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Bond Wire Modeling Standard

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BOND WIRE MODELING STANDARD

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BOND WIRE MODELING STANDARD

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BOND WIRE MODELING STANDARD

(From JEDEC Council Ballot JCB-96-22, formulated under the cognizance of JC-15 Committee on Electrical and Thermal Characterization Techniques for Electronic Packages and Interconnects)

1 Objective

The objective of this standard is to standardize the first order modeling of bond wires and the way bond wires are modeled in three dimensional electromagnetic field solvers.

2 Scope

This standard describes the modeling of a bond wire from an integrated circuit (IC) die to a package lead in a ball or wedge type wire bond configuration.

3 Introduction

This standard provides a means of describing a bond wire through the use of five parameters. By specifying these parameters, anyone may duplicate the drawing of the bond wire either on a plot or with a three dimensional field solver.

4 Parameter descriptions

There are five