Application Note 61

Additional Pad Features for Modelithics CLR Library™ Models–

PCB Layers and Pad Connection Options in Keysight ADS

Starting in the v17.0 release of the Modelithics library for Keysight ADS, some additional pad handling parameters, affecting both layout and simulation accuracy, were added to the dynamic pad models in the CLR Library™. These new options are an addition to the pad parameters introduced in Application Note 57 – Advanced Pad Model Feature in the Modelithics Library. Among the new features is one specifically addressing applications for shunt parts mounted directly on microstrip lines that has been requested by multiple customers. This note will provide an overview of all the latest pad features and how to use them.

The new features allow the user to change the angle at which the model’s pad is connected to the adjacent element, set the placement of the pad and the amount of the pad calculated by the model, and add solder mask and solder paste layers in the layout. The parameters for the new features are not listed with the model symbol in the schematic but are found by viewing the detailed model properties information. The default setting for these new features are set so that the simulation and layout are unaffected.

FIGURE 1 – EXAMPLE MODEL SYMBOL FOR AN ATC CAPACITOR MODEL IN KEYSIGHT ADS, WITH THE NEW MODEL FEATURES DISPLAYED: SOLDER MASK/MASK APERTURE, SOLDER PASTE/PASTE APERTURE, PADANGLE (1 AND 2), AND PADINMODEL (1 AND 2).
**Solder Mask**

The Solder Mask parameter as well as the associated Solder Paste parameter were added in response to customer requests. The Solder Mask parameter has three settings:

- 0 - No Solder Mask
- 1 - Pads Separately
- 2 - Pads Together

The default value “No Solder Mask” does not draw a solder mask in the layout. The “Pads Separately” option draws a box around each of the pads in the layout. Use the MaskAperture parameter to define the size of the solder mask opening around both pads. The default value of the aperture is 75um.

The final option for the Solder Mask parameter is “Pads Together”. This option will define a single solder mask aperture around both pads. This option is typically used for smaller components (0201 or smaller). The option also uses the Mask Aperture setting to define the size of the solder mask aperture around the pads.
FIGURE 3 - EXAMPLE OF ADDED SOLDER MASK LAYER IN AN ADS LAYOUT WITH SOLDER_MASK PARAMETER SET TO 2 (“PADS TOGETHER”)

The Mask Aperture parameter can be positive or negative. A positive value will extend the aperture outside the pad, whereas a negative value will create the aperture inside the pad.

**Solder Paste**

Like Solder Mask, this feature only affects the model layout. Neither feature changes the model’s simulation response. The Solder Paste feature has 2 settings:

- 0 - No Solder Paste
- 1 - Include Solder Paste

As with Solder Mask, the Solder Paste default is to not draw the solder paste layer and is set to “No Solder Paste”. When the parameter is set to “Include Solder Paste” an additional layer with specified aperture is created in the layout, using the “Paste Aperture” parameter value to determine the size of the aperture relative to the pad. As with the Mask Aperture setting, this value
can be either positive or negative which determines if the aperture circumscribes or inscribes the pads respectively. The default value for this parameter is -75um.

**FIGURE 4 - EXAMPLE OF ADDED SOLDER PASTE LAYER IN AN ADS LAYOUT WITH SOLDER_PASTE PARAMETER SET TO 1 (“INCLUDE SOLDER PASTE”)**

Figure 4 shows the Solder Paste feature alone, however the Solder Paste and Solder Mask options are generally used together. Figure 5 shows an example of both features in use. Lines were added to help identify the various objects in the image.

**FIGURE 5 - EXAMPLE OF ADDED SOLDER MASK AND SOLDER PASTE LAYERS IN A KEYSIGHT ADS LAYOUT WITH SOLDER_MASK=1 (PADS SEPARATELY) AND SOLDER_PASTE=1 (INCLUDE SOLDER PASTE).**
**MSUB**

In Keysight ADS, the names of layout layers, including those used by both Solder_Mask and Solder_Paste features can be customized using one of the Modelithics substrate model MSUB blocks included with the Modelithics Library. The substrate definitions in the Modelithics substrate library include layer name settings for standard layout layers, as well as the layers that correspond to Solder Mask and Solder Paste options in Modelithics models. The ADS layout layer names used by any Modelithics model can be customized in the extra parameters of a Modelithics MSUB substrate definition block. Figure 6 is an example of a Modelithics substrate definition in ADS showing some of the layer definition parameters that can be used to change Modelithics’ model layout layers. While the Modelithics substrate library MSUB definition includes these additional parameters, they can still be used by built-in ADS components and the extra parameters will be ignored.

```plaintext
MSub
Mdix10MiiRogers4350B
MSub1
Cond1="cond: drawing"
Hole="hole: drawing"
Package="packages: drawing"
Leads="leads: drawing"
Solder_mask="solder_mask: drawing"
Solder_paste="pc1: drawing"
```

**FIGURE 6 – EXAMPLE ADS MSUB BLOCK FROM THE MODELITHICS SUBSTRATE LIBRARY SHOWING SELECTED MODEL LAYOUT LAYERS AND CORRESPONDING ADS LAYOUT LAYER DEFINITIONS.**

**Pad Angle**

“Pad Angle” was added with the v17.0 release. This parameter changes how the pads are connected in the layout and alters the model response accordingly. There are two PadAngle parameters in each model, so that the pad connection angle can be set for each pad independently. That is, the PadAngle1 parameter affects the pad at port 1 and PadAngle2 affects the pad at port 2.

