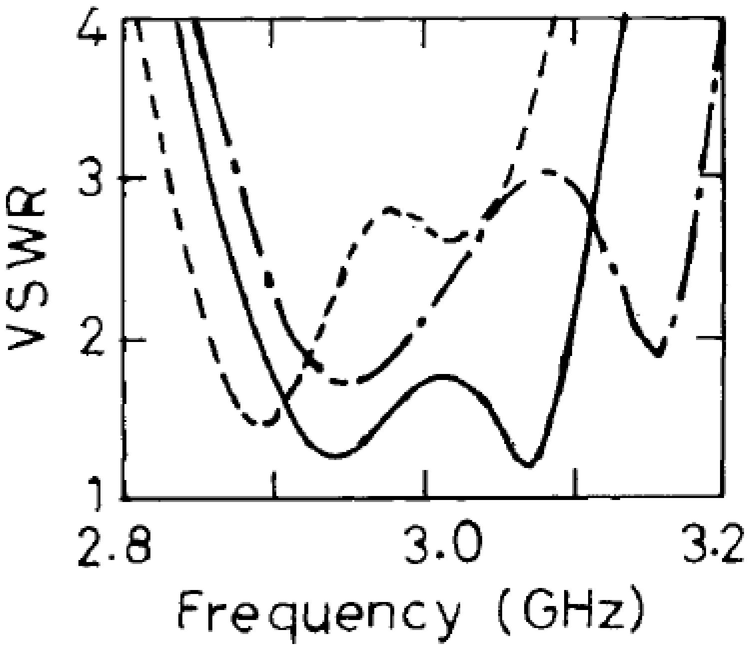


As x increases from 0.7 to 1.1 cm, input impedance plot shifts right and the loop is inside VSWR = 2 circle.

For x = 1.1 cm, BW for VSWR $\leq$ 2 is 207 MHz (~7%). This BW is more than three times the BW of a single RMSA.

Effect of Length L_1 - Two Gap Coupled RMSA

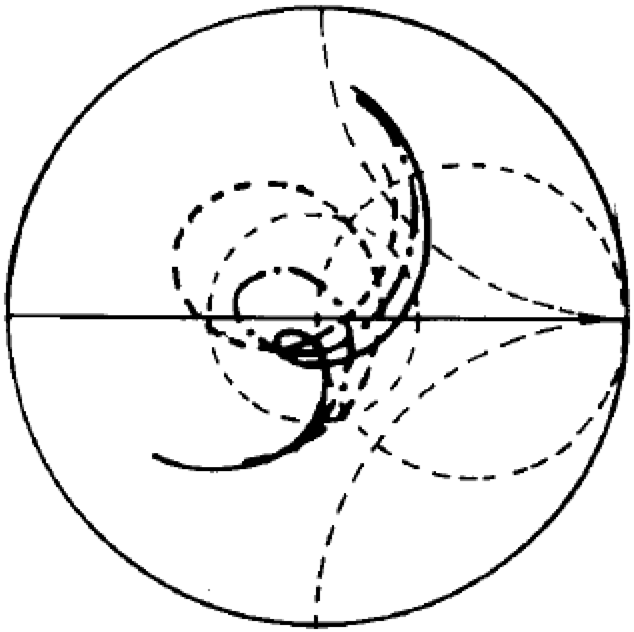


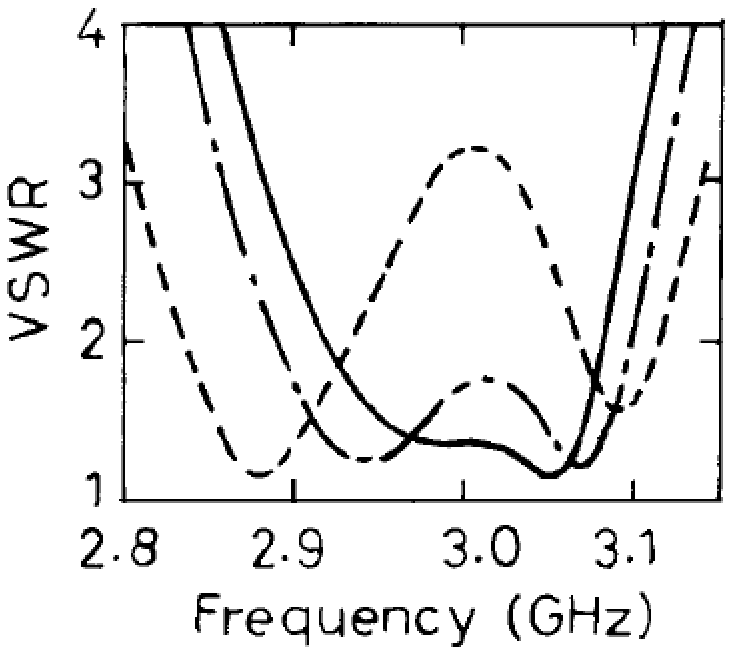


L $_1$: (- - -) 2.8, (——) 2.9, and (– - –) 3.0 cm

As L_1 decreases from 3.0 to 2.8 cm, its resonance frequency increases, so the loop in the input impedance plot shifts towards higher frequency region, i.e. in clockwise direction.

Effect of Gap *S* - Two Gap Coupled RMSA

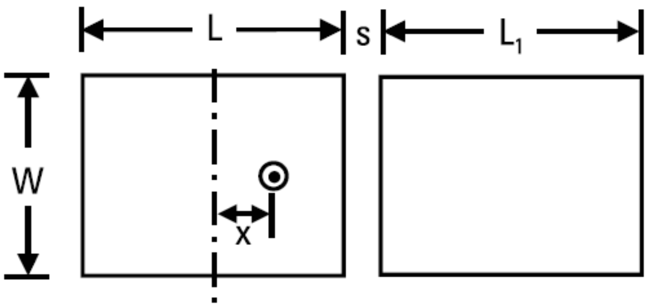


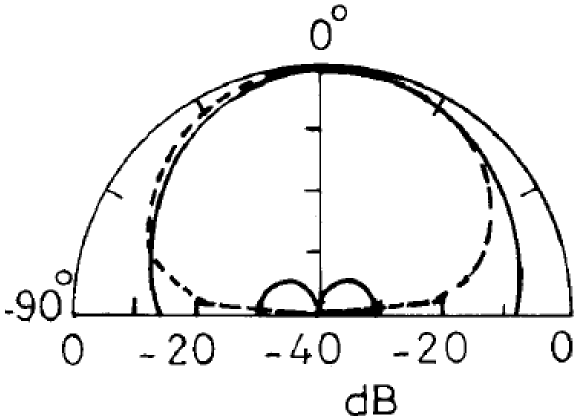


S: (- - -) 0.05, (– - –) 0.1, and (——) 0.15 cm.

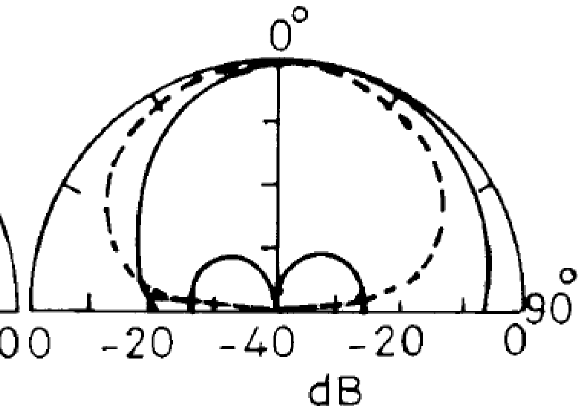
As gap *S* increases from 0.05 to 0.15 cm, the coupling between the two patches is reduced and hence size of the loop in the input impedance plot reduces.

Radiation Pattern of Two Gap Coupled RMSA





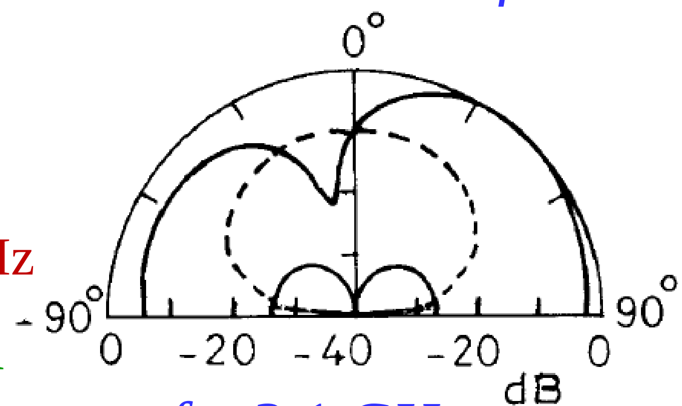
f = 2.9 GHz



f = 3.0 GHz

L = 3 cm and W = 4 cm,
ε_r = 2.55 and h = 0.159 cm,
L_1 = 2.9 cm, W = 4 cm,
s = 0.1 cm and x = 1.1 cm.

BW for VSWR $\leq$ 2 is 2.895 to 3.102 GHz

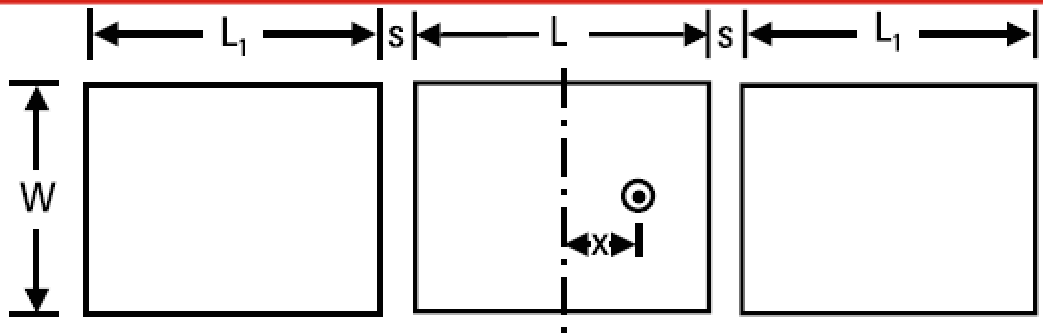


f = 3.1 GHz

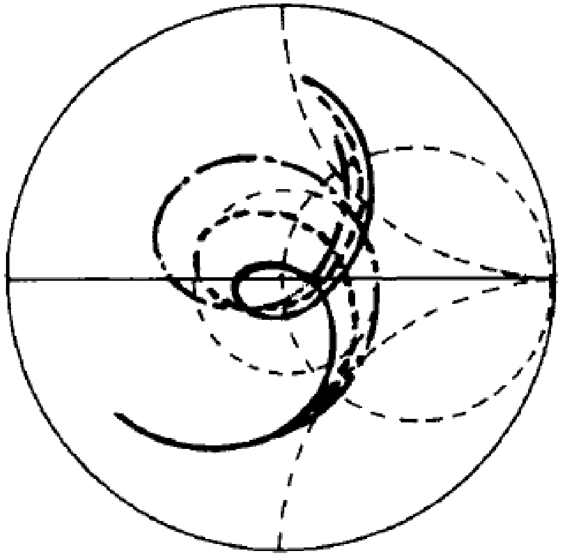
In the E-plane, the beam maxima shifts away from the broadside as frequency increases from 2.9 to 3.1 GHz.

