EMCoS Studio
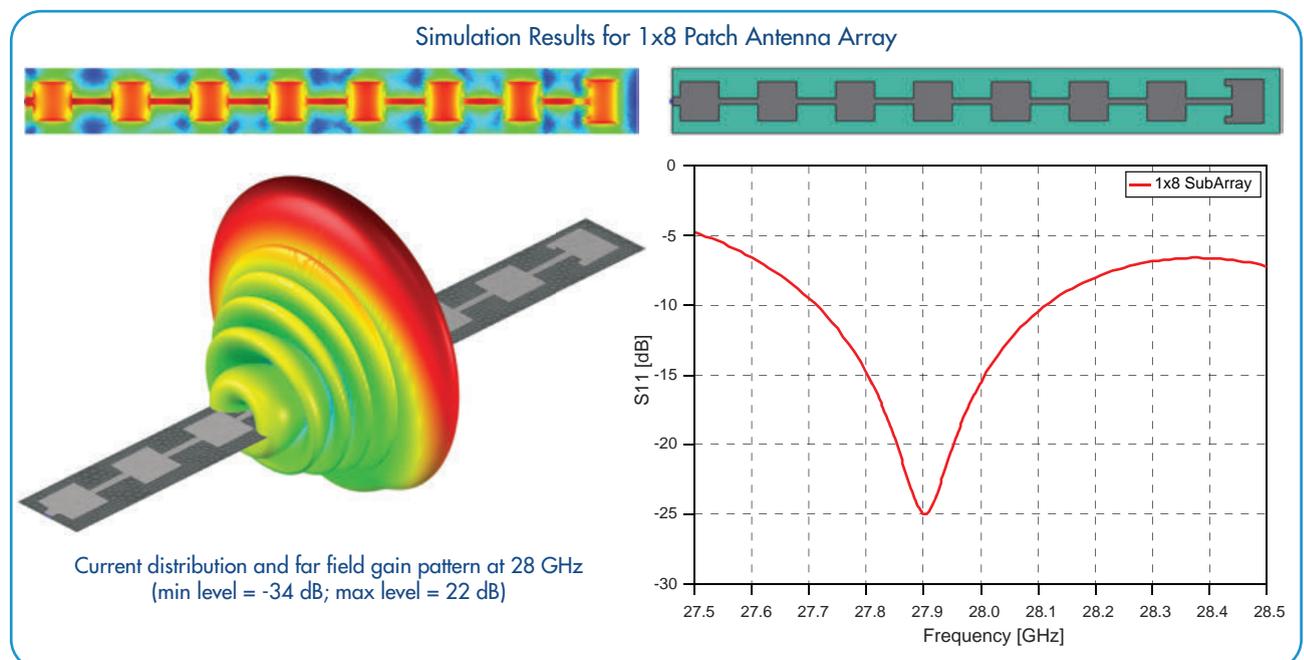
Introduction

5G, the fifth generation wireless technology, is focusing on modern antenna technologies like massive MIMO (multi-input and multi-output), phased arrays and mm-wave band to obtain data rates up to 10 Gbps. Frequencies are above 24 GHz reaching up to 72 GHz.

This application note demonstrates modeling and 3D full wave simulations of 64 elements, 8x8 phased series-fed patch antenna array for 28 GHz, mm-wave band 5G mobile base station antennas. The phased array steers its beam along the horizontal axis to provide the coverage in different directions. The array contains 8 rows of 8-element series fed arrays. The initial geometry of the antenna model was automatically constructed in EMCoS CAD Engine using scripting language and exported to ACIS SAT file for modeling and simulations in EMCoS Studio environment. The antenna geometry and design parameters are shown below:

Geometry Model of 28 GHz Series-Fed Patch Antenna Array

Parameter	Value	Comments
Wp	3.539 mm	Length and width of the each single patch element
Lc	3.539 mm	Length of interconnecting transmission line of adjacent array elements
Wc	0.494 mm	Width of interconnecting transmission line of adjacent array elements
Wf	0.720 mm	Width of the feeding microstrip line
Wm	2.727 mm	Width of matching inset feeding at the last array element
Lm	0.6269 mm	Length of matching inset feeding at the last array element

8x8 Series-fed patch array (Larr = 55.3 mm, Warr = 41 mm) with vertical inter-element spacing, d = lambda/2 = 3.54 mm

Simulation Results for Single 1x8 Patch Sub Array

The antenna is printed on substrate with dielectric constant of 2.33, loss tangent of 0.0012 and thickness of 0.254 mm (based on characteristics of RT/duroid ® 5870 material from Rogers Corporation). The reflection coefficient, surface current distribution and 3D far field gain pattern (with maximum gain level 22 dB at 28 GHz) are shown below for single 1x8 patch antenna sub array:

Simulation Results for 1x8 Patch Antenna Array

Current distribution and far field gain pattern at 28 GHz
(min level = -34 dB; max level = 22 dB)

EMCoS Studio Application Note: #36

Simulation Model and Results for Series-Fed 8x8 Patch Antenna Array

Depending on the phasing of the input signals at each port different beams can be formed. The phase shift is applied to the input ports that are fed by voltage sources, so the 1st source will have a shift of 0^0., the 2nd -22.5^0, the 3rd -45^0, etc.