Pad Angle changes the direction at which the adjacent component connects with the model pad. The available options are:

- 0 - 0 Degrees (Default)
- 1 - 90 Degrees
- 2 - -90 Degrees
The default setting of “0 Degrees” leaves the pin at the outside edge of the pad along the width of the pad. The 90 Degrees setting rotates the pin clockwise and -90 Degrees setting rotates the pin counter-clockwise. In Figure 7, PadAngle1 is changed to show all 3 available options “(-90) Degrees”, “0 Degrees” (default) and “90 Degrees” while PadAngle2 is left at the default value. The Pad Angle parameters are completely independent of each other and can be set to any combination.

**FIGURE 7 – EXAMPLE OF PADANGLE1= (-90) DEGREES (LEFT), 0 DEGREES (CENTER – DEFAULT) AND 90 DEGREES (RIGHT). THE PIN ON THE PORT 1 PAD ROTATES AND THE MODEL IS CONNECTED TO THE ADJACENT MICROSTRIP LINE ELEMENT AT THE NEW PIN LOCATION. IMAGE SHOWN IS FROM KEYSIGHT ADS.**

Due to the change in the location of the pin on the pad there is a slight change in the model performance. The graphs shown in Figure 9 use the following schematic (Figure 8) in Keysight ADS to illustrate the slight change in the model performance with pad angle for an example 0805 size capacitor.
FIGURE 8 – EXAMPLE SCHEMATIC USING PADANGLE SETTINGS. THE PADANGLE1 SETTING FOR THE PAD ON PORT1 IS CHANGED FROM 0° (DEFAULT) TO 90°. PADANGLE2 IS LEFT AT THE DEFAULT SETTING. THE MODEL USED IS CAP-JOH-0805-101 ON A 6.6MIL ROGERS 4350B SUBSTRATE.
FIGURE 9 – EXAMPLE OF PADANGLE1 SIMULATION RESULTS. RED LINES ARE PADANGLE1 = 0° (DEFAULT) AND BLUE LINES ARE PADANGLE1 = 90°. TOP GRAPHS ARE S11 MAGNITUDE (LEFT) AND PHASE (RIGHT). LOWER GRAPHS ARE S21 MAGNITUDE (LEFT) AND PHASE (RIGHT).

Pad In Model

Pad In Model is another feature that was added with the v17.0 release and can be applied to each pad separately. The PadInModel parameters alter the percentage of the pad calculated by the model and change the location of the pin. Valid values for Pad In Model are:

- 100%: reference plane at edge of pad (Default)
- 50%: reference plane at center of pad.
- 0%: reference plane at edge of part.
- Shunt: part mounted on microstrip line.

As with the other pad parameters, the default value (100%) does not alter the original model’s performance or layout. At 50%, the model calculates half the pad and moves the pin to the center of the pad. Figure 10 shows PadInModel1 set to 3 of the options 100% (default), 50% and 0% while leaving PadInModel2 to the default 100%. The reference plane for PadInModel at 50% is moved to the center of the pad and to the part edge for 0%.

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FIGURE 10 – EXAMPLE OF PADINMODEL PARAMETER ADJUSTMENT WITH PADINMODEL1=100% (DEFAULT – LEFT), 50% (CENTER) AND 0% (RIGHT) AND PADINMODEL2=100% (DEFAULT - ALL)

The Pad In Model setting of 0% removes the pad from the layout and places the pin at the edge of the part. This is similar to the Sim_mode = 2 setting (See Application Note 57 Advanced Pad Model Features in the Modelithics Library for more information on the Sim_mode parameter), except that it only affects a single pad. The graphs below use the following schematic (similar to the previous schematic) in Keysight ADS to illustrate the slight change in the model performance.

FIGURE 11 – EXAMPLE SCHEMATIC USING PADINMODEL1 SETTING. THE PADINMODEL1 SETTING FOR THE PAD ON PORT 1 IS CHANGED FROM 100% (DEFAULT) TO 50%. PADINMODEL2 IS LEFT AT THE DEFAULT SETTING. THE MODEL USED IS CAP-JOH-0805-101 ON A 6.6MIL ROGER'S 4350B SUBSTRATE.
FIGURE 12 – EXAMPLE OF PADINMODEL1 SIMULATION RESULTS. RED LINES ARE PADINMODEL1 = 100% (DEFAULT) AND BLUE LINES ARE PADINMODEL1 = 50%. TOP GRAPHS ARE S11 MAGNITUDE (LEFT) AND PHASE (RIGHT). LOWER GRAPHS ARE S21 MAGNITUDE (LEFT) AND PHASE (RIGHT).

FIGURE 13 – EXAMPLE LAYOUT IN ADS WITH PADINMODEL1 SET TO “SHUNT: PART MOUNTED ON MICROSTRIP LINE”. THE PORT 1 TERMINAL OF THE PART IS MOUNTED ON THE EDGE OF THE MICROSTRIP LINE AND NO EXTRA PAD EXTENDS FROM THE LINE.
The final setting of the Pad In Model feature is called “Shunt: Part mounted on microstrip line”. This setting simplifies the circuit and layout setup for the case where a part is in shunt configuration with one terminal mounted on a microstrip line as shown in Figure 13. For more information on this setting, see the updated Application Note 016 Using Modelithics CLR Library Models in Shunt Connections.

Pad In Model and Pad Angle settings are mutually exclusive when defining the same pad. The associated Pad Angle setting will be ignored if Pad In Model is changed from the default.

See Also

- Application Note 16 – Using Modelithics CLR Library Models in Shunt Connections
- Application Note 25 – The Importance of Pad Geometry in Maximizing Surface Mount Component Performance
- Application Note 27 – Pad Scaling Effects on Lumped Filters
- Application Note 57 – Advanced Pad Model Features in the Modelithics Library

About this note

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