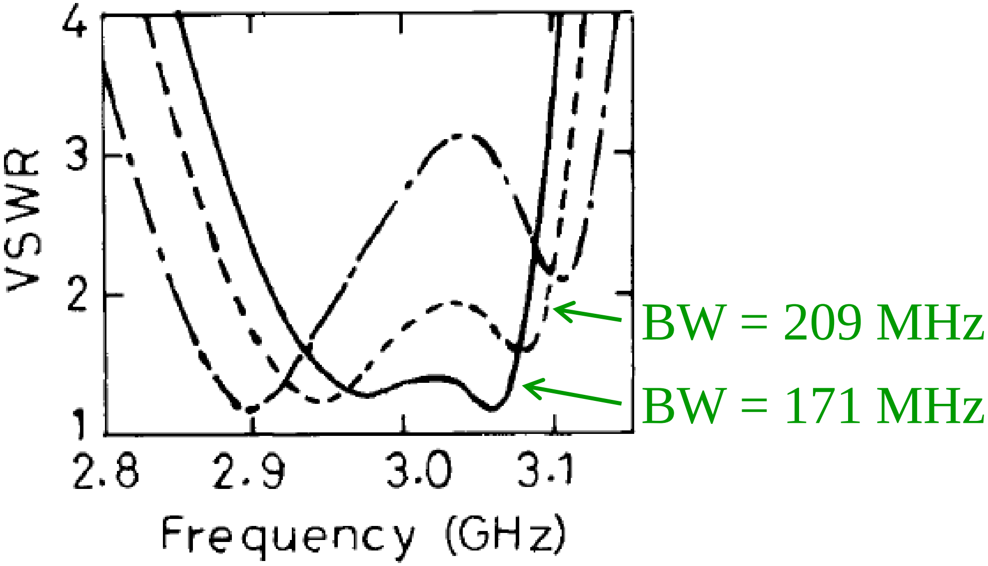
Radiation Pattern:
(——) E-plane and (- - -) H-plane

Three Gap Coupled RMSA – Effect of Gap *S*



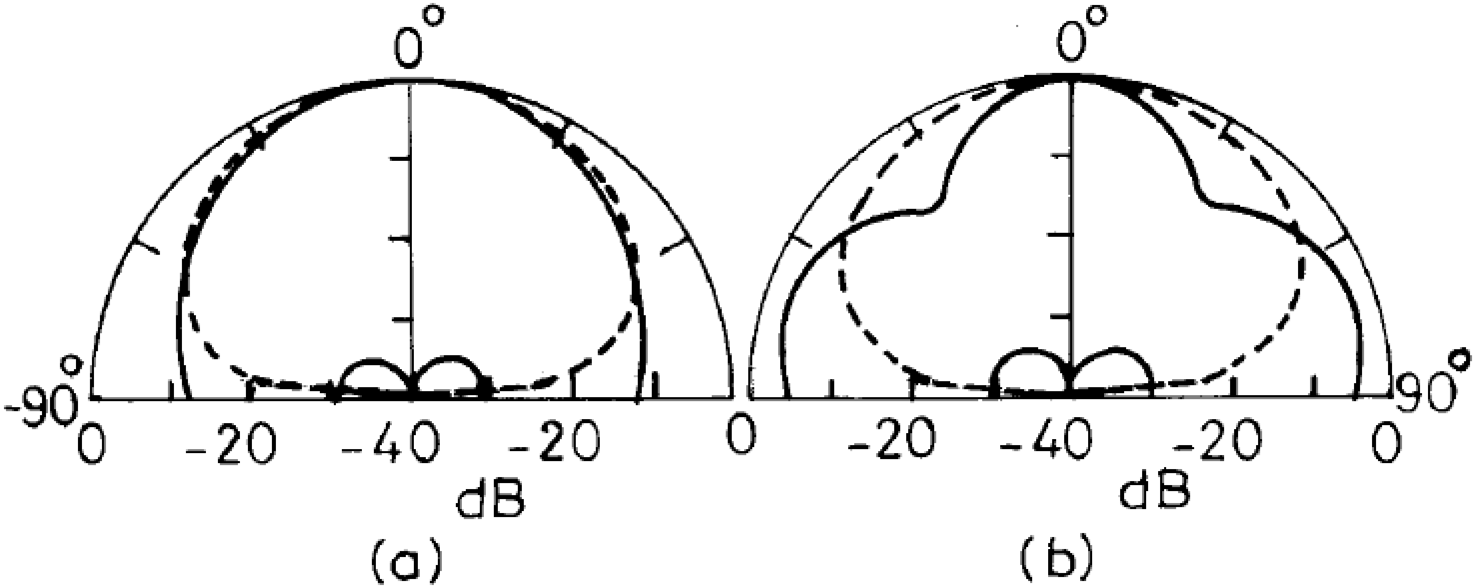
L = 3 cm, *W* = 4 cm, ε_r = 2.55 and *h* = 0.159 cm,
L_1 = 2.9 cm, *W* = 4 cm, and *x* = 1.1 cm.





S : (– - –) 0.1, (- - -) 0.15, and (——) 0.2 cm

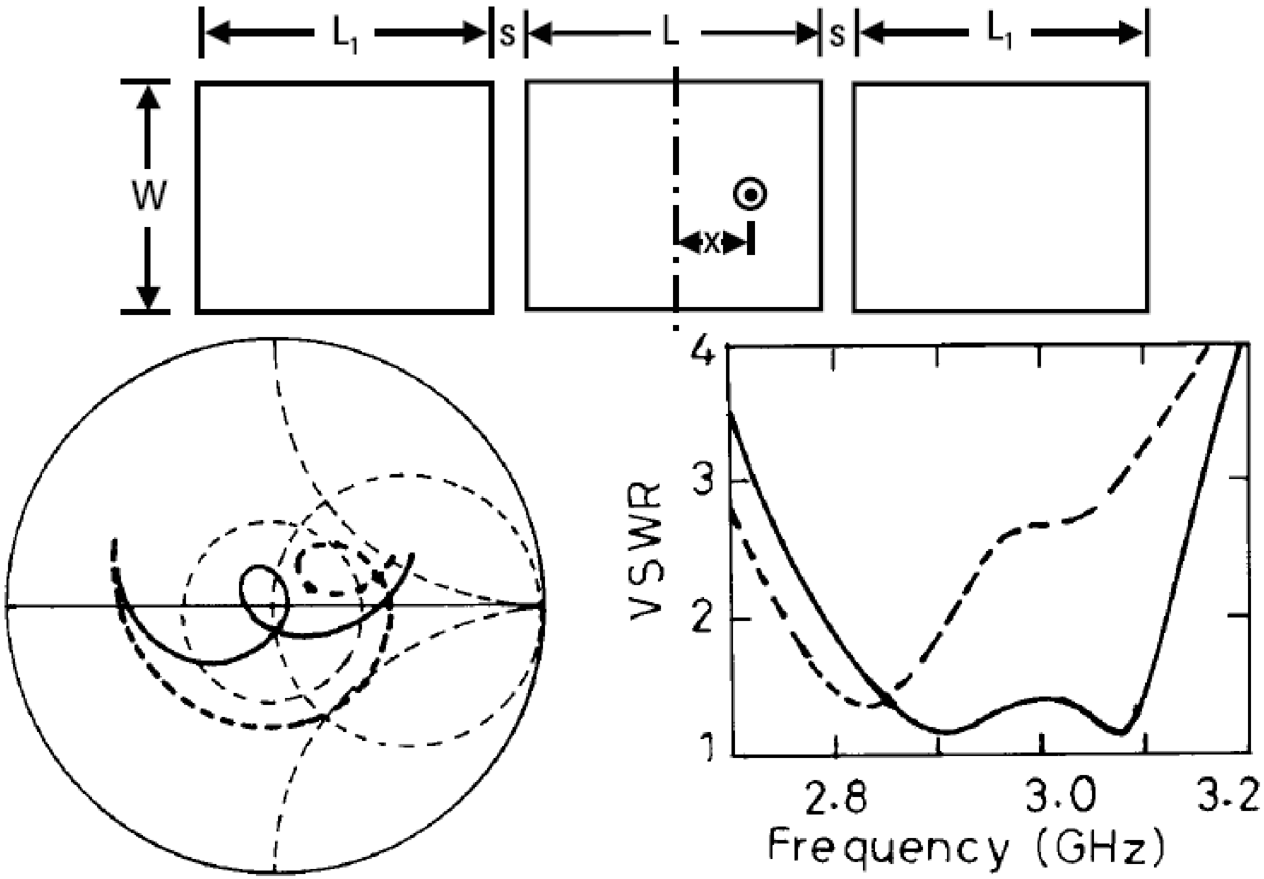
Radiation Pattern of Three Gap Coupled RMSA



For S = 0.15 cm, Radiation pattern at
(a) 2.89 and (b) 3.09 GHz
(——) E-plane and (- - -) H-plane.

Gain of Three Gap Coupled RMSA is 9.4 dB at 3 GHz, which is 2.7 dB more than the single RMSA.

