

Microstrip Antenna Arrays

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MSA Array Feed Networks

- Series Feed
- Corporate (Parallel) Feed
- Series and Corporate Feed

Series Feed

Advantages :

- Reduced feed length
- Reduced losses
- Lower Sidelobe

Disadvantages:

- Beam tilt with Frequency
- Narrow BW

Corporate Feed

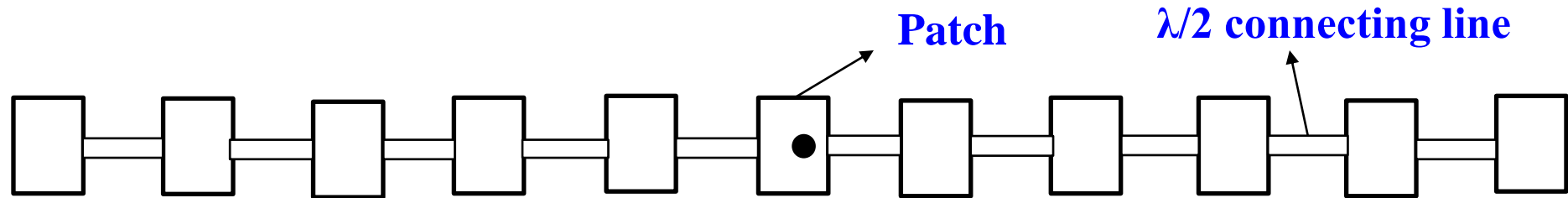
Advantages:

- Equal power to all element
- Larger BW
- Modular in nature

Disadvantages:

- Higher Feed losses
- Higher cross polar

Series Fed MSA Array



Elements	Value (mm)
Patch Length (pl)	2.68
Patch Width (pw)	3.2
Connecting line length (cl)	2.77
Connecting line width (cw)	0.4
Space between patches	5.45

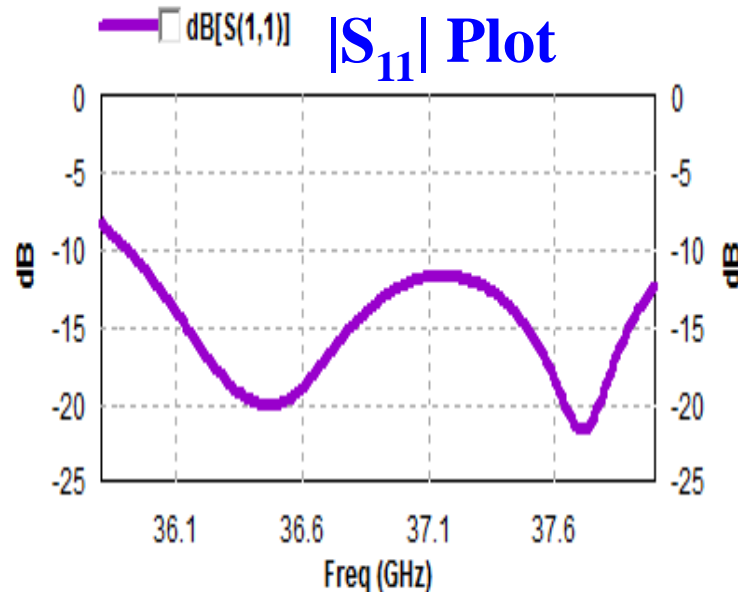
Antenna at Ka-Band

RT 5880 substrate:

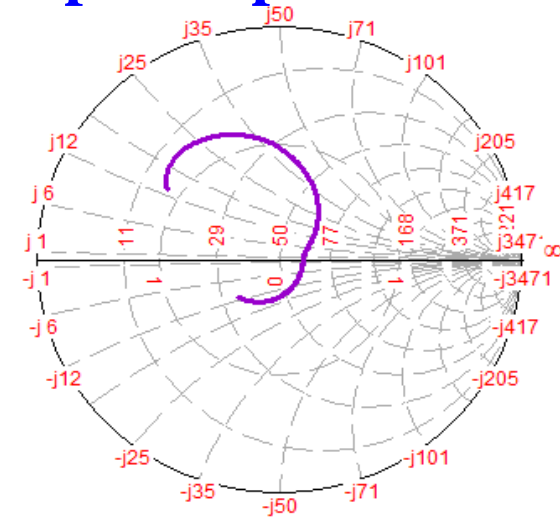
$\epsilon_r = 2.2$, $h = 0.254\text{mm}$

and $\tan\delta = 0.0015$

23×1 Series Fed Array at Ka Band

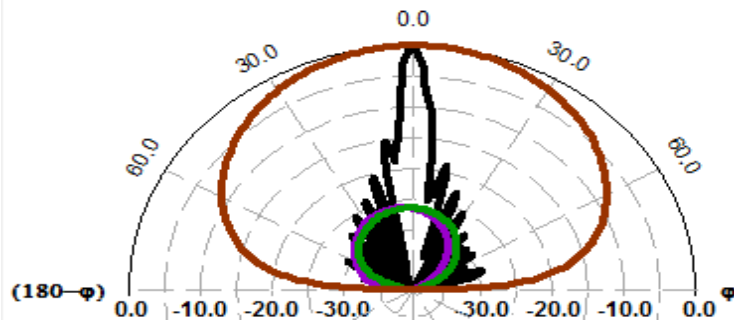


Input Impedance Plot

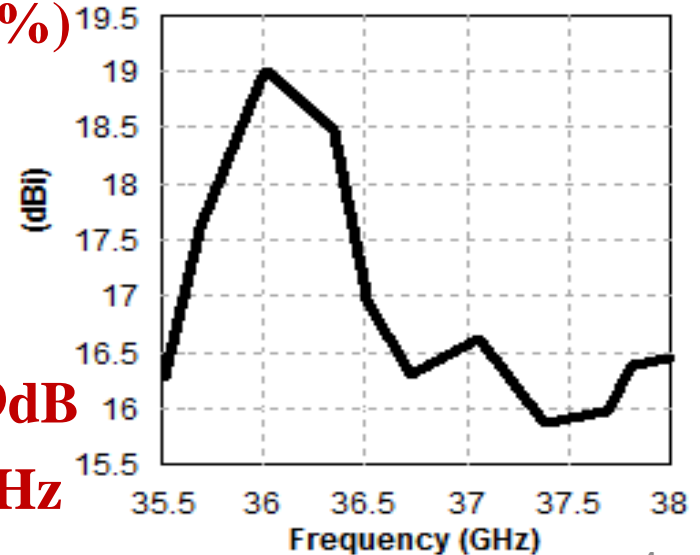


BW for $|S_{11}| \leq -10\text{dB}$ -35.9 to 38 GHz (5.6%)

- 36GHz, E-th, phi=0
- 36GHz, E-th, phi=90
- 36GHz, E-phi, phi=0
- 36GHz, E-ph, ph=90



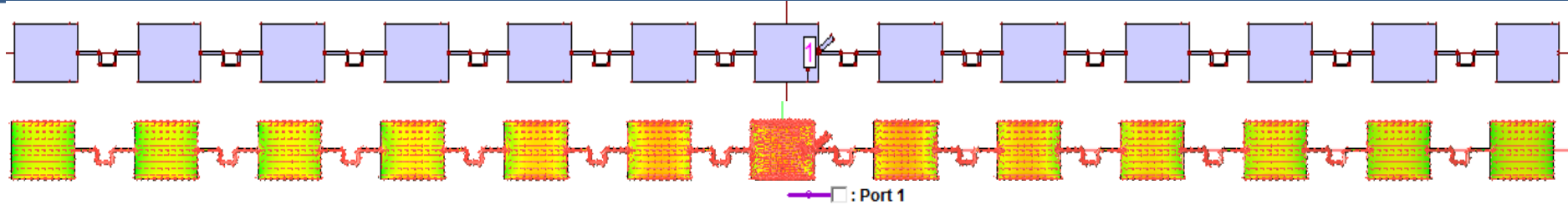
**Gain: 19dB
at 36 GHz**



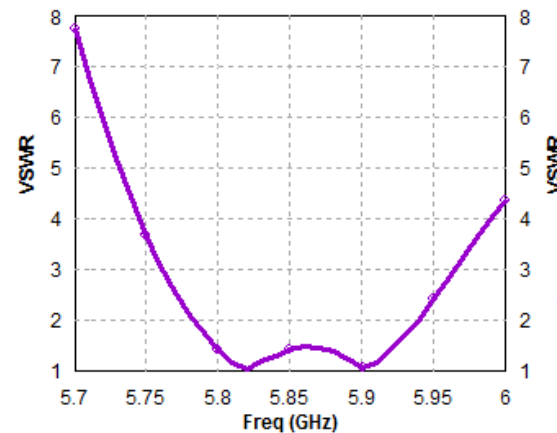
Radiation Pattern at 36GHz

Gain vs Frequency plot

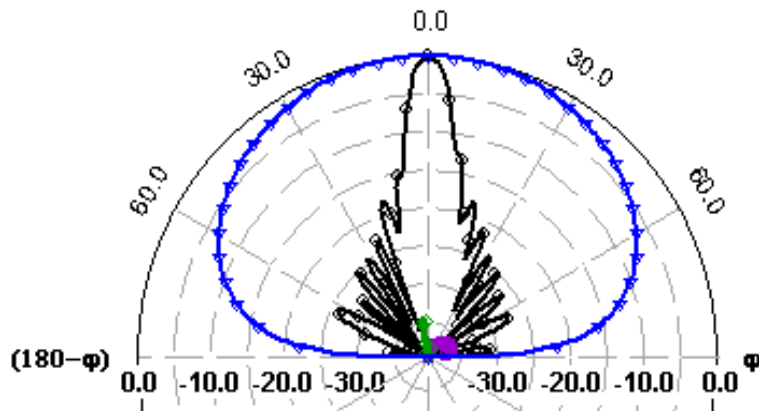
13x1 Series Fed MSA Array at 5.8 GHz



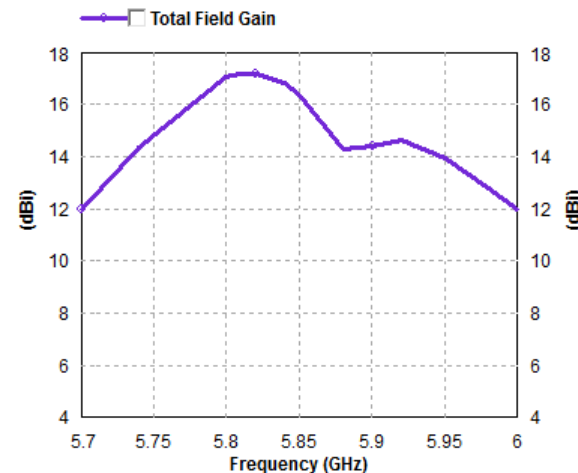
Patch Length = 16.84mm
Patch width = 12.7mm
Feed line length = 18.85mm
Inter element spacing = $0.6\lambda_0$