### Simulation Model of 28 GHz Series-Fed Patch Antenna Array

The phase shift angles:
$\pm22.5^0$
$\pm67.5^0$
$\pm112.5^0$
$\pm157.5^0$

Excitation Sets
- Phase_Shift_22.5deg
- Phase_Shift_67.5deg
- Phase_Shift_112.5deg
- Phase_Shift_157.5deg
- Phase_Shift_-22.5deg
- Phase_Shift_-67.5deg
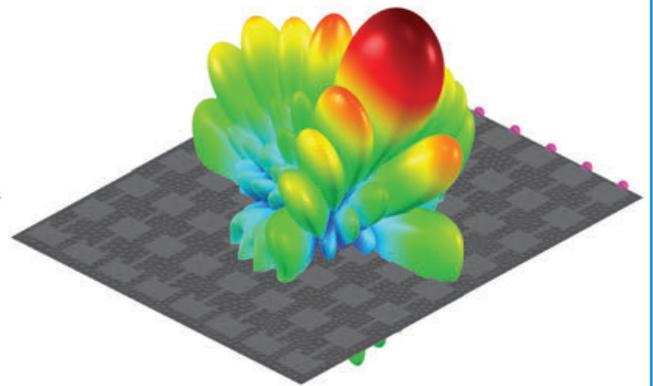- Phase_Shift_-112.5deg
- Phase_Shift_-157.5deg
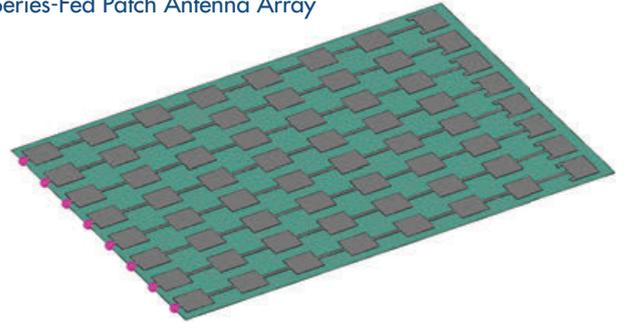
The gain patterns formed for beam with each phase shift are presented on the picture below. The eight beam steering angles obtained after simulation are: $\pm7^0$, $\pm22^0$, $\pm38^0$, $\pm56^0$:
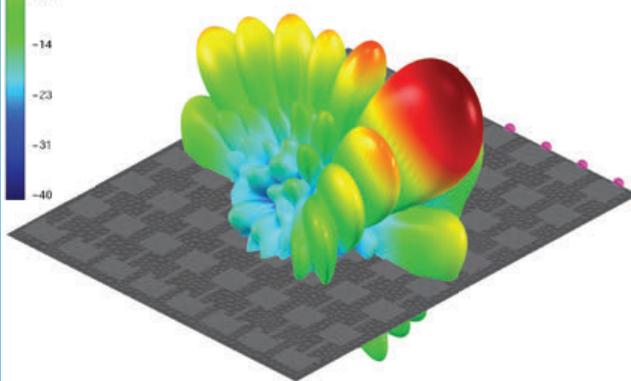
Beam Forming Results for Series-Fed 8x8 Patch Antenna Array
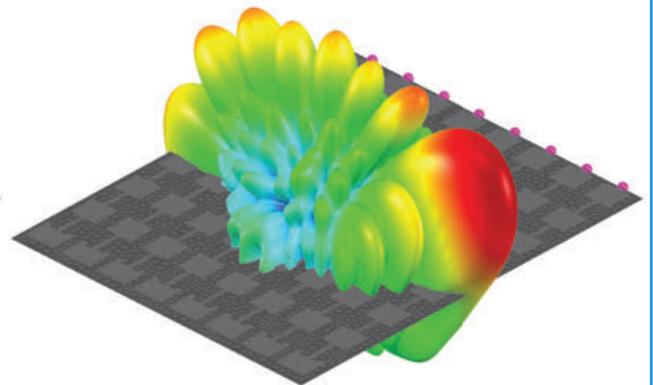(min level = -40 dB; max level = 21 dB)
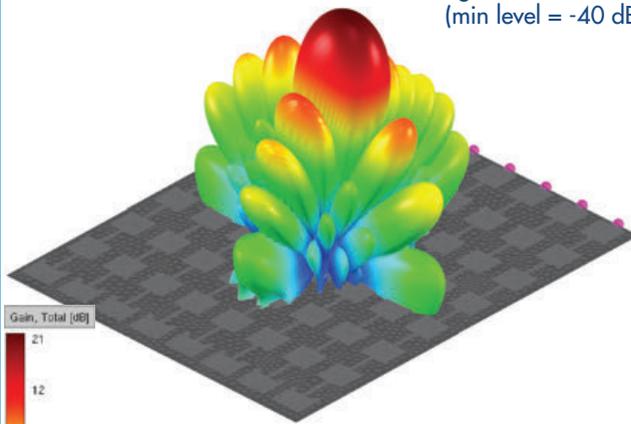
The gain pattern formed for beam with phase shift (22.5 deg. per port) has maximum gain at 7 deg.

The gain pattern formed for beam with phase shift (67.5 deg. per port) has maximum gain at 22 deg.

The gain pattern formed for beam with phase shift (112.5 degrees per port) has maximum gain at 38 deg.

The gain pattern formed for beam with phase shift (157.5 deg. per port) has maximum gain at 56 deg.

References

- M. K. Ishfaq, T. A. Rahman, Y. Yamada, and K. Sakakibara, "8x8 Phased Series Fed Patch Pantenna Array at 28 GHz for 5G Mobile Base Station Antennas," 2017 IEEE-APS Topical Conference on Antennas and Propagation in Wireless Communications (APWC), pp. 160-162, 2017. https://ieeexplore.ieee.org/document/8062268

- https://rogerscorp.com/-/media/project/rogerscorp/documents/advanced-connectivity-solutions/english/data-sheets/rt-duroid-5870---5880-data-sheet.pdf

EMCoS Studio Application Note: #36

EMCoS Studio

EMCoS
Consulting and Software