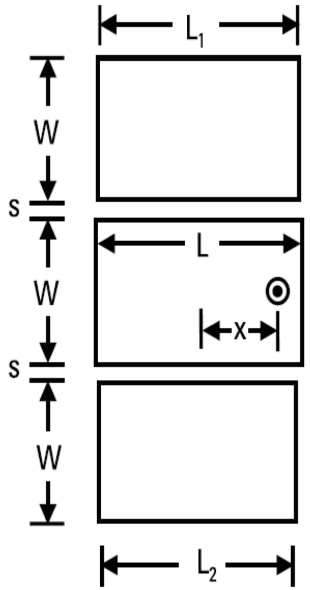
Three Gap Coupled RMSA – Effect of Length L_1



h = 3.18 mm, ε_r = 2.55, L = W = 30 mm, x = 14 mm, s = *3mm*, two values of L_1 (- - -) 29 mm and (——) 27.5 mm

For L_1 = 27.5 mm, the loop is completely inside VSWR = 2 circle yielding BW of 335 MHz (11.3%)

Non-Radiating Edge Gap Coupled RMSA



h: (——) 0.159 cm

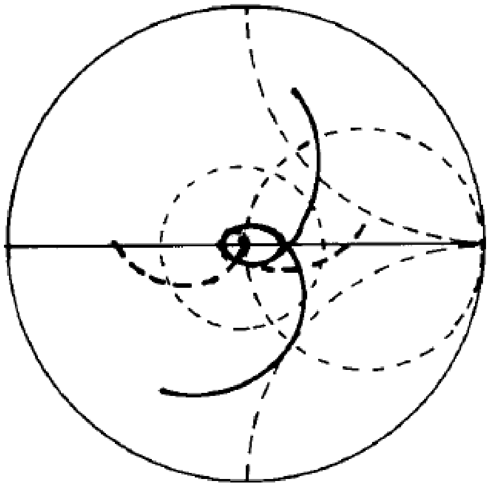
L = 3 cm, W = 4 cm, ε_r = 2.55 s = 0.05 cm,

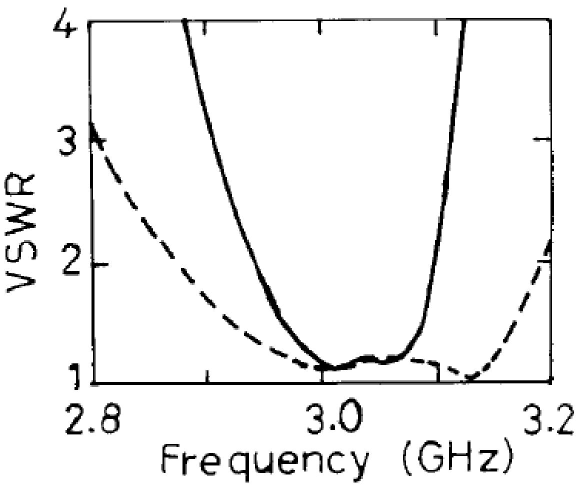
$L_1 = L_2$ = 2.9 cm, W = 4 cm, and x = 1.1 cm.

h: (- - -) 0.318 cm

L = 3 cm, W = 3 cm, ε_r = 2.55 s = 0.05 cm,

$L_1 = L_2$ = 2.7 cm, W = 3 cm, and x = 1.4 cm.





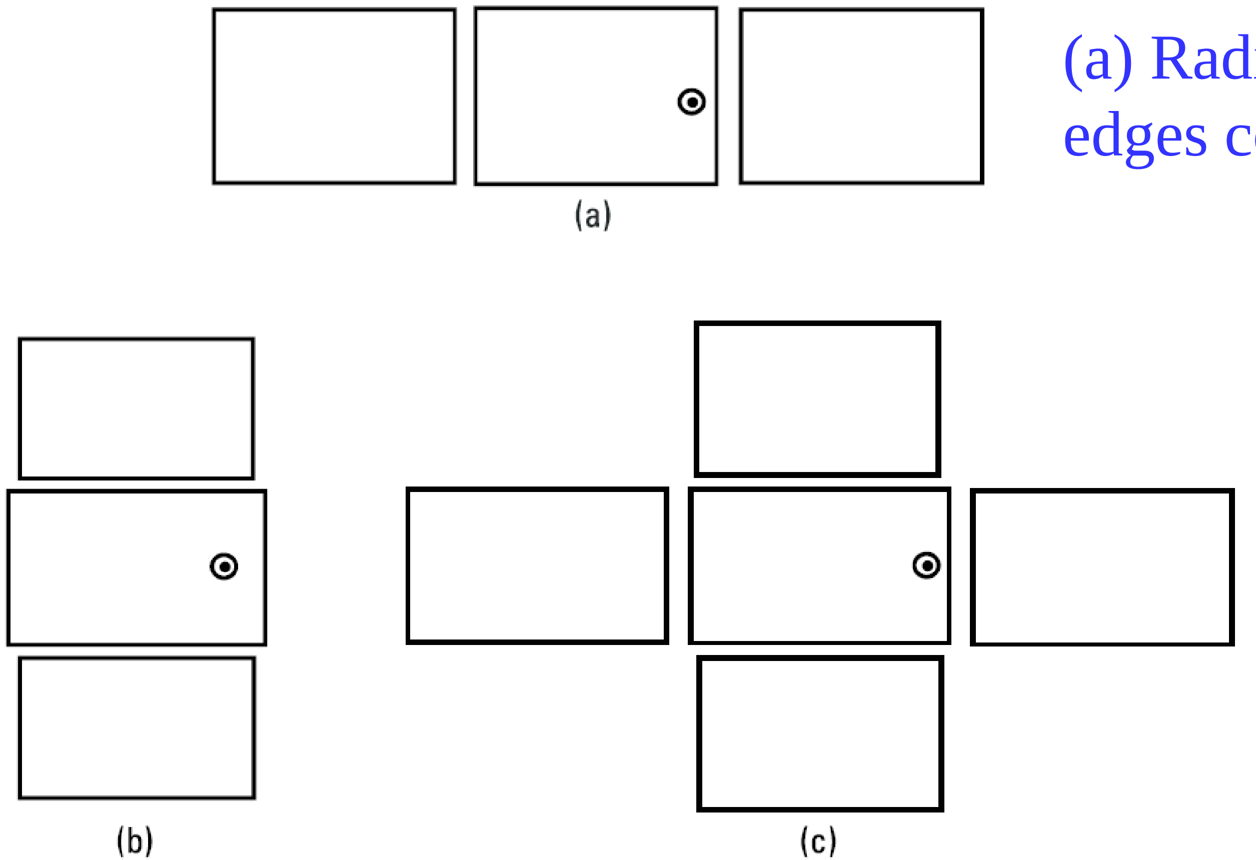
h: (——) 0.159 cm

BW = 159 MHz (5.3%)

h: (- - -) 0.318 cm

BW = 390 MHz (12.7%)