Bandwidth for $VSWR \leq 2$ is
5.78 to 5.94 GHz

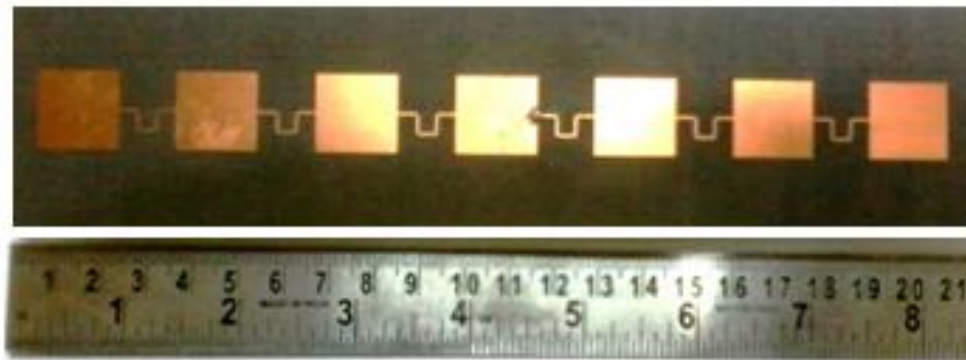


Radiation Pattern at 5.8GHz

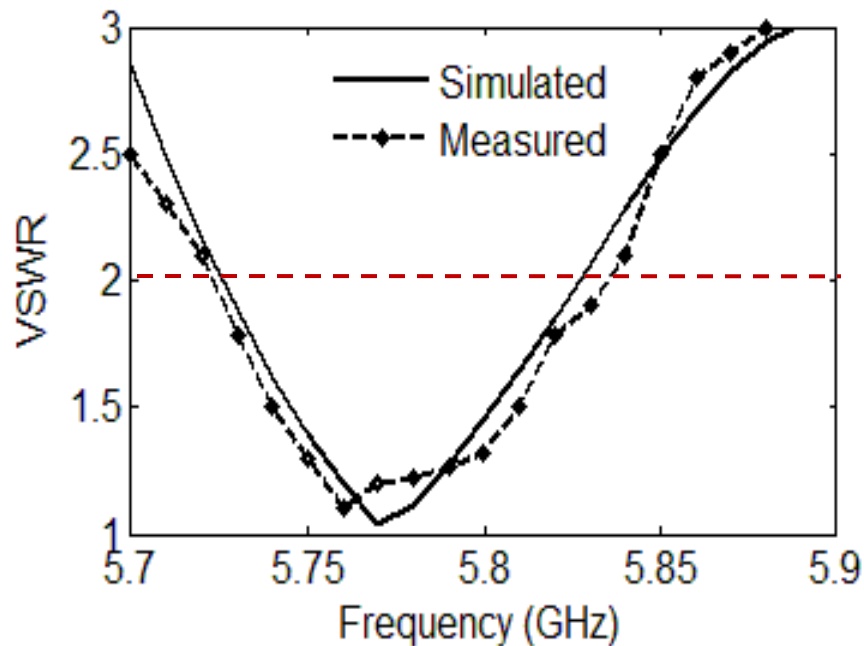


Max Gain
at
5.82 GHz
is ≈ 17 dB

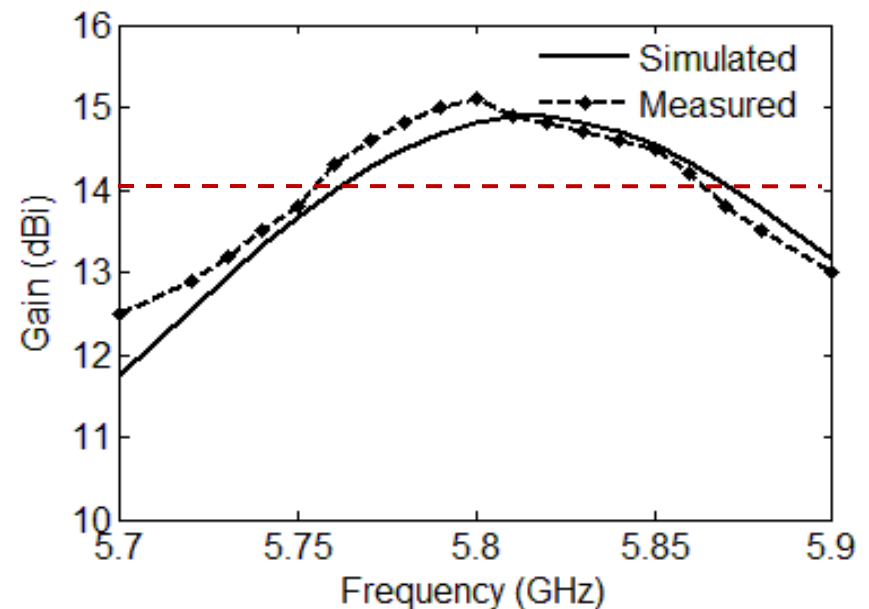
7x1 Series Fed MSA Array at 5.8 GHz



Fabricated 7-element series-fed Array

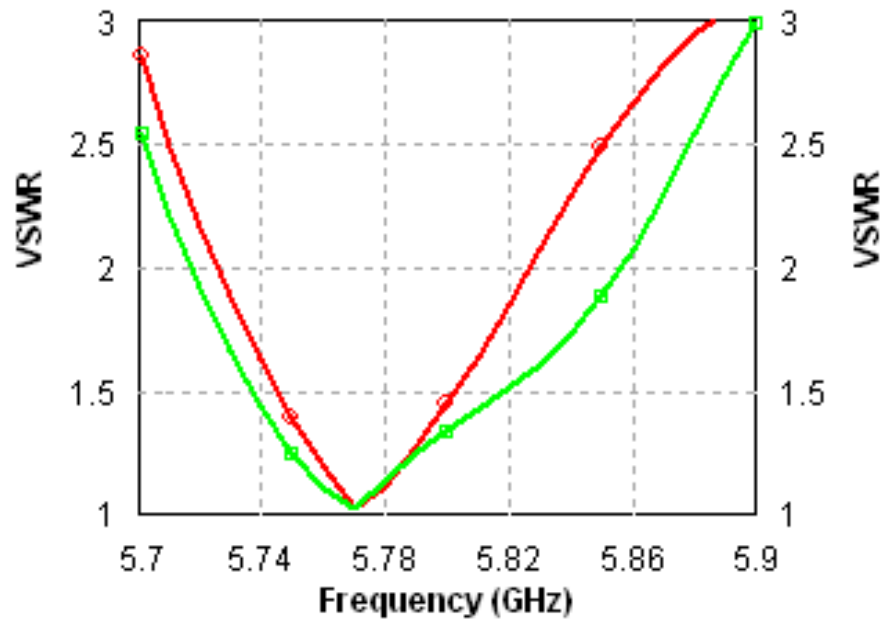
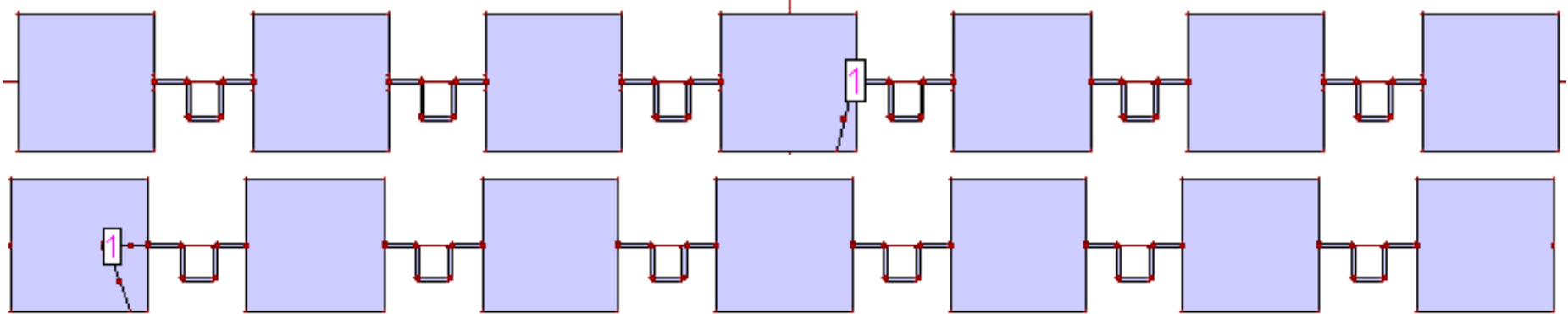


VSWR vs. Frequency Plot

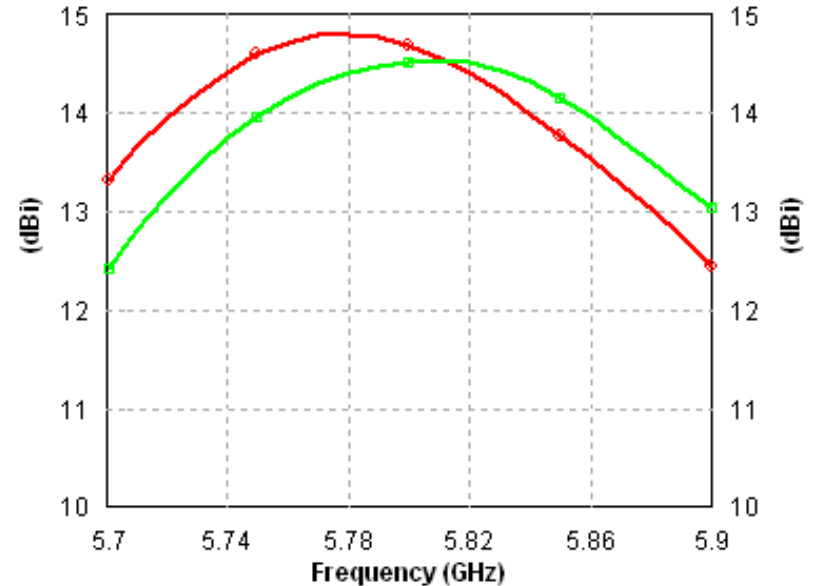


Gain vs. Frequency Plot

Comparison of Central feed with End feed MSAA



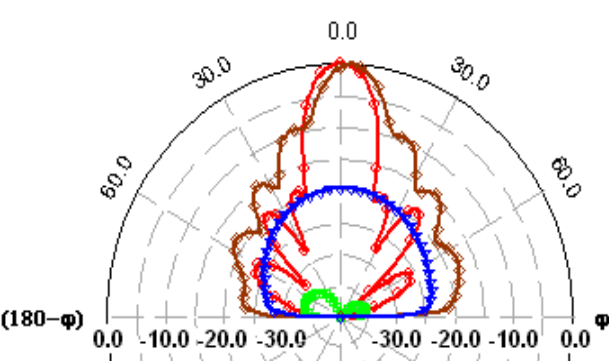
(—○— Central Feed, —□— End Feed)
VSWR vs. frequency



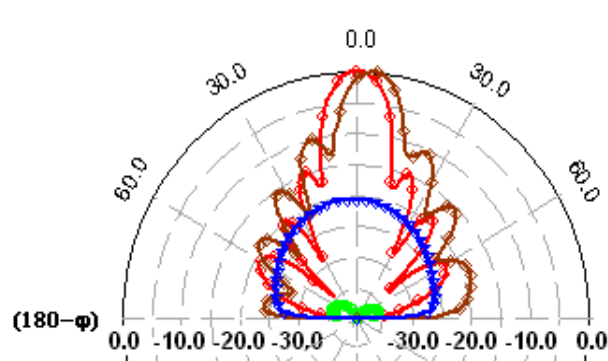
Gain vs. frequency plot

Comparison of Central feed with End feed (Cont.)

