surface mount chip capacitor model

Model Features*
- Broadband validation: DC – 30 GHz
- Equivalent circuit based
- Applicable for horizontal mounted capacitors
- Substrate scalable: (1 ≤ H/Er ≤ 16.7 mil)
- Part value scalable: (0.1 to 220 pF)
- Validation: Equivalent series resistance
- Developed for microstrip interconnects

* See Technical Notes for more details

Model Update

The CAP-PPI-0805N-101 is a replacement to the CAP-PPI-0805N-001 model and is recommended for new designs with horizontal mounted parts. This update is based on a new manufacturing design for the capacitor family.

Model Description

The CAP-PPI-0805N-101 is a substrate scalable Microwave Global Model™ for the Passive Plus P/N 0805N surface mount chip capacitor family (additional information is available at www.passiveplus.com). The models are for use with microstrip applications and account for substrate (or printed circuit board) related parasitic effects. Substrate height, dielectric constant, loss tangent, interconnect metal thickness, component tolerance, pad width, pad length, and pad gap are model input parameters. Models account for up to two higher-order resonant frequency pairs beyond the fundamental series resonant frequency. The model is validated with measured equivalent series resistance (ESR). A single, substrate scalable pad scalable Microwave Global Model™ is available that accurately emulates all capacitor values within the valid capacitance range. A Sim_mode switch allows pad stack effects to be disabled.

Model simulation may vary slightly based on simulator used.

The pad dimensions used to develop datasheet plots for the model are: length = 47.2 (1.20), width = 61.0 (1.55), gap = 23.6 (0.60). Units in mil (mm).

### Frequency Sweep

![Frequency Sweep Graph](image)

Legend: □ 4 mil Rogers 4350B, + 20 mil Rogers 4003C, ◊ 60 mil Rogers 4003C, Lines - Model, Symbols - Measured data. Measured data stops at highest valid frequency for each substrate. S11 for a 2.7 pF capacitor mounted on various substrates from 0.05 to 30 GHz.

### Part Value Sweep

![Part Value Sweep Graph](image)

Legend: □ 4 mil Rogers 4350B, + 20 mil Rogers 4003C, ◊ 60 mil Rogers 4003C, O Ideal Model S11 at 0.6 GHz for capacitor values from 0.1 to 220 pF on various substrates compared to an ideal capacitor response.

www.modelithics.com  sales@modelithics.com  Rev. 20180820©2018
Technical Notes

- Two-port S-parameters were measured using a vector network analyzer and on-board probing with calibration referenced to the outside edges of the component pad stack.
- Capacitors were measured in a 2-port series configuration using a 50-ohm microstrip test fixture. Models for alternative interconnect configurations (e.g. coplanar waveguide) are available upon request.
- Nominal part value range (0.1 to 220 pF)
  - Tolerance on low value: ± 0.1
  - Tolerance on high value: 5%
  - Actual part value range (0.1 to 231 pF).
- Pad scalable models are validated with S-parameter measurements within the recommended pad range.
- Substrates used to extract the models: 4 mil Rogers 4350B, 20 mil Rogers 4003C, and 60 mil Rogers 4003C.
- Validated substrate range of substrate height and dielectric constant ratios based on substrates used to develop the model:
  \[1.0 \leq \frac{H}{E_r} \leq 16.7 \text{ (mil)}\]
  \[0.03 \leq \frac{H}{E_r} \leq 0.42 \text{ (mm)}\]
- Equivalent series resistance (ESR) was measured using a Boonton model 34A coaxial resonator line.
- Highest frequency for measurement validation: 30 GHz (4 mil Rogers 4350B), 12 GHz (20 mil Rogers 4003C), and 6 GHz (60 mil Rogers 4003C)
- Multiple simulation modes (Sim_mode) are available - full mode, ideal mode and no pad stack.

Device Image

Capacitor Values (pF)

<table>
<thead>
<tr>
<th>Value</th>
<th>0.1</th>
<th>0.2</th>
<th>0.3</th>
<th>0.4</th>
<th>0.5</th>
<th>0.6</th>
<th>0.7</th>
<th>0.8</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.9</td>
<td>1.0</td>
<td>1.1</td>
<td>1.2</td>
<td>1.3</td>
<td>1.4</td>
<td>1.5</td>
<td>1.6</td>
<td></td>
</tr>
<tr>
<td>1.7</td>
<td>1.8</td>
<td>1.9</td>
<td>2.0</td>
<td>2.1</td>
<td>2.2</td>
<td>2.4</td>
<td>2.7</td>
<td></td>
</tr>
<tr>
<td>3.0</td>
<td>3.3</td>
<td>3.6</td>
<td>3.9</td>
<td>4.3</td>
<td>4.7</td>
<td>5.1</td>
<td>5.6</td>
<td></td>
</tr>
<tr>
<td>6.2</td>
<td>6.8</td>
<td>7.5</td>
<td>8.2</td>
<td>9.1</td>
<td>10</td>
<td>11</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>15</td>
<td>16</td>
<td>18</td>
<td>20</td>
<td>22</td>
<td>24</td>
<td>27</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>33</td>
<td>36</td>
<td>39</td>
<td>43</td>
<td>47</td>
<td>51</td>
<td>56</td>
<td></td>
</tr>
<tr>
<td>62</td>
<td>68</td>
<td>75</td>
<td>82</td>
<td>91</td>
<td>100</td>
<td>110</td>
<td>120</td>
<td></td>
</tr>
<tr>
<td>130</td>
<td>150</td>
<td>160</td>
<td>180</td>
<td>200</td>
<td>220</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Highlighted capacitor values are measurement-based models. Other models found via interpolation. Table shows 70 part values in the model range based on manufacturer's datasheet.

PC Board Footprint

Model Input Parameters

- C - Nominal component value in pF. The full parasitic model is invoked if the part value is within the valid limits of the model, otherwise an ideal element model is used.
- Subst - Microstrip substrate instance name. The model will reference the named substrate instance to obtain values for H, Er, T and TanD.
- Sim_mode - 0 for full parasitic model, 1 for ideal element, 2 for removing pad effects.
- Pad_mode - 0 for default to Sim_mode, 1 for pads always in layout, 2 for pads never in layout
- Tolerance - Tolerance of the part value. The nominal value for this parameter should be set to 1. Use for statistical distribution.
- Pad_Width - Width of land pattern footprint
- Pad_Length - Length of land pattern footprint
- Pad_Gap - Pad - to - pad spacing (inside pad edge - to - inside pad edge)
- C_Discrete - Discrete input parameter based on manufacturer available part values can be used for tuning and optimization. Overrides C input parameter.
Model vs. Measured Series 2-port S-parameter Data

4 mil Rogers 4350B (H/Er = 1.0 mil):

20 mil Rogers 4003C (H/Er = 5.4 mil):

60 mil Rogers 4003C (H/Er = 16.7 mil):

Legend: □ 0.4 pF, + 6.8 pF, ◊ 180 pF, Solid lines - Model data, Symbols - Measured data
Effective Capacitance

Legend: Red solid lines - Model response on 60 mil Rogers 4003C
       Blue symbols - Measurement on 60 mil Rogers 4003C
       Note: Plot shows selected values within the model range.

Simulated Q-Factor

Legend: solid lines - Model response on 60 mil Rogers 4003C
       Note: Plot shows selected values within the model range.

Model and Datasheet Revision Notes

8/13/2018       Original model and datasheet development
Denotes plated copper land pattern free of solder mask.