Gap Coupled RMSA Configurations

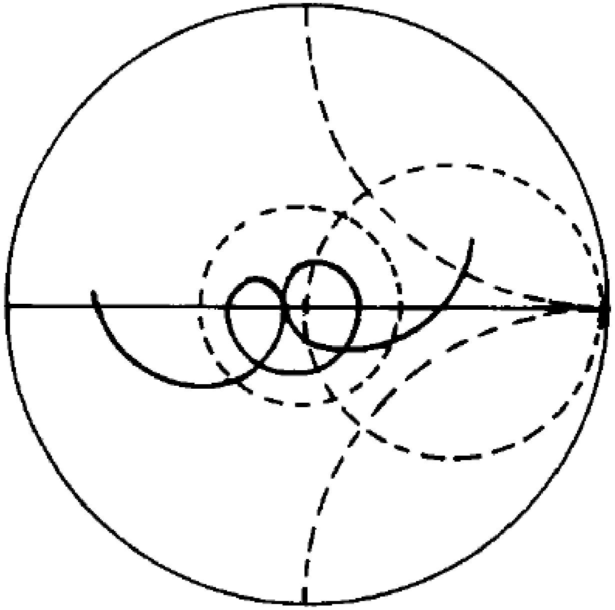


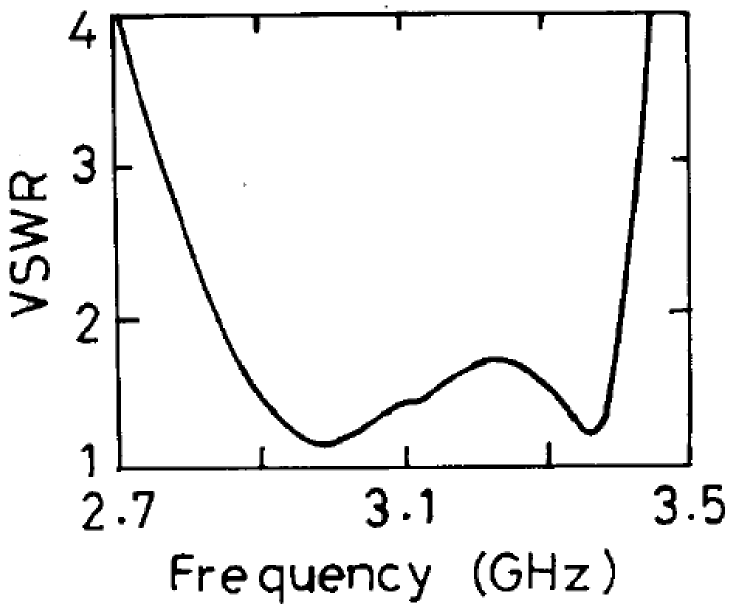
(a) Radiating edges coupled

(b) Non-radiating edges coupled

(c) Four edges coupled

Four Edges Gap Coupled RMSA





ε_r = 2.55, h = 3.18 mm, L = W = 30 mm,

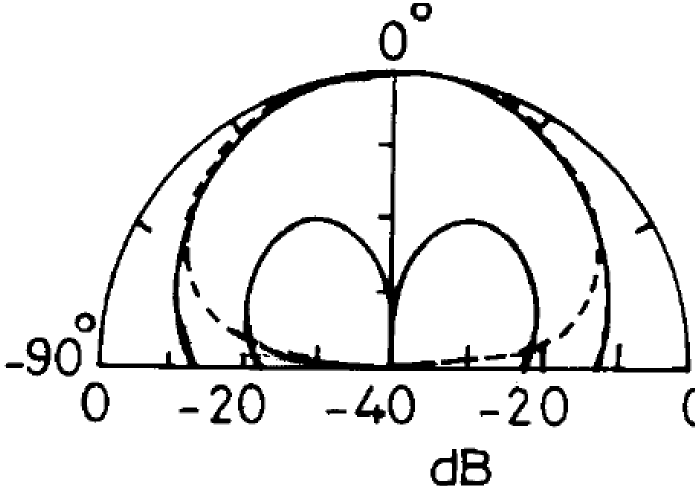
L_1 = 27.5 mm, s_1 = 2.5 mm,

L_2 = 25.5 mm, s_2 = 0.5 mm, x = 14 mm

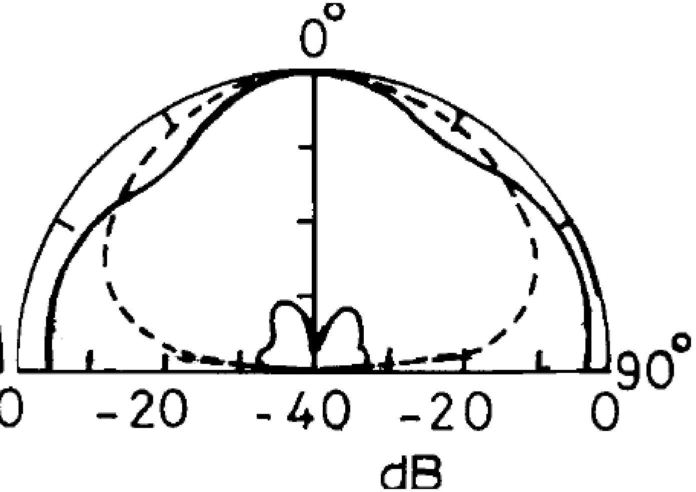
Two loops in Smith chart within VSWR = 2 circle.

BW for VSWR $\leq$ 2 is 569 MHz (18%)

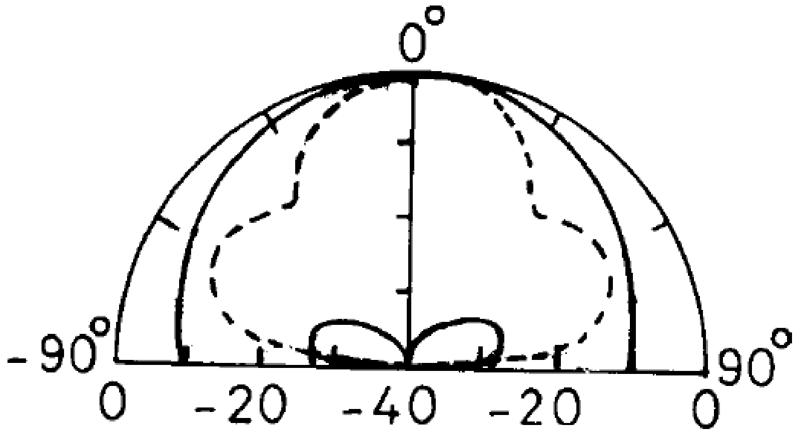
Four Edges Coupled MSA–Radiation Pattern