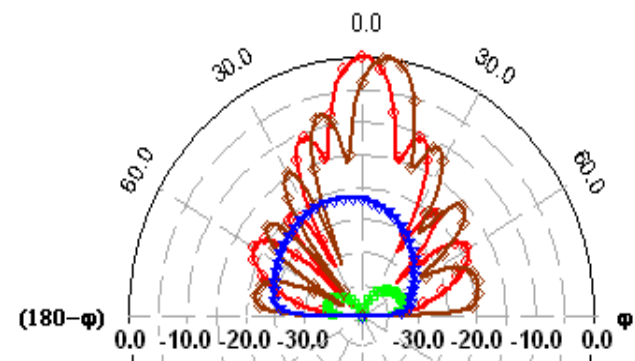
S. No.	Parameters	Central Feed	End Feed
1	VSWR <2 Bandwidth (MHz)	100	141
2	Maximum Gain (dBi)	14.8	14.5
3	E-plane HPBW at 5.73 GHz (degrees)	-7.2 to 7.2	-4.3 to 9.7
4	E-plane HPBW at 5.78 GHz (degrees)	-6.7 to 6.8	-2.2 to 10.6
5	E-plane HPBW at 5.83 GHz (degrees)	-6.3 to 6.3	0.7 to 12.7
6	Cross-polar levels (dB)	35	20



(a)



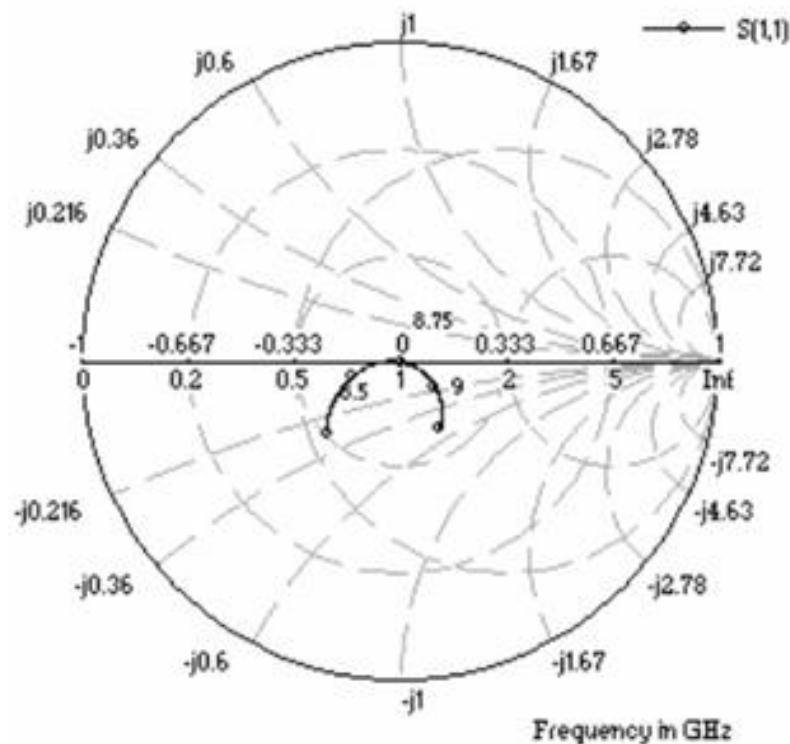
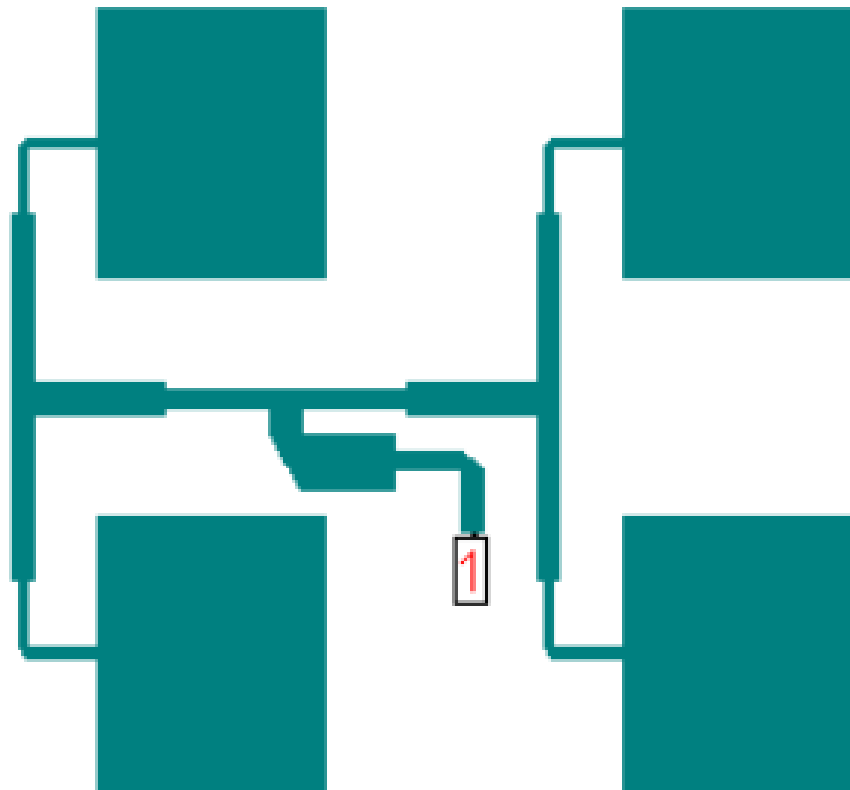
(b)



(c)

Radiation Pattern at (a) 5.73, (b) 5.78 and (c) 5.83 GHz

Corporate Feed Planar MSA Array at X-Band



Input Impedance Plot

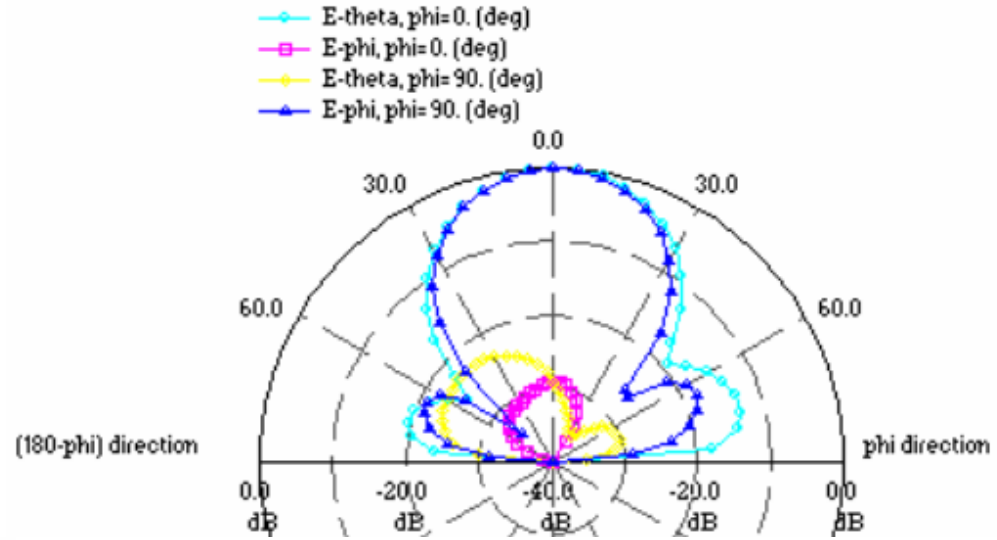
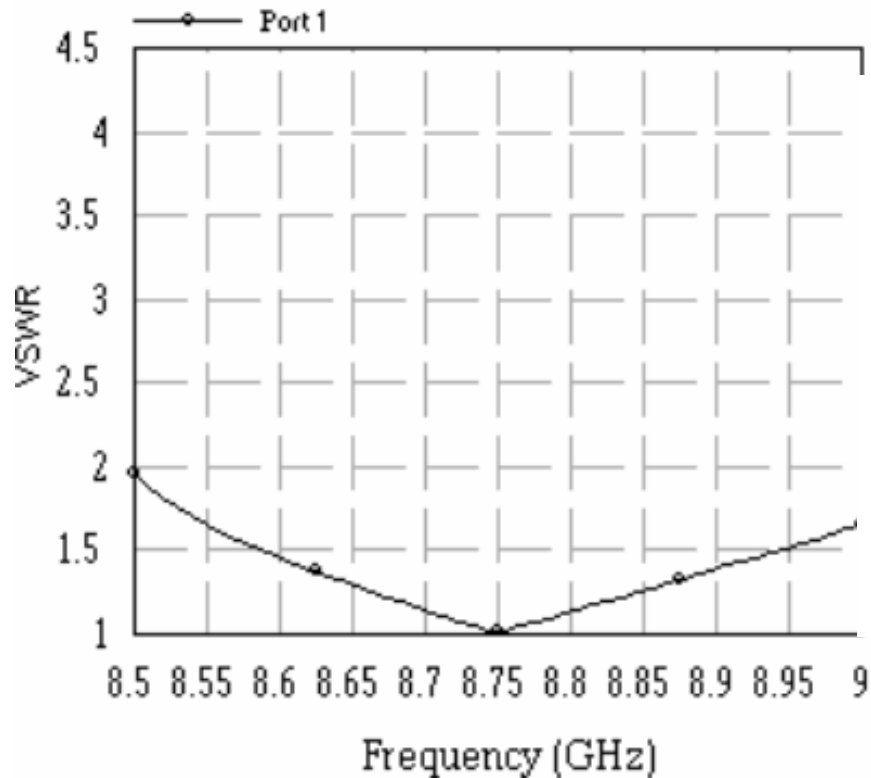
X-band antenna designed at $f = 8.75$ GHz

Substrate: RT Duroid 5880 ($\epsilon_r = 2.2$, $h = 1.59$ mm and $\tan\delta = 0.001$)

Patch Length = 13.23 mm, Patch Width = 10.17 mm

Inter element spacing in the E and H planes = 23 mm ($0.67\lambda_0$)

