Electronically Steerable Parasitic Array Radiator antenna

What is ESPAR antenna?

Parasitic element  Fed element

Beamforming by electromagnetic mutual coupling between elements

Advantages over phased array

- Smaller size
- Lower consumption power
- Lower fabrication cost

Azimuthal directivity patterns of 3-element ESPAR antenna for a variety of dc bias

3-element ESPAR antenna on a USB circuit board

Prospective applied system

- Wireless secret key generator and sharer
- SDMA for ad-hoc network
- Direction-of-arrival finder
Fast calculation method of RF current distribution on antenna elements for variation on loading reactances

Conventional method

START

analyze electromagnetic field

calculate current distribution

change \(x_1, x_2\)
-500Ω to 500Ω
1Ω increment

END

Proposed method

START

calculate \(y_{ij}(z) : i, j = 0, 1, 2\)
by EM analysis

no need to repeat EM analysis

END

\[
i_0(z) \begin{bmatrix} y_{00}(z) & y_{01}(z) & y_{02}(z) \\ y_{10}(z) & y_{11}(z) & y_{12}(z) \\ y_{20}(z) & y_{21}(z) & y_{22}(z) \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} + \begin{bmatrix} jx_1 \\ jx_2 \end{bmatrix} \begin{bmatrix} y_{00}(0) & y_{01}(0) & y_{02}(0) \\ y_{10}(0) & y_{11}(0) & y_{12}(0) \\ y_{20}(0) & y_{21}(0) & y_{22}(0) \end{bmatrix}^{-1}
\]

Application example

Wireless Secret Key Generator and Sharer

① How can RSSI deviate?
Thanks to ESPAR antenna’s variable directivity

② How Alice and Bob’s RSSI agree?
Because of wave propagation reciprocity

③ Why Eve cannot guess the key?
Because of wave propagation’s strong location dependency

RSSI profile makes a key