2.84 GHz

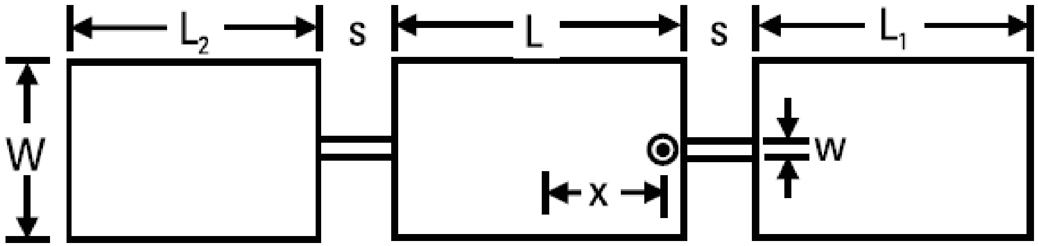


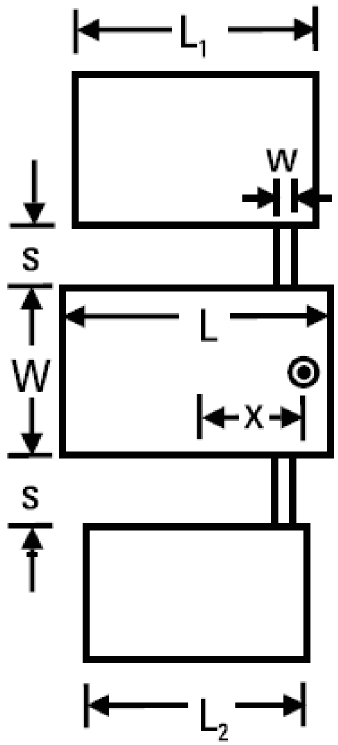
3.12 GHz

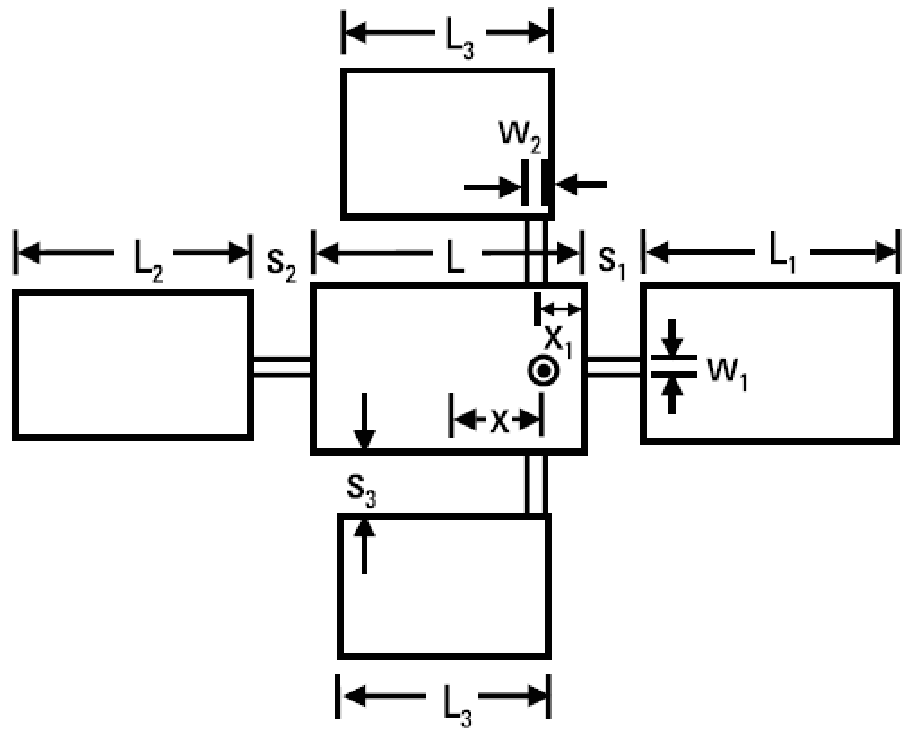


3.40 GHz

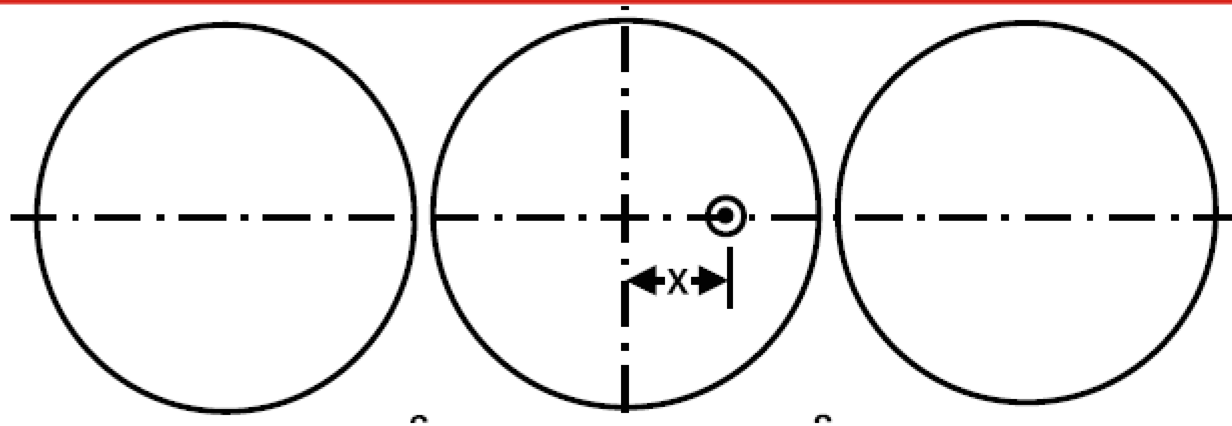
Directly Coupled RMSA

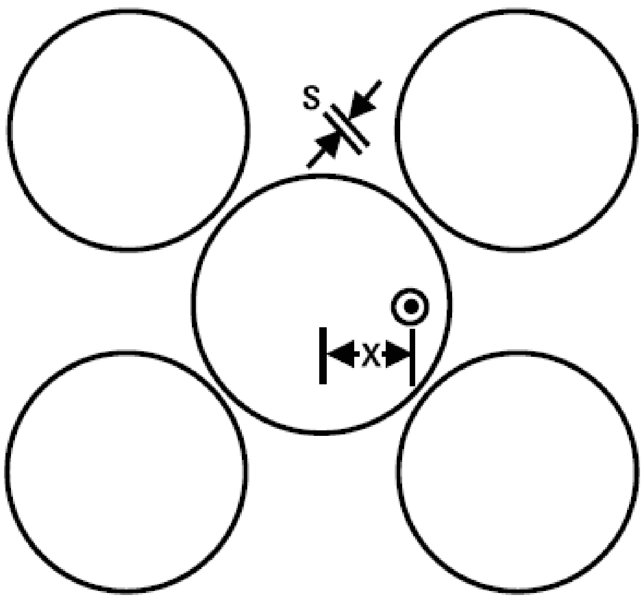


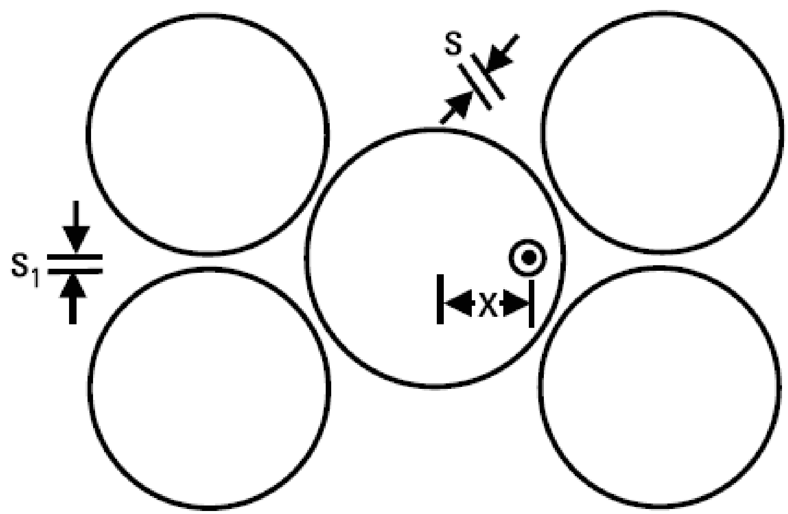




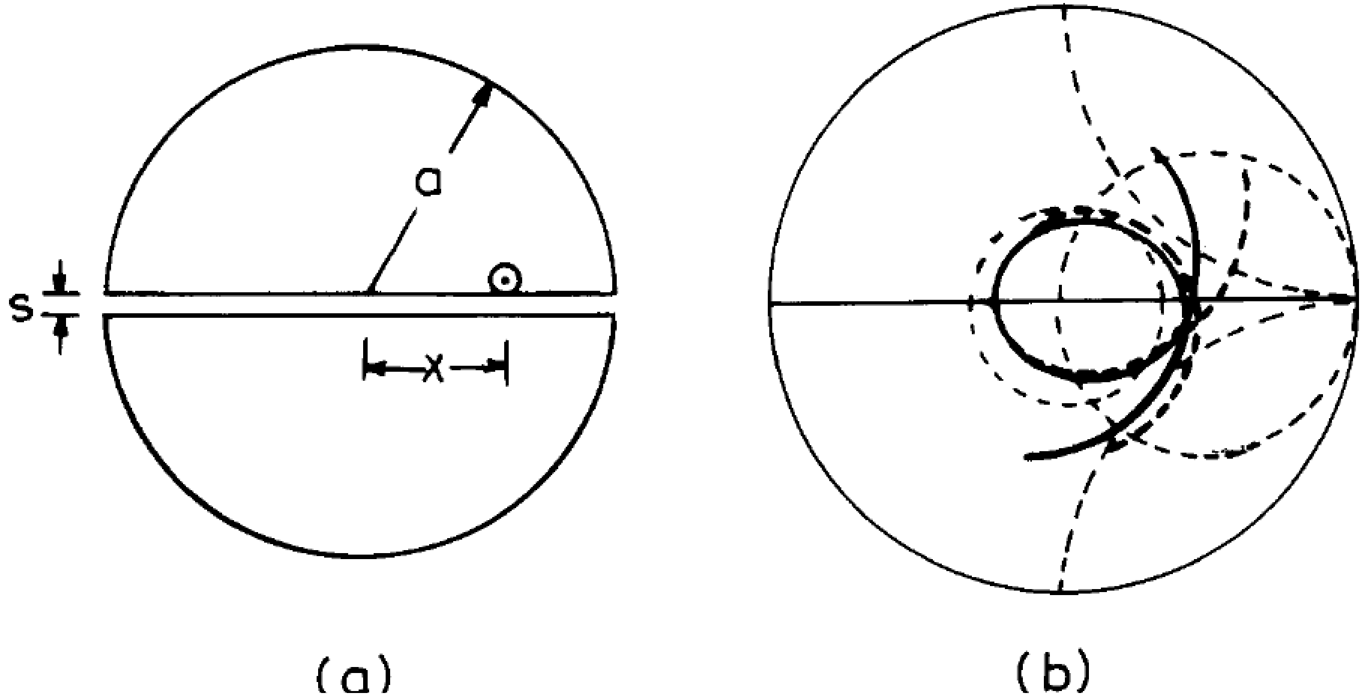
Gap Coupled Circular MSA







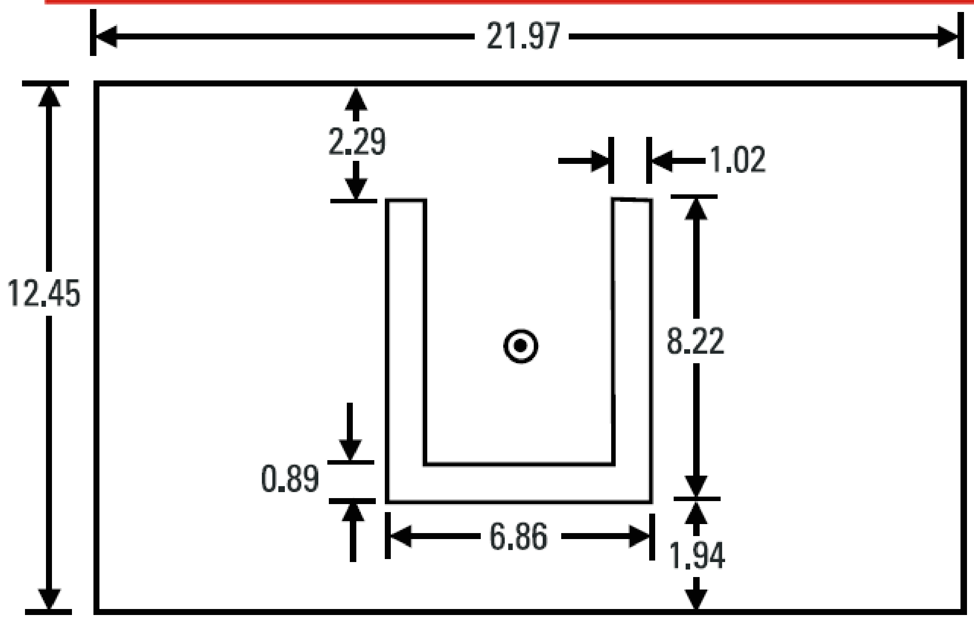
Gap Coupled Semi-Circular MSA

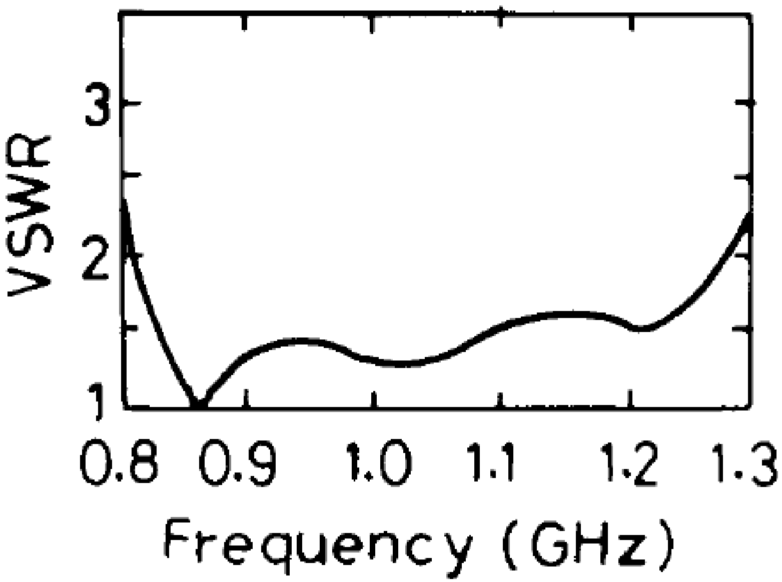


(a) Two gap-coupled SCMSA and (b) its input impedance plot: (- - -) theoretical and (——) measured.

BW for VSWR $\leq$ 2 is 143 MHz at 2.72 GHz, which is more than twice the BW of CMSA on same substrate but gain is not uniform over the bandwidth.

RMSA with U-Slot



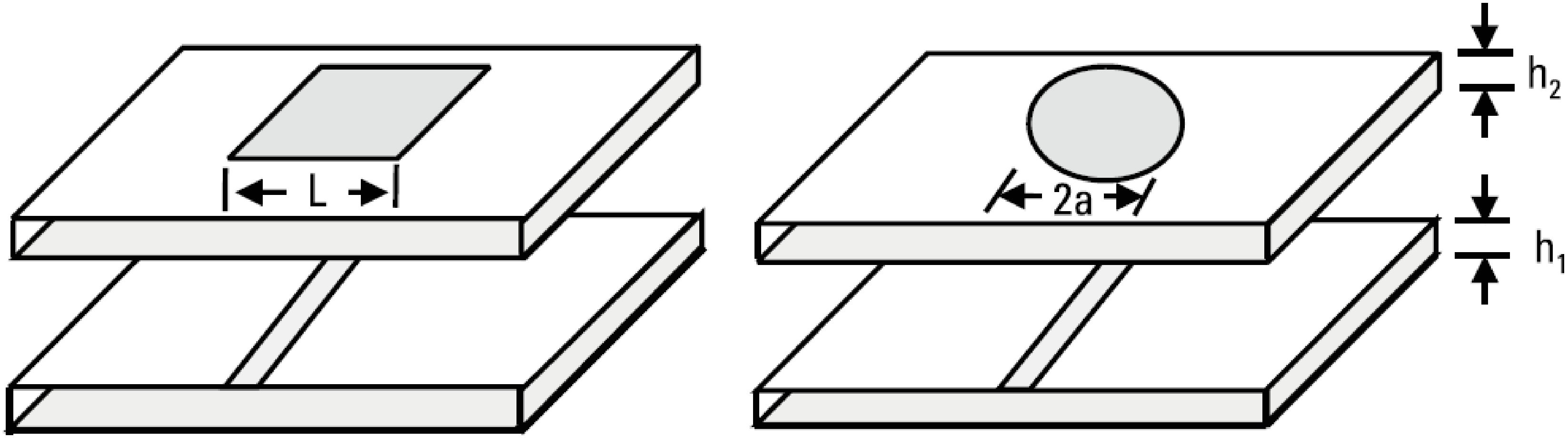


By cutting a U-slot inside a RMSA, BW is increased without increasing the volume of the antenna.