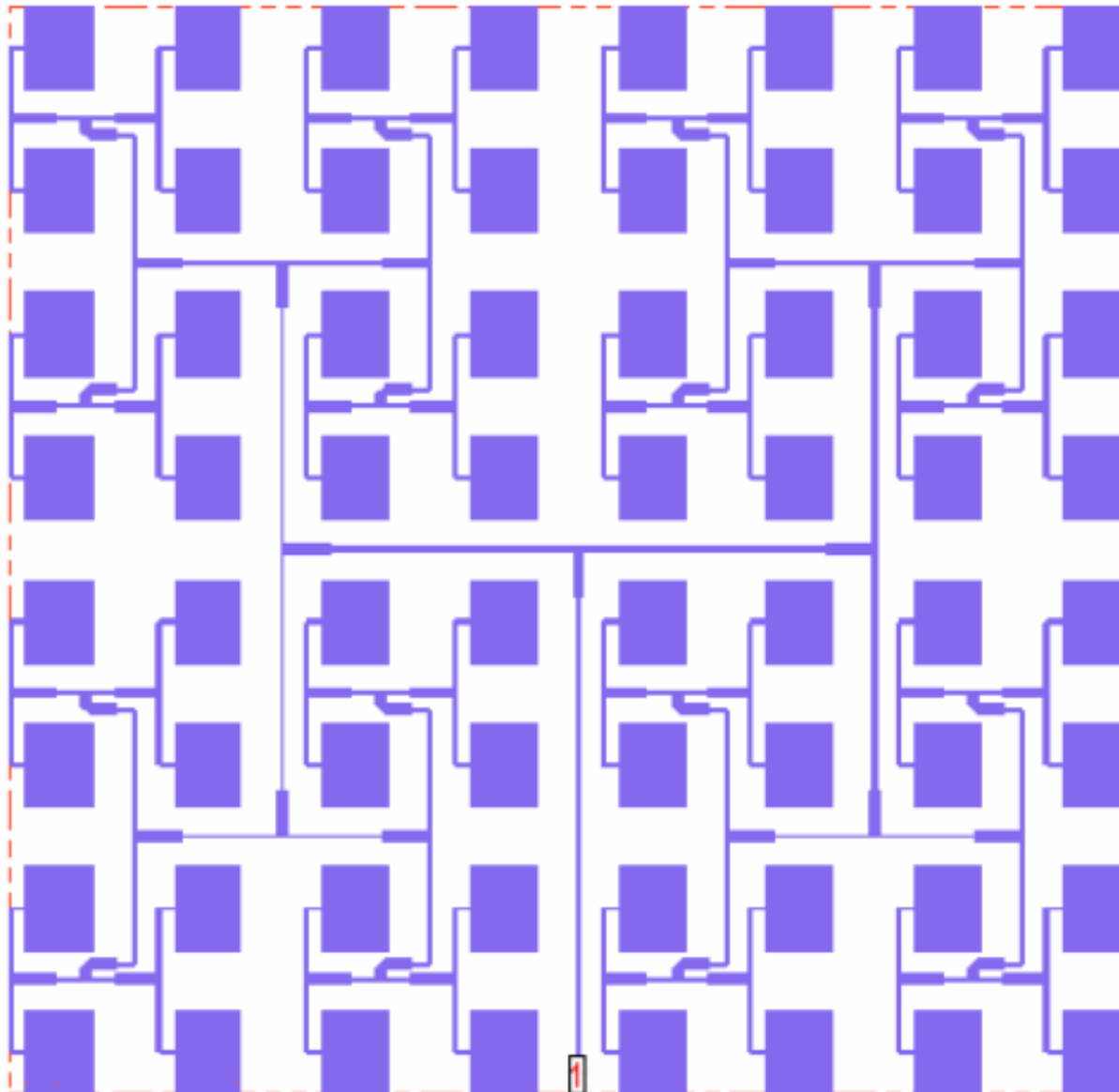
Corporate Feed 2x2 MSA Array Results



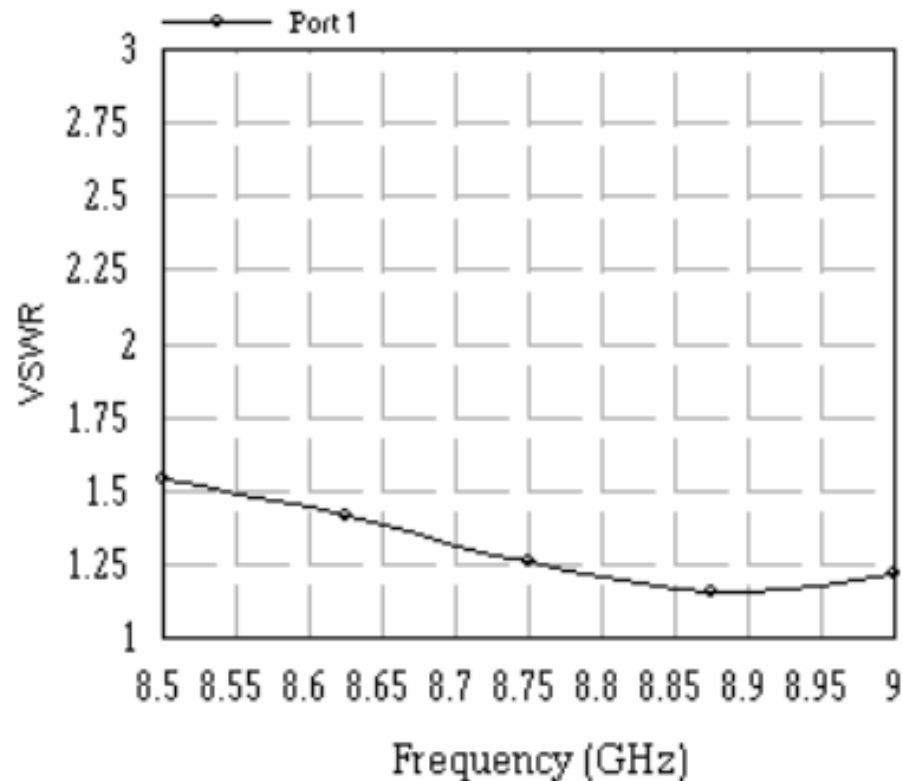
BW for $VSWR \leq 2$ is more than 500 MHz (~6%)

Radiation Pattern at 8.75 GHz

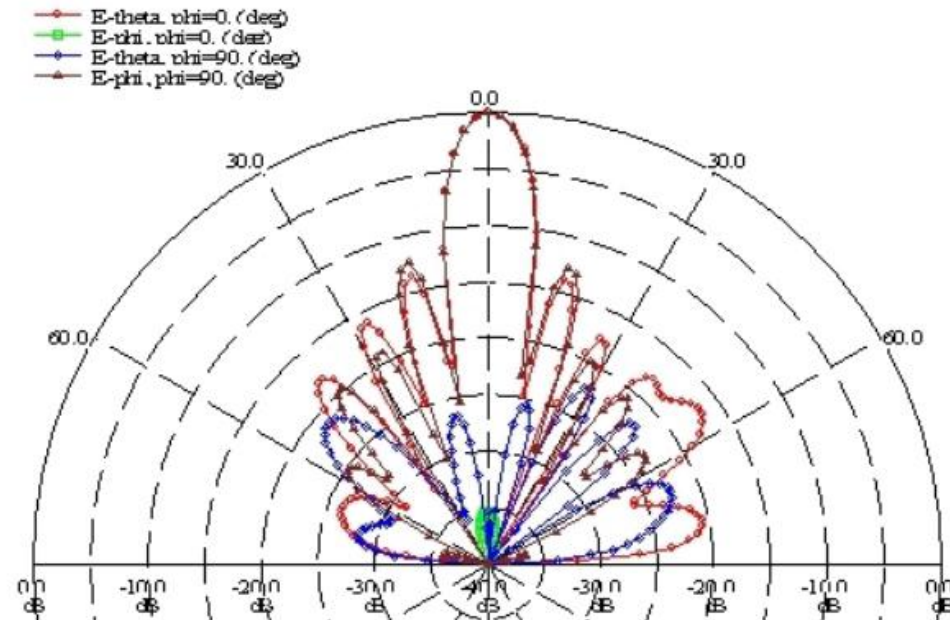
8x8 Corporate feed MSA Array



8x8 Corporate feed MSA Array Results



**BW for $VSWR \leq 1.5$ is
8.55 - 9.0 GHz (~5%)**



Radiation Pattern at 8.75 GHz

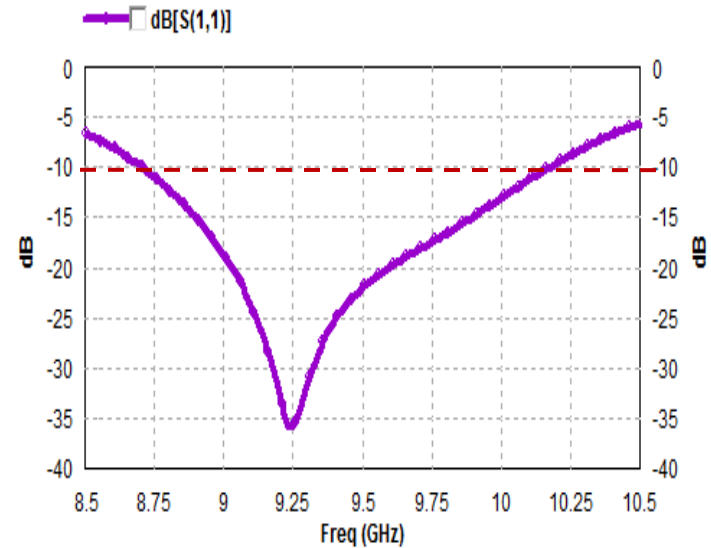
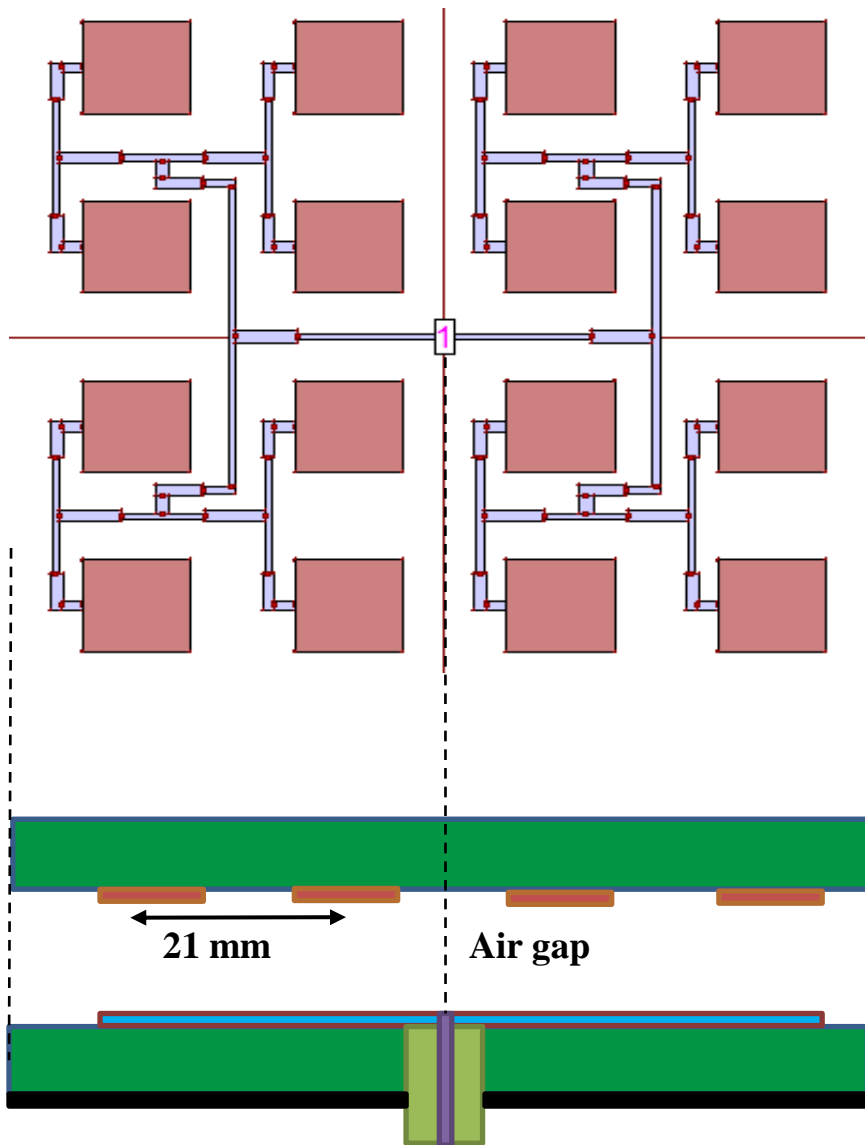
E-Plane HPBW = 9.9°

