Project #1 – Design of Microstrip Transmission lines

Part-I Microstrip Transmission Line

Objective

(i) To design a microstrip transmission line
(ii) To obtain reflection coefficient, and input impedance varying Z_L and length ‘l’
(iii) To compare analytical and simulated (Designer) results.

Circuit Diagram

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\[ \vec{V}_g \quad \hat{Z}_g \quad Z_0 \quad Z_0 \quad \epsilon_r \quad \hat{Z}_L \]
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Procedure

Use Designer, to design in microstrip configuration the transmission line show above, using RT5880 dielectric constant \( \epsilon_r = 2.22 \) of thickness, \( h = 31 \) mils

1. Assign port #1 impedance as \( Z_g = 50 \ \Omega \) and assign Port #2 impedance as \( Z_L \)
2. Perform simulations for a frequency range 100 MHz to 1 GHz in steps of 0.01GHz for each of the values shown in the table below.
3. Plot input impedance, \( Z_{in} \), complex reflection coefficient, \( S_{11} \), at the input
4. From the analytical expression, obtain the input impedance at \( f = 600 \) MHz
5. Compare with simulation results.

<table>
<thead>
<tr>
<th>Case</th>
<th>( Z_L )</th>
<th>( Z_0 )</th>
<th>( l )</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a)</td>
<td>150 – j 75 (( \Omega ))</td>
<td>75 (( \Omega ))</td>
<td>0.6 ( \lambda )</td>
</tr>
<tr>
<td>(b)</td>
<td>200 + j 50 (( \Omega ))</td>
<td>50 (( \Omega ))</td>
<td>0.42 ( \lambda )</td>
</tr>
<tr>
<td>(c)</td>
<td>– j 90 (( \Omega ))</td>
<td>60 (( \Omega ))</td>
<td>0.3 ( \lambda )</td>
</tr>
<tr>
<td>(d)</td>
<td>j 50 (( \Omega ))</td>
<td>25 (( \Omega ))</td>
<td>0.2 ( \lambda )</td>
</tr>
<tr>
<td>(e)</td>
<td>0 (( \Omega ))</td>
<td>90 (( \Omega ))</td>
<td>0.25 ( \lambda )</td>
</tr>
<tr>
<td>(f)</td>
<td>0 (( \Omega ))</td>
<td>90 (( \Omega ))</td>
<td>0.5 ( \lambda )</td>
</tr>
</tbody>
</table>
Part 2 – Branched Transmission lines

Objective
(i) To design a branched microstrip transmission line system
(ii) To obtain reflection coefficient (S_{11}), SWR and input impedance.
(iii) To compare analytical and simulated results

Circuit Diagram

Procedure

1. Use Designer, to design in microstrip configuration the transmission line system shown above, using RT5880 dielectric constant ε_r = 2.22 of thickness, h = 31 mils
2. Assign port #1 impedance as \( Z_g = Z_0 \), Port #2 impedance as \( Z_L \) and Port #3 impedance as \( Z_S \)
3. Use the values given in the table below for calculations.
4. Perform simulations for a frequency range 100 MHz to 1 GHz
5. Plot SWR and the complex reflection coefficient, S_{11}, at plane BB
6. From the value of S_{11} at 600 MHz, obtain and plot the input impedance \( Z_{in} = Z_{BB} \)
7. For #2 only, obtain the SWR, the complex reflection coefficient, S_{11} and the input impedance \( Z_{BB} \) at \( f = 600 \) MHz by the following methods
   a. Perform calculations on the Smith Chart
   b. Use analytical expressions.
   c. Compare simulation results with analytical and graphical results.

<table>
<thead>
<tr>
<th></th>
<th>( Z_L ) (Ω)</th>
<th>( Z_S ) (Ω)</th>
<th>( Z_0 ) (Ω)</th>
<th>( Z_{0S} ) (Ω)</th>
<th>( d/\lambda )</th>
<th>( l/\lambda )</th>
<th>( y/\lambda )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>70 + j 90</td>
<td>50 – j 50</td>
<td>100</td>
<td>50</td>
<td>0.186</td>
<td>0.078</td>
<td>0.25</td>
</tr>
<tr>
<td>2</td>
<td>50 – j 100</td>
<td>100 + j 50</td>
<td>100</td>
<td>50</td>
<td>0.206</td>
<td>0.43</td>
<td>0.15</td>
</tr>
<tr>
<td>3</td>
<td>30 + j 140</td>
<td>75 – j 90</td>
<td>100</td>
<td>75</td>
<td>0.47</td>
<td>0.082</td>
<td>0.25</td>
</tr>
<tr>
<td>4</td>
<td>100 – j 100</td>
<td>75 + j 130</td>
<td>100</td>
<td>75</td>
<td>0.075</td>
<td>0.435</td>
<td>0.5</td>
</tr>
</tbody>
</table>
Part 3 – Microstrip Transmission line feed system

Using Ansoft Designer, design a power divider in microstrip configuration starting from a 50 Ω source and feeding four antennas, each with an input impedance of 100 Ω. The inputs to each antenna are equal in magnitude and in phase.

Use Duroid RT5880 with dielectric constant, $\varepsilon_r = 2.2$, substrate thickness, $h = 1/16”$.

- Perform the design at a frequency, $f = 10$ GHz
- Using spacing $d = \lambda_0 / 2$
- Perform simulations in the X-band (8-12 GHz)
- Plot the complex reflection coefficient, $S_{11}$, the return loss, $RL$ (in dB) and the input impedance $Z_{in}$
- Plot SWR and determine the frequency bandwidth over which $SWR \leq 1.5$

Some hints

- Microstrip Lines characteristic impedances range $25 \leq Z_0 \leq 120$ Ω
- The 50 Ω feedline splits to 100 Ω each.
- If it splits again it will become 200 Ω, which is not acceptable.
- Therefore design a quarter wave transformer (QWT) to convert the 100Ω to 50 Ω before splitting it again.
- Place a “MS step” between lines of different widths.
- Place a “MS Tee” when a line splits into two.
- Place a “MS Bend” when the line curves around.