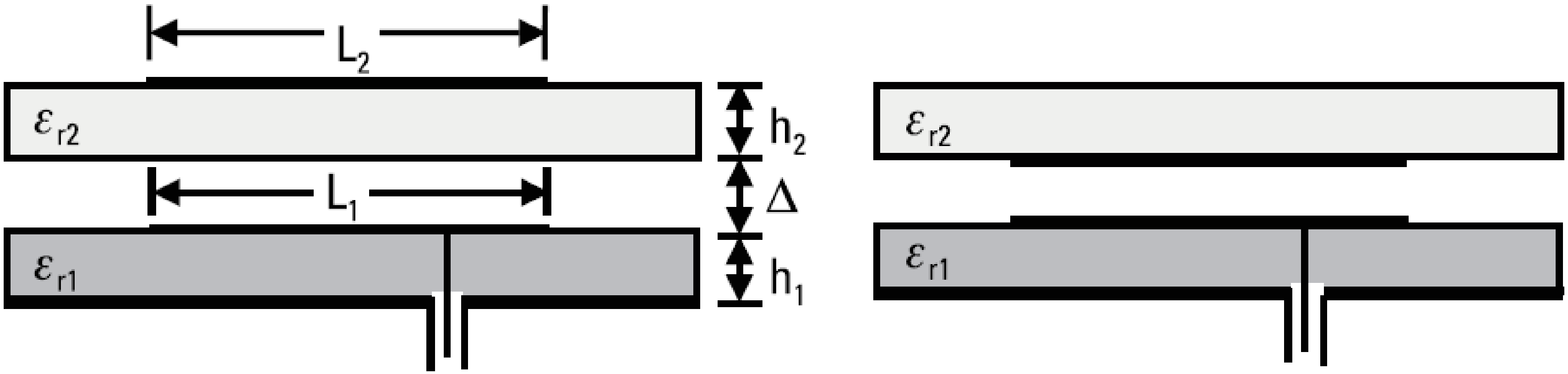
Resonance of U-slot should be close to that of RMSA

Disadvantage – gain is not uniform over the bandwidth

Electromagnetically Coupled MSA (ECMSA)

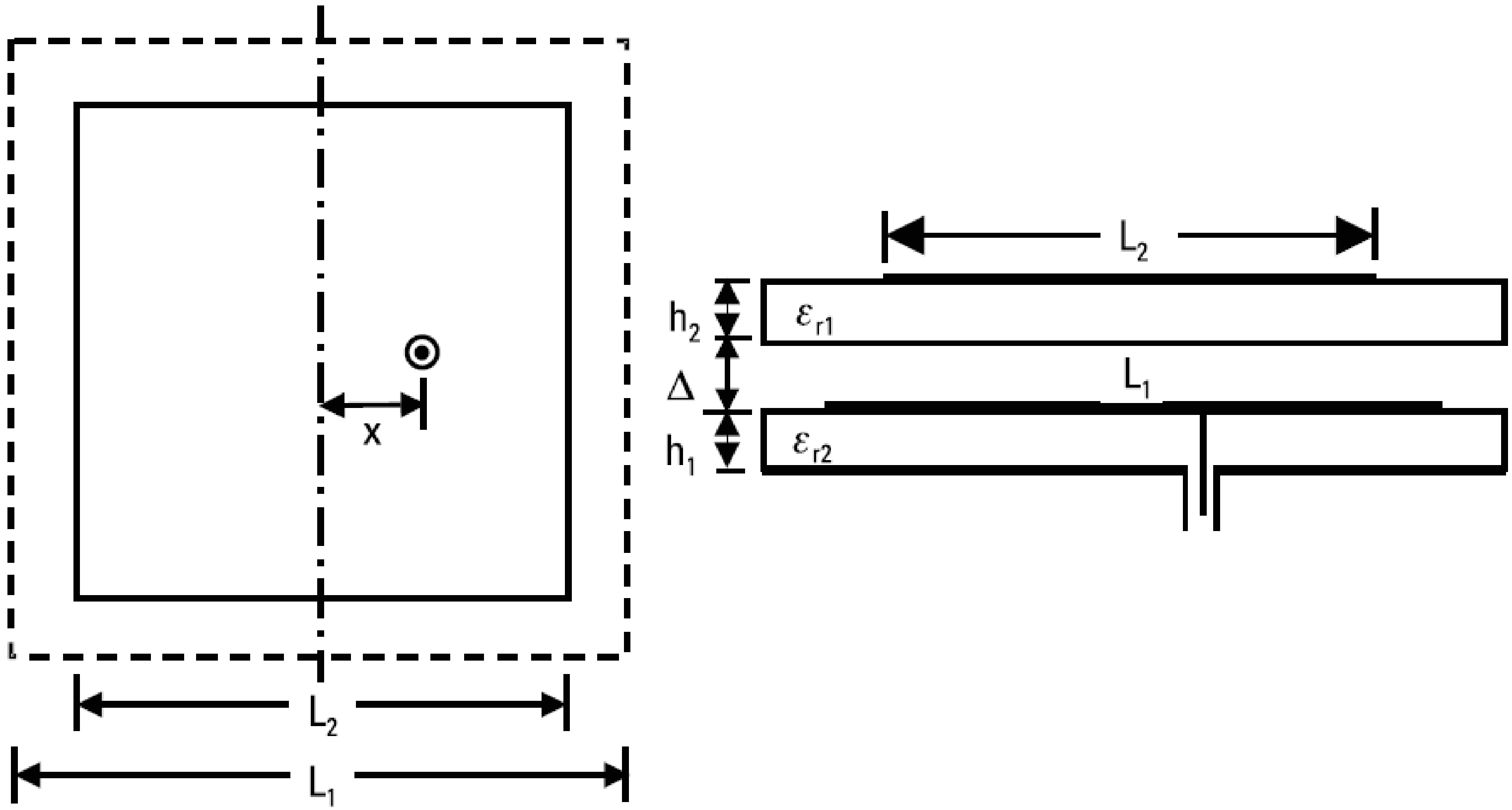


Microstrip line fed MSA (Rectangular and Circular MSA)



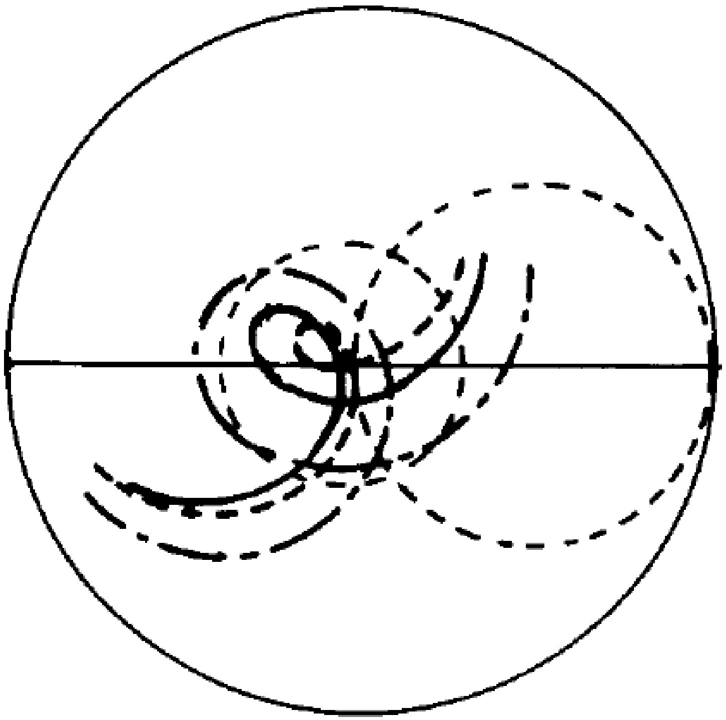
Two MSA are stacked. Only bottom patch is fed

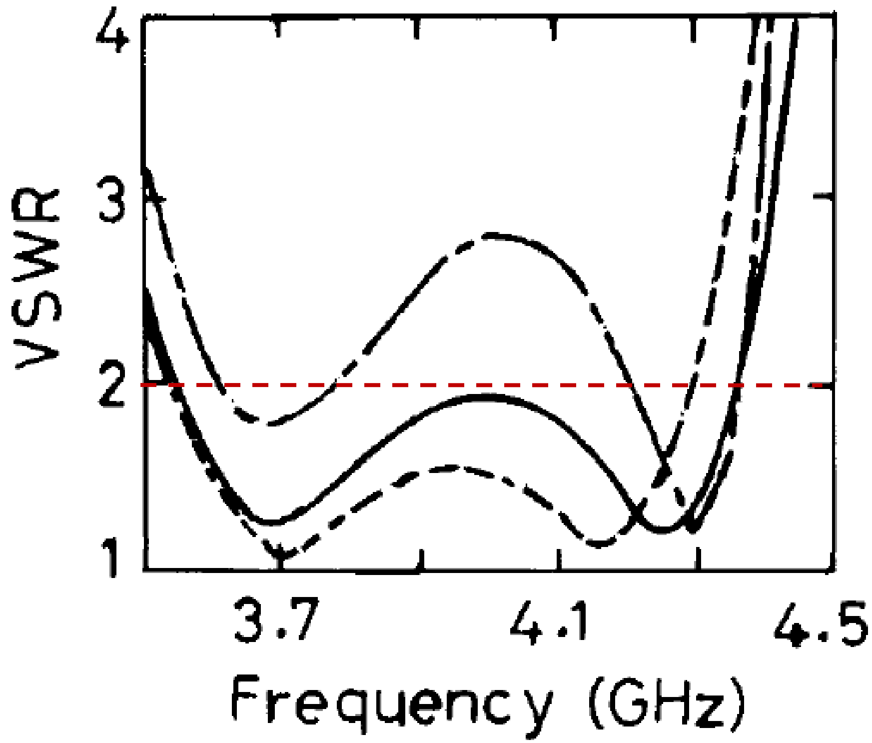
Electromagnetically Coupled RMSA



Resonance frequency of the top patch should be slightly more than the bottom patch. Gap between the substrates control the coupling between the patches.