H-Plane HPBW = 9.4°

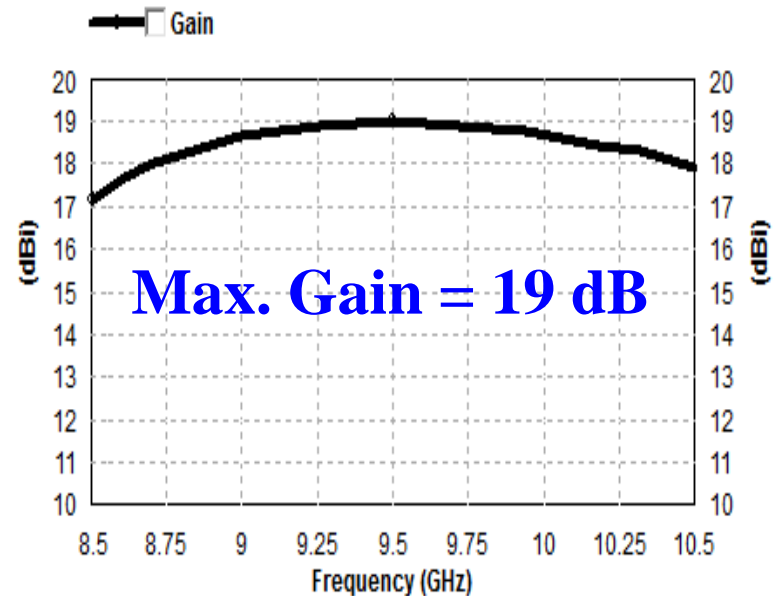
Max SLL = -12.5

Max Gain = 21.3 dB

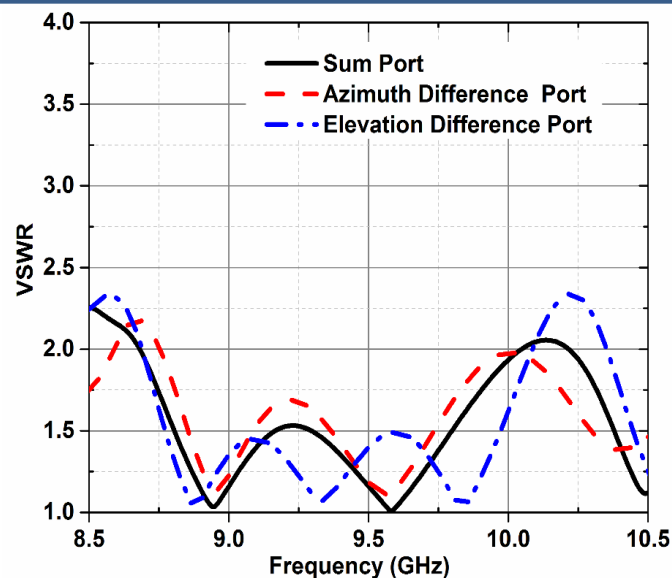
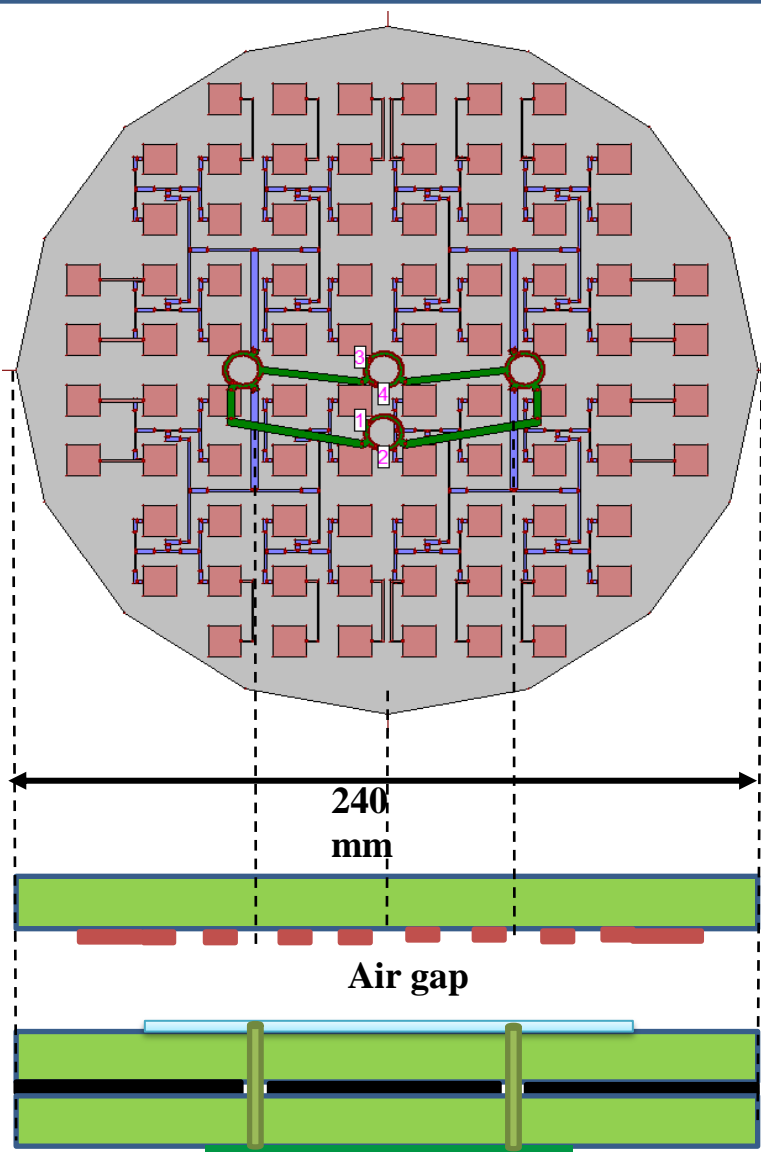
Broadband 4x4 EMCP MSA Array



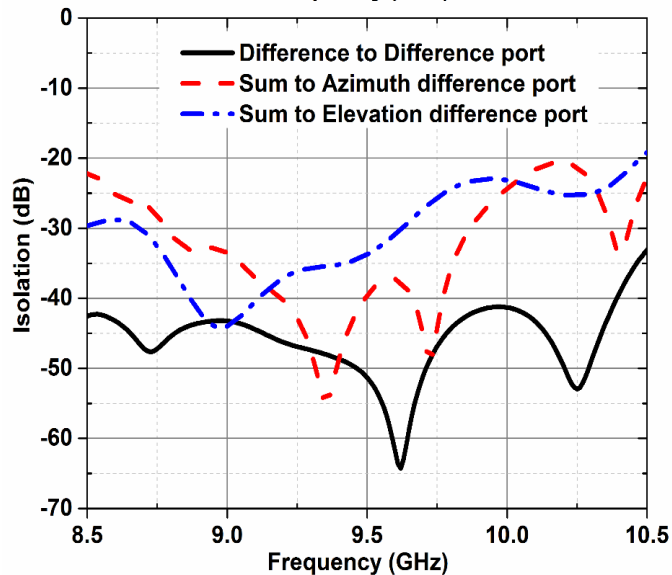
BW is 16% (8.7 - 10.2 GHz)



Monopulse System using EMCP MSA Array having Series and Corporate Feeds

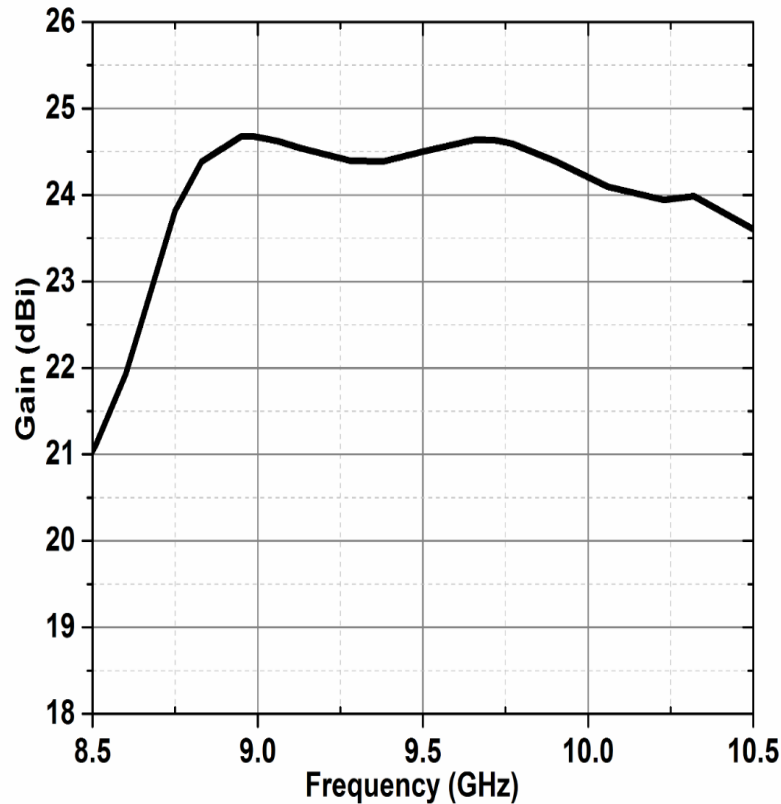


**BW for
VSWR ≤ 2 is
13% (8.75 to
10 GHz)**

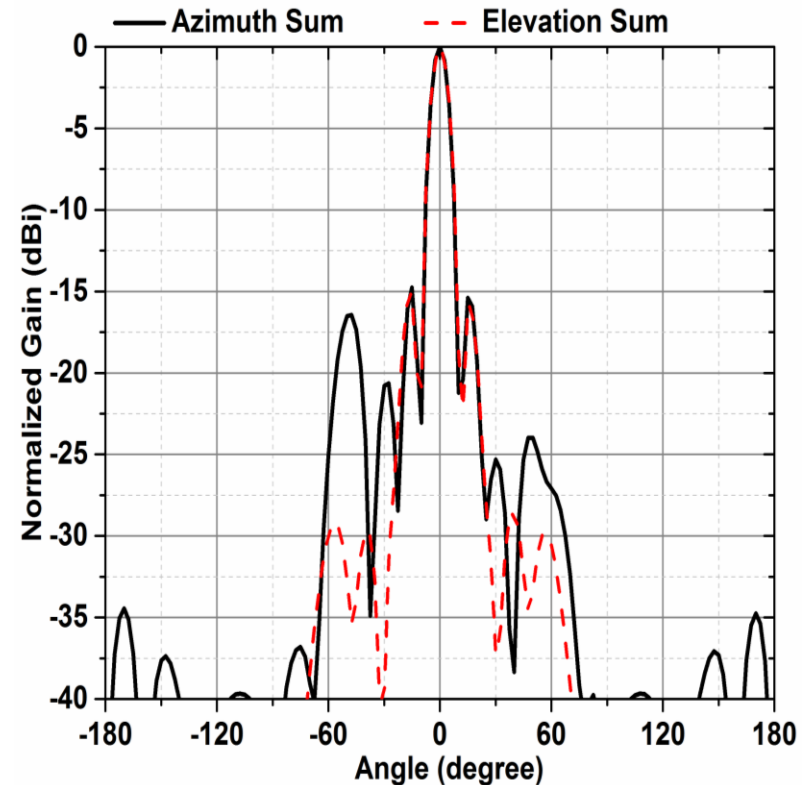


**Isolation
between
ports:
Sum to Diff.
< -20 dB
Diff. to Diff.
< -40 dB**

Monopulse System using EMCP MSA Array having Series and Corporate Feeds - Results

