The Rectangular Patch Antenna: Comparing Numerical Simulations and Analytical Models

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Introduction

- Two analytical models for the rectangular patch antenna with coaxial feed are compared to the results by a finite element method (FEM) simulator.
- The properties of rectangular patch antennas are computed over a wide width and height range.
- First through a classical procedure based on the cavity model and secondly through a new procedure.

Context and Simulation

The two analytical models are:

- The cavity model, we refer to as the Patch Cavity Model (PCM).
- The original model, we developed and refer to as the Line Cavity Mix (LCM).

The simulation steps:

- The comparisons are performed for 64 \((w, h)\) couples covering the usual design range: \(60 \leq w \leq 165\) mm, \(0.5 \leq h \leq 4\) mm and \(l = 100\) mm.
- The following properties are examined at the resonant frequency \(f_0\), maximum gain \(G_M\), efficiency \(\eta\), maximum resistance \(R_s\), and relative bandwidth \(bw_s\).
- The discrepancies between both analytical models and the FEM simulator are examined.

Numerical Results

- The table shows the RMS and Peak discrepancies for the different properties, the symbol \(\Delta\) means absolute discrepancy, whereas \(\delta\) is for relative discrepancy.

<table>
<thead>
<tr>
<th>Property</th>
<th>PCM RMS</th>
<th>PCM Peak</th>
<th>LCM RMS</th>
<th>LCM Peak</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\delta R_s) (%)</td>
<td>21.8</td>
<td>49.7</td>
<td>4.4</td>
<td>9.1</td>
</tr>
<tr>
<td>(\Delta G_M) (dB)</td>
<td>0.3</td>
<td>0.5</td>
<td>0.1</td>
<td>0.3</td>
</tr>
<tr>
<td>(\Delta \eta) (%)</td>
<td>2.3</td>
<td>5.0</td>
<td>2.4</td>
<td>4.7</td>
</tr>
<tr>
<td>(\delta bw_s) (%)</td>
<td>5.3</td>
<td>12.1</td>
<td>3.3</td>
<td>6.3</td>
</tr>
</tbody>
</table>

- The figures (a) and (b) show how the discrepancies for \(R_s\) depend on \(w\) and \(h\) with both models.

Conclusion

- The LCM model is an obvious improvement over the widely used PCM model as it strongly reduces the discrepancy on the antenna impedance while providing better or similar results for all other parameters.
- The computation time remains for below that of FEM simulator.