Electromagnetically Coupled RMSA - Results



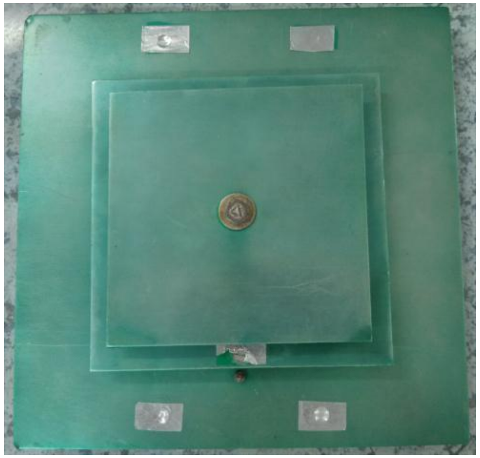


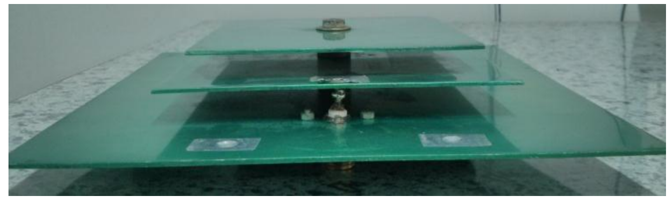
L_1 = 2.5 cm, L_2 = 2.5 cm, x = 1.1 cm, ε_r = 2.22, h = 0.159 cm

Gap Δ: (– - - –) 0.1 cm, (——) 0.3 cm, and (- - -) 0.4 cm

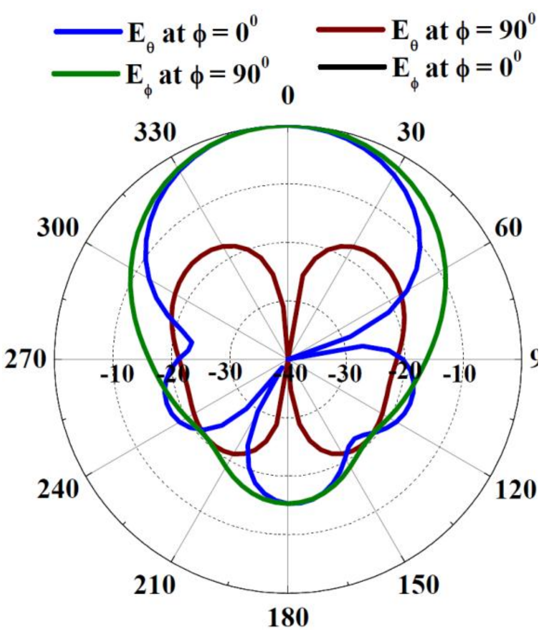
BW for VSWR $\leq$ 2 is 816 MHz (20.6%) for gap = 0.3 cm and gain is 8.3 dB at 3.95 GHz.

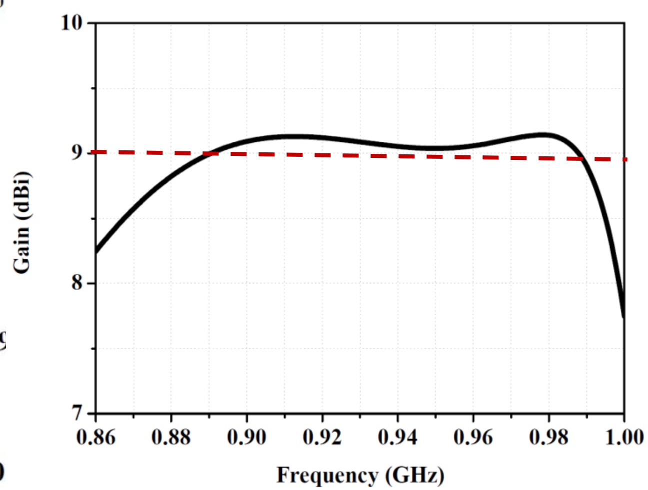
Electromagnetically Coupled SMSA for GSM 900





L_1 = 15.2cm, L_2 = 12.8cm, Δ_1 = 1.1cm, Δ_2 = 1.3cm, x = 6.5cm, and L_g = 24cm

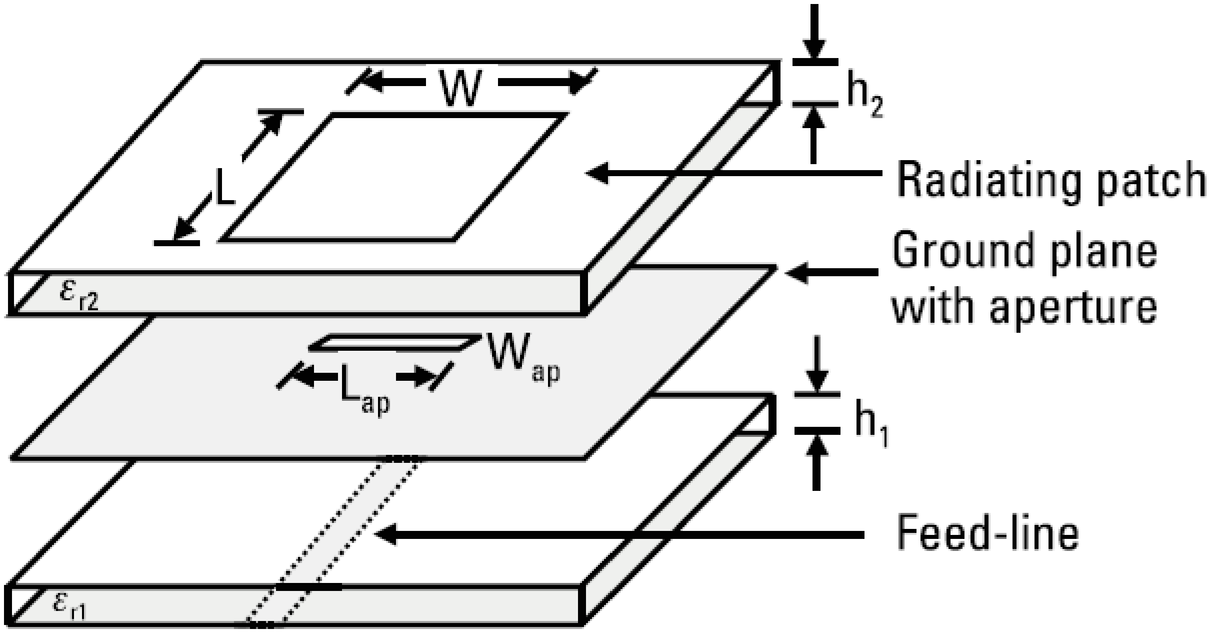




Gain $\simeq$ 9dB

Measured BW for VSWR $\leq$ 2 is from 872 to 1000 MHz

Aperture Coupled MSA

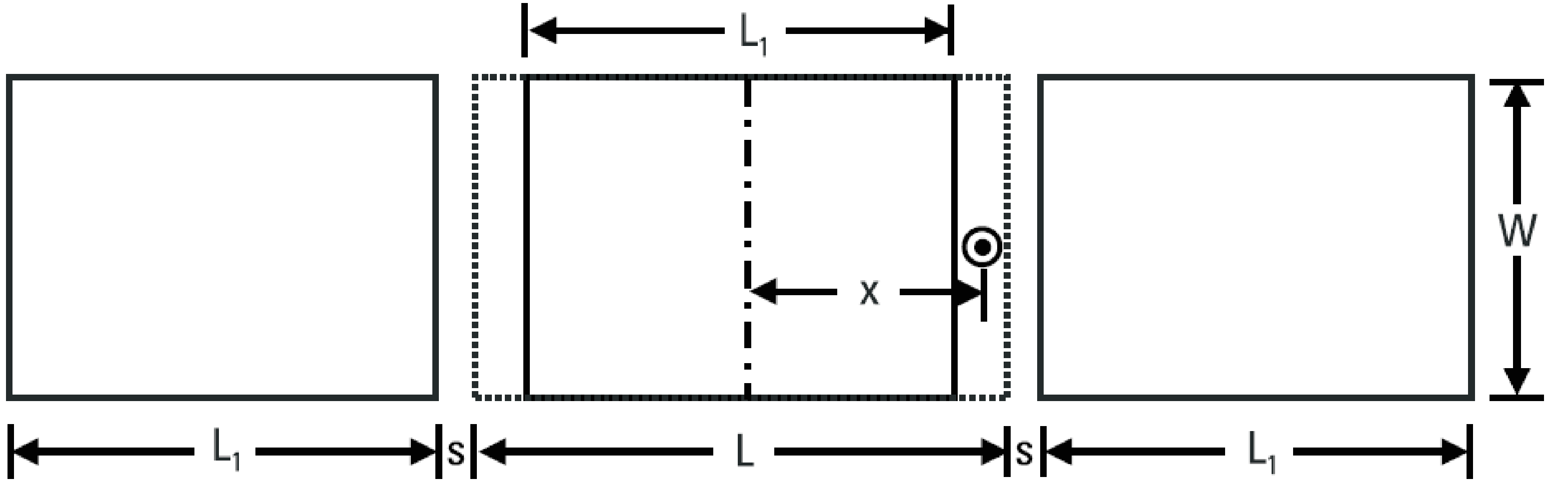


Aperture shape: rectangular, H shape, dog-bone, hour-glass

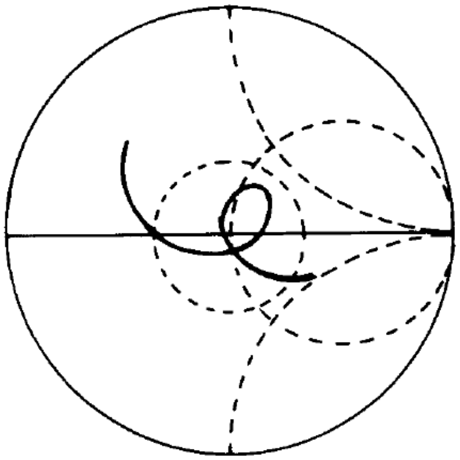
Advantages: Large BW, design flexibility

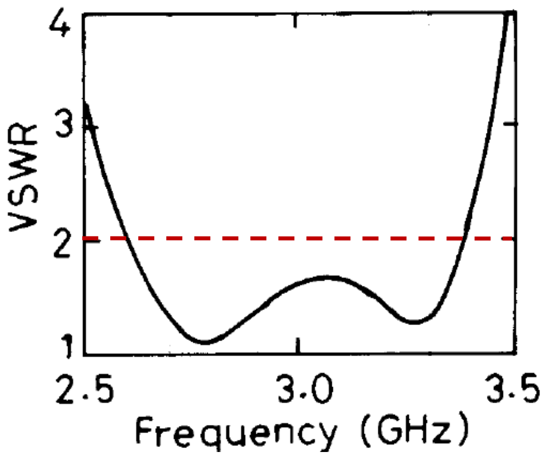
Disadvantages: Back radiation, multi-layer substrates, alignment

Stacked Planar MSA – 1B3T



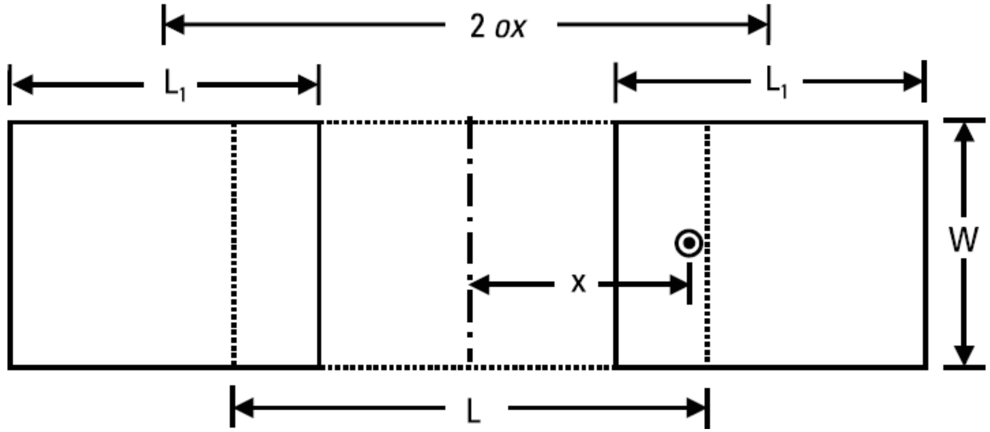
L= 4.0 cm, L_1 = 3.6 cm, *s* = 0.25 cm, *x* = 1.4 cm, ε_r = 2.22, *h* = 0.159 cm, and h_1 = 0.4 cm





BW for VSWR $\leq$ 2 is 782 MHz (26.1%) and gain is more than 10 dB

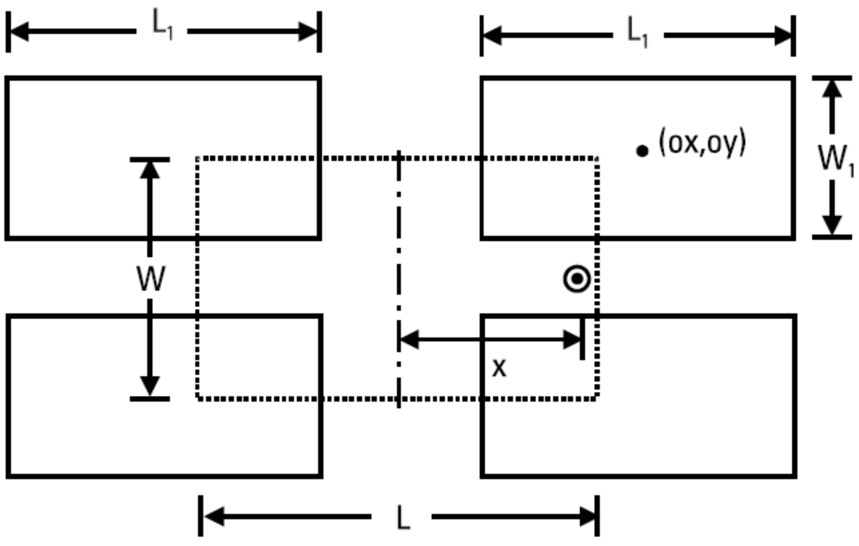
Stacked Planar MSA – 1B2T



Variation of BW and Gain of 1B2T RMSA with h_1
(L = 5 cm, W = 3 cm, x = 2.4 cm, and h = 0.5 cm)

h_1 (cm)	L_1 (cm)	ox (cm)	BW (MHz)	Gain (dB)
0.4	3.8	4.7	650	11.3
0.5	3.7	4.5	789	11.3
0.6	3.6	4.4	819	11.2
0.7	3.6	4.3	847	11.1
0.8	3.4	4.0	958	10.9
0.9	3.4	3.7	1,043	10.8
1.0	3.4	3.4	1,011	10.7
1.1	3.2	2.5	997	10.0

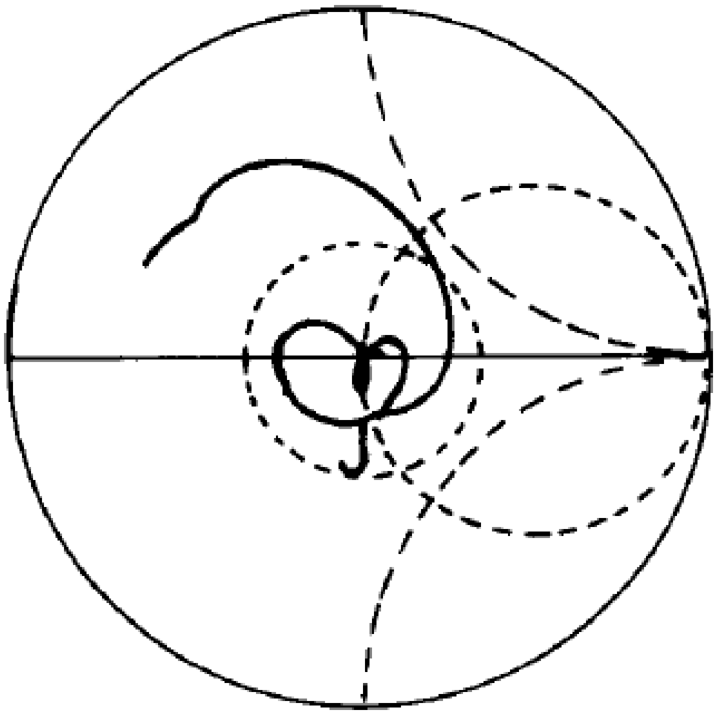
Stacked Planar MSA – 1B4T

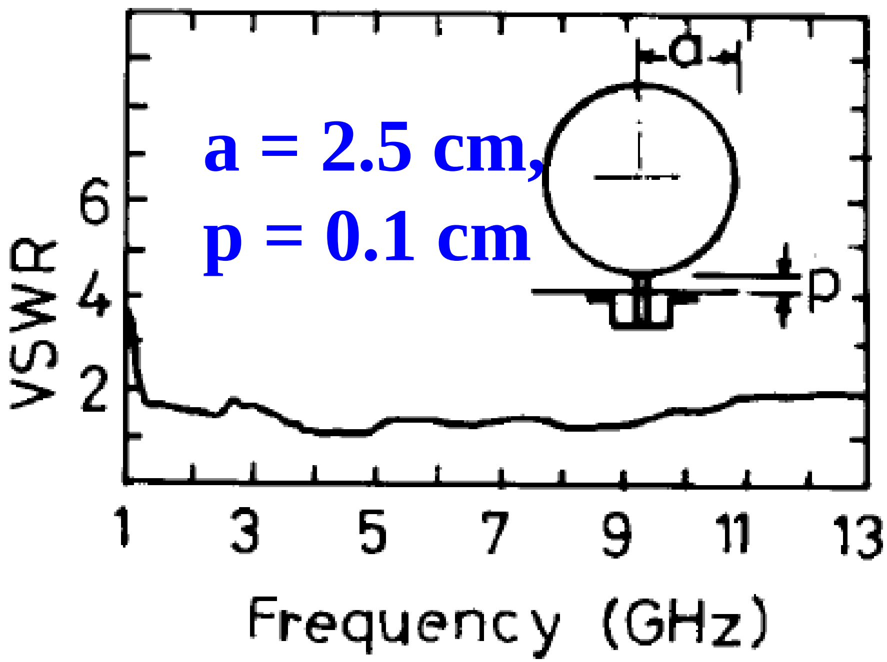


Variation of BW and Gain of the 1B4T RMSA with h_1
(L = 5 cm, W = 3 cm, W_1 = 2 cm, x = 2.4 cm, and h = 0.5 cm)

h_1 (cm)	L_1 (cm)	ox, oy (cm)	f_0 (GHz)	BW (MHz)	Gain (dB)
0.4	3.9	3.8, 2.3	2.938	816	12.7
0.5	3.9	3.7, 2.2	2.915	868	12.2
0.6	3.8	3.6, 2.1	2.930	910	12.3
0.7	3.7	3.5, 2.0	2.955	933	12.0
0.8	3.6	3.2, 1.7	2.958	1,070	11.5

Broadband Circular Monopole Antenna





Metallic circular plate is fed by a co-axial feed

BW for VSWR $\leq$ 2 is from 1.17 to 12 GHz (BW ratio 1:10.2)

Disadvantage – pattern variation over the bandwidth.

Broadband Triangular Monopole - RF Harvesting

CONCLUSIONS

- Broadband Antenna Technology is rapidly changing.

  - Planar coupled, stacked, planar and stacked

  - Broadband monopole antennas

- Requirement for innovative thinking to meet future challenges:

  - Broadband directional high gain antenna

  - Uniform pattern over the broad bandwidth

- Design is the key thing.

- Low cost without sacrifice in performance.