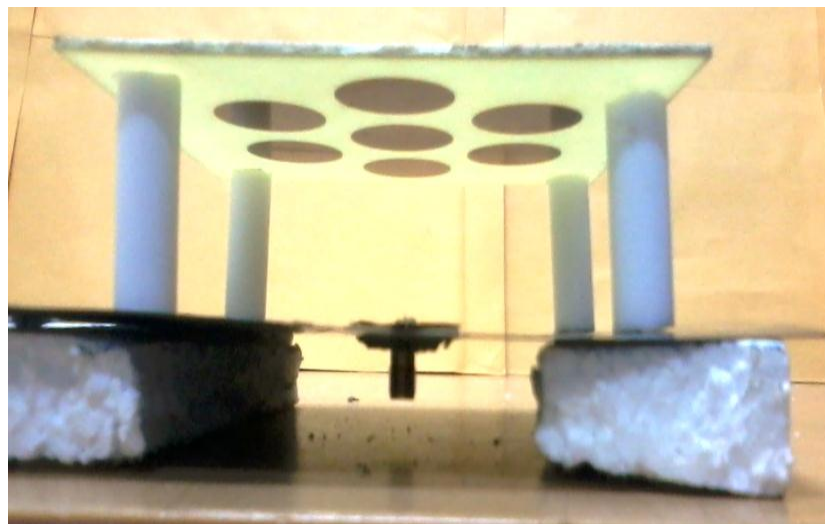
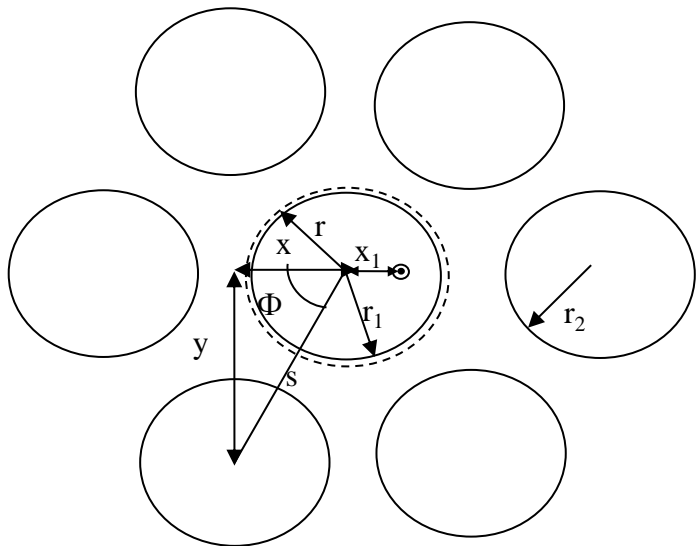


- Max. Gain = 24.7 dBi at 9.7GHz
- Variation in Gain < 0.5 dB over the bandwidth of 1 GHz

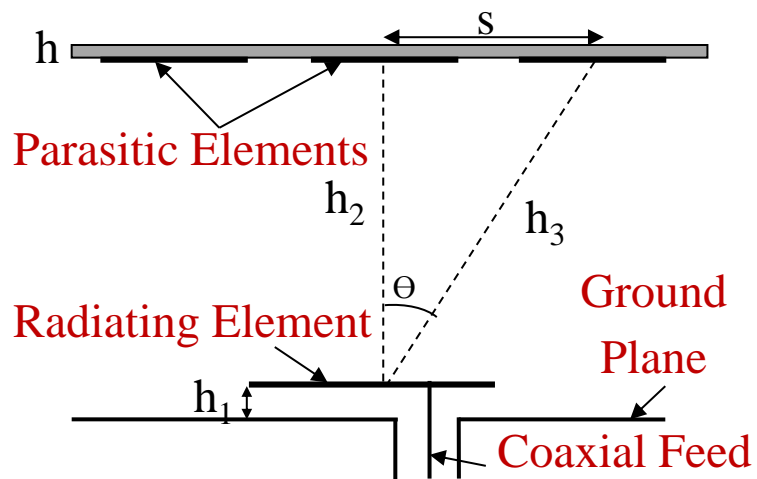


- HPBW: 9° in Azimuth and Elevation Planes
- SLL ≤ -15 dB

Space Fed CMSA Array (1B7T)



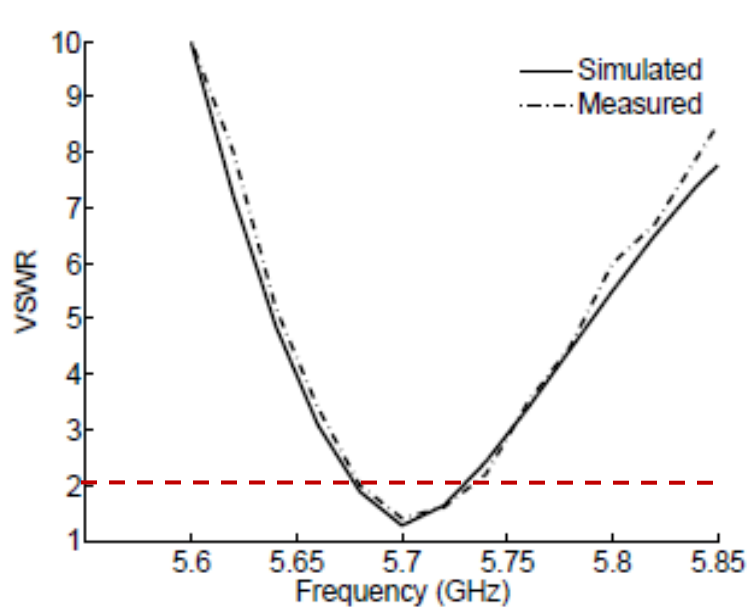
1B7T Space-Fed Array Top View



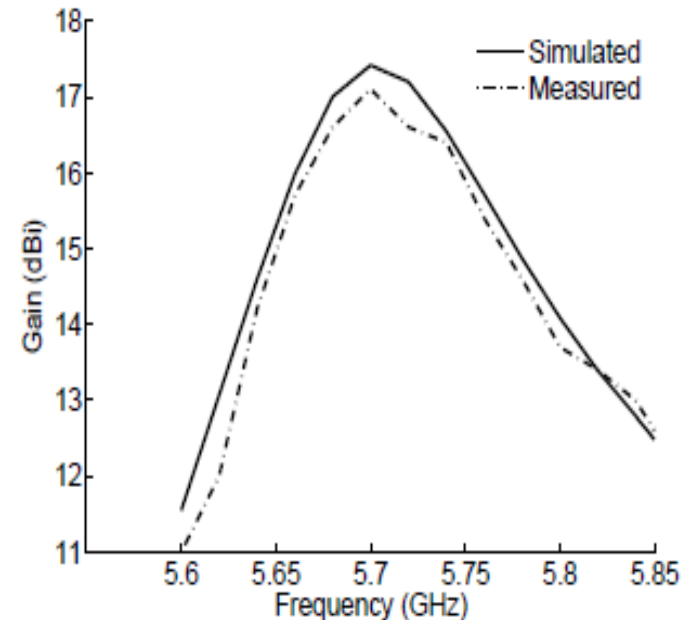
1B7T Space-Fed Array Side View

Elements	Value (mm)
Bottom element radius (r)	13.1
Top element radius (r_1, r_2)	13.1, 12.7
Inter-element Spacing (s)	33
Air gap (g)	25.85 ($\lambda_0/2$)

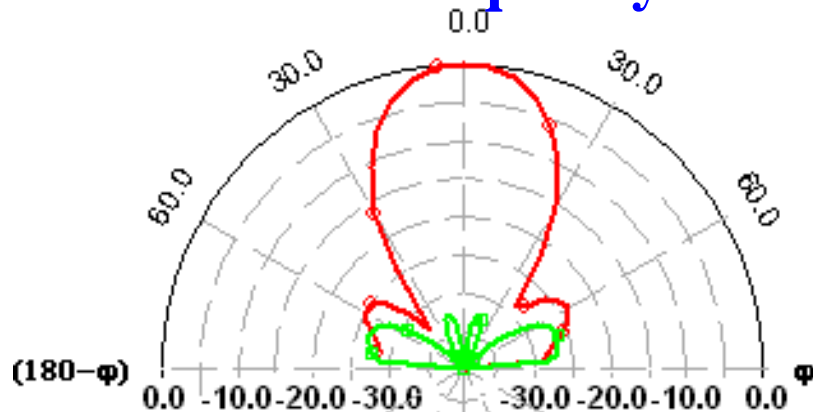
1B7T Space-Fed CMSA Array Results



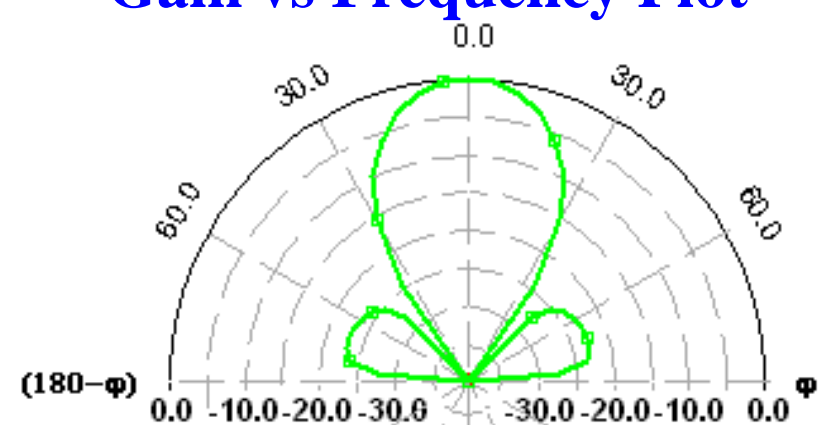
VSWR vs Frequency Plot



Gain vs Frequency Plot

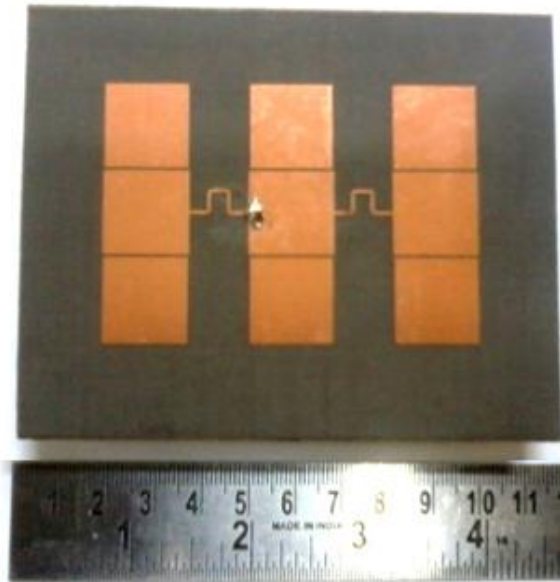


E-Plane Radiation Pattern

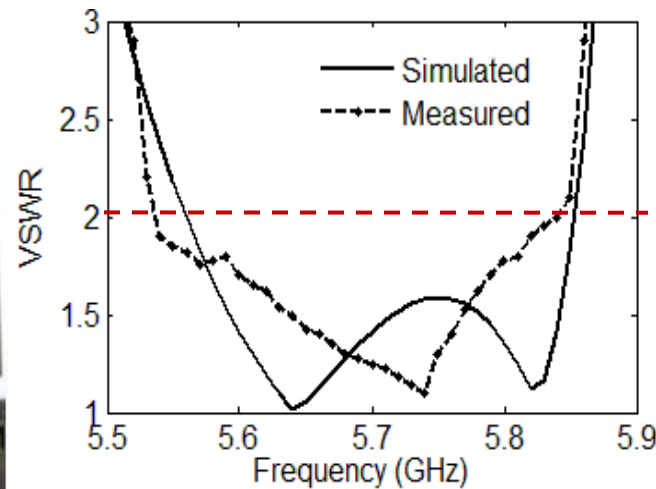


H-Plane Radiation Pattern

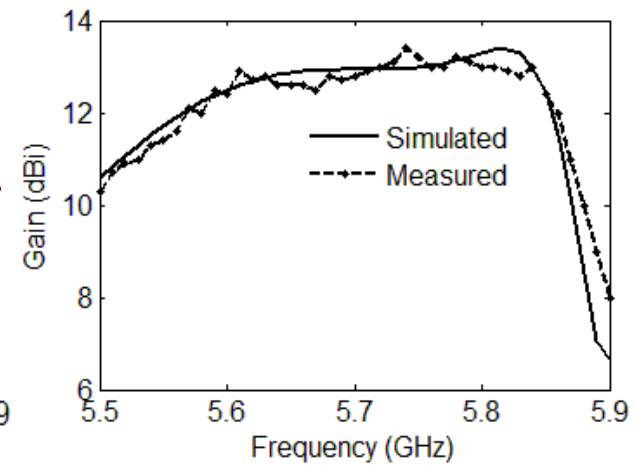
Series-Fed Array of Gap Coupled RMSEA



(a)



(b)



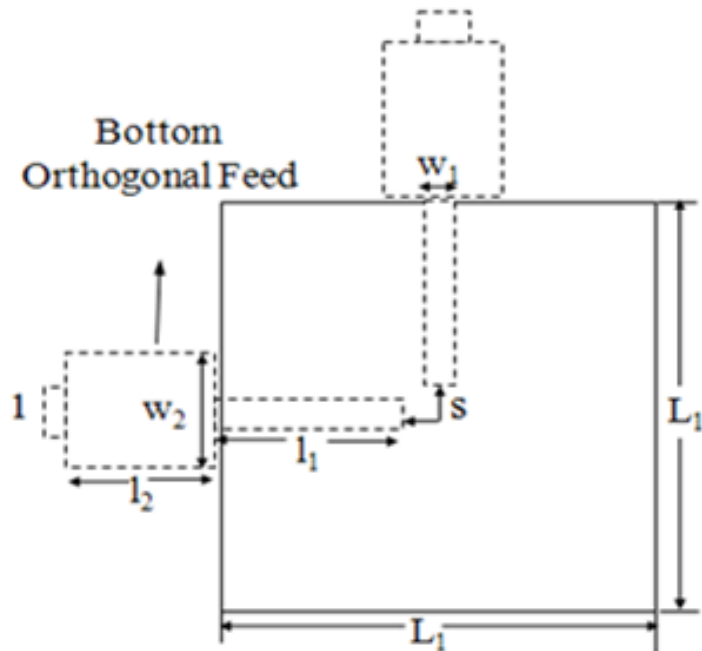
(c)

(a) Fabricated 3-element broadband linear series-fed antenna array on finite ground plane of 115 mm x 100 mm. Simulated and measured (b) VSWR and (b) Gain vs. frequency plots

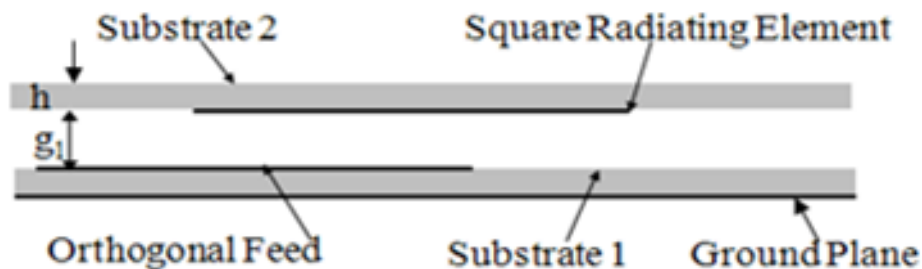
Measured $VSWR \leq 2$ BW = 5.535 to 5.84 GHz (~5%)

Max gain of antenna array = 13.4 dBi

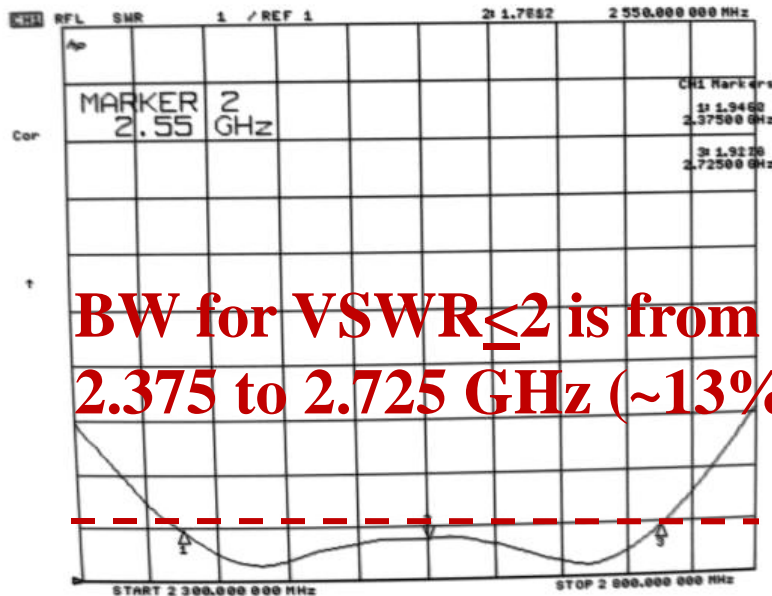
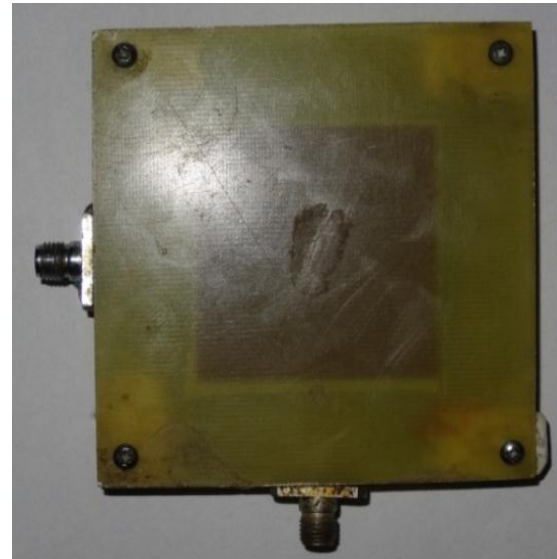
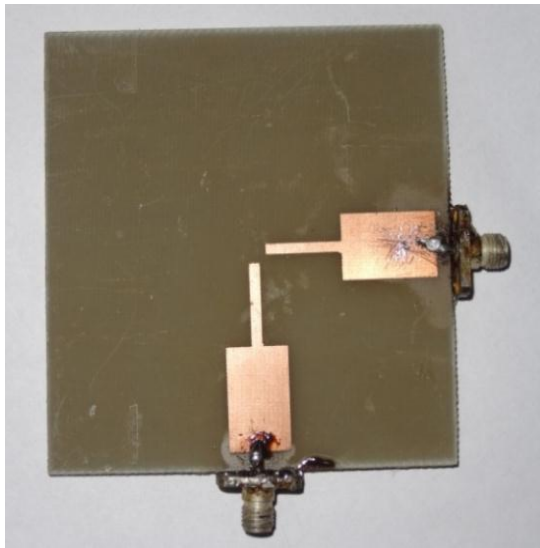
EMCP Dual Polarized MSA in S-Band



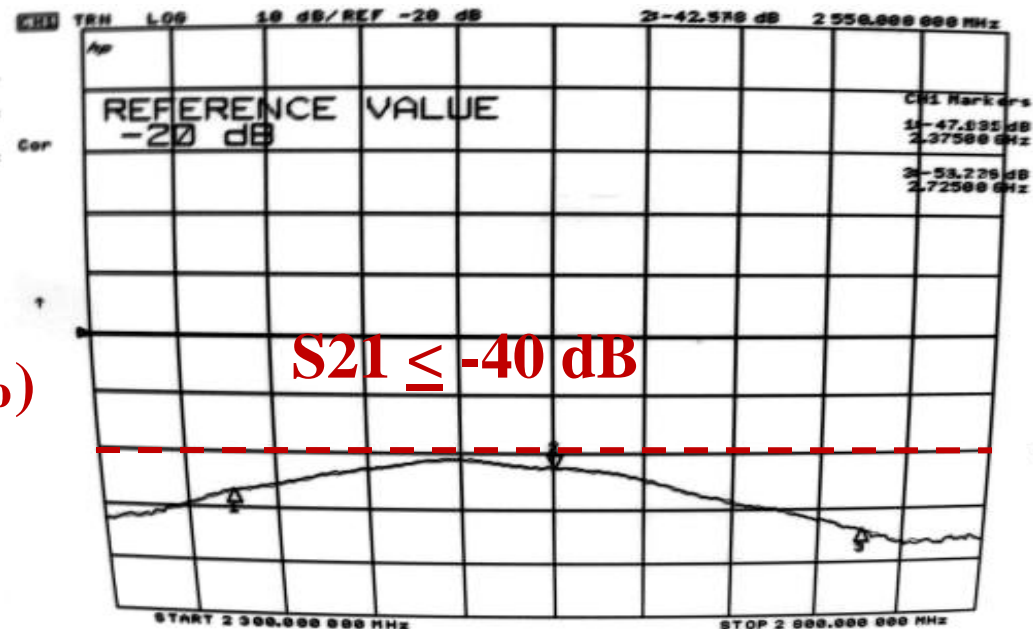
Elements	Value (mm)
Square Element (L_1)	39.6
Air gap (g_1)	3
Feed Offset (s)	2.3
Quarter wave Transformer ($l_2 \times w_2$)	16 x 9.2



EMCP Dual Polarized MSA Results

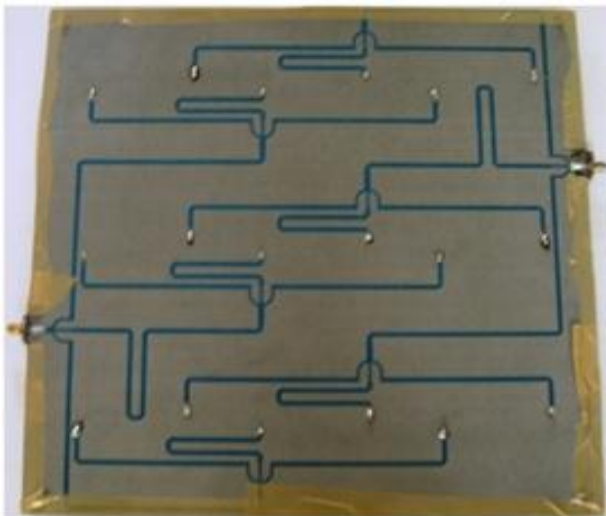


BW for $VSWR \leq 2$ is from 2.375 to 2.725 GHz (~13%)

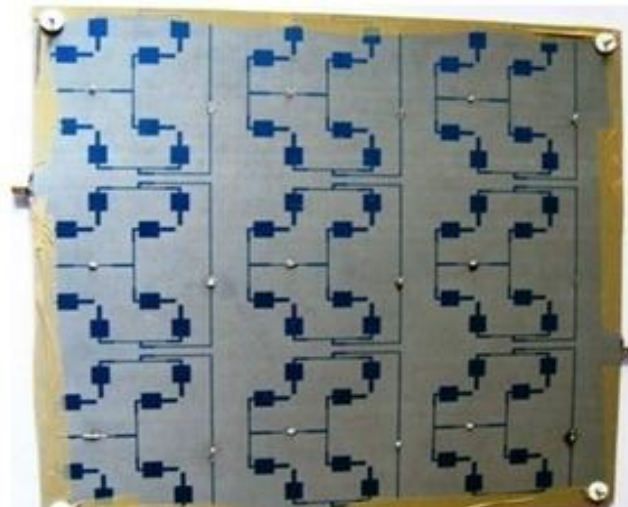


$S_{21} \leq -40$ dB

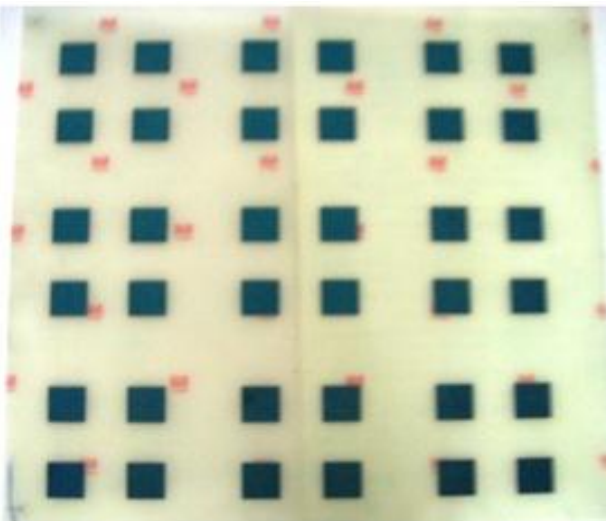
EMCP Dual Polarized MSA Array at 5.8 GHz



3x3 Power Divider for Two Ports



Microstrip Line Feed Network

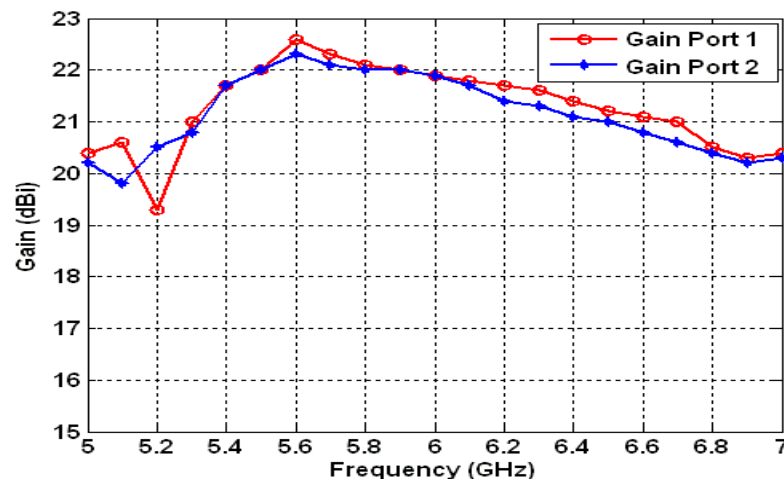
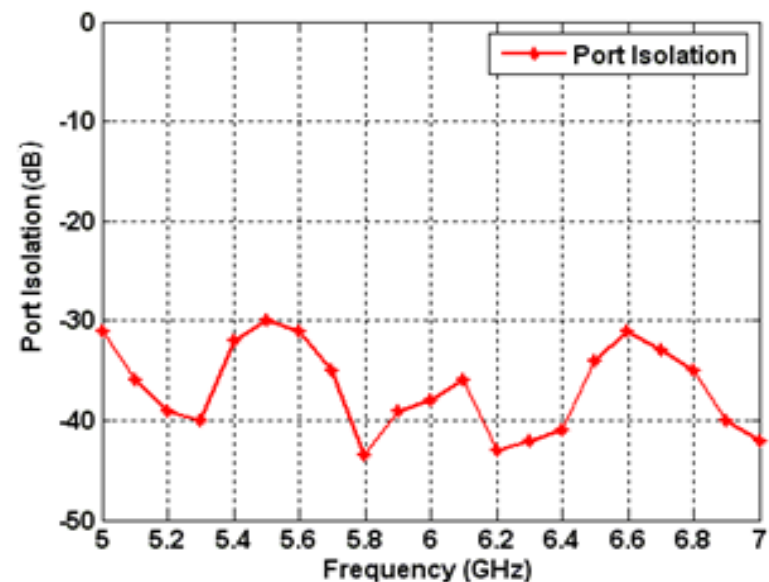
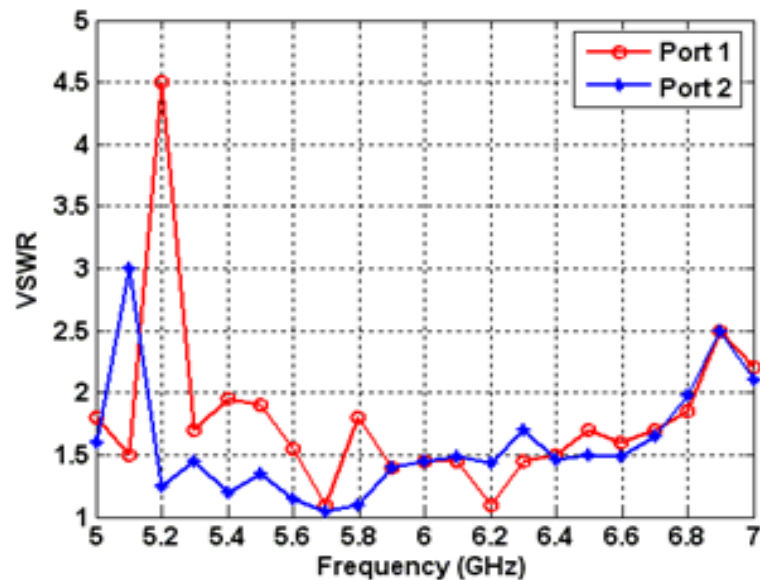


Top 6x6 Radiating Elements



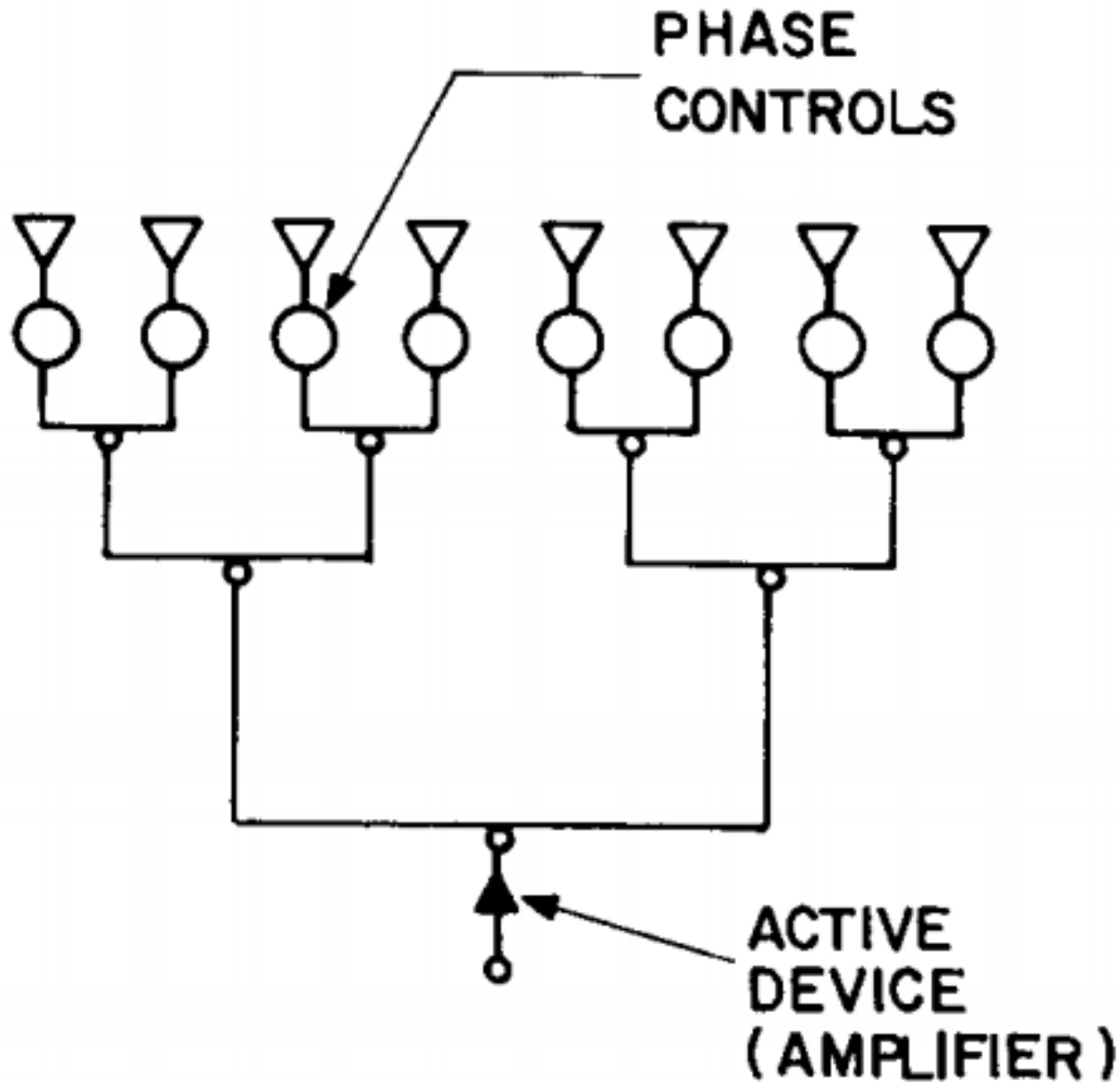
Integrated 6x6 EMCP Antenna Array

EMCP Dual Polarized MSA Array at 5.8 GHz - Results



Measured (a) VSWR, (b) S_{21} and (c) Gain vs. frequency plots of 6x6 array of EMCP dual polarized antenna

Phased Array Antenna



Active Phased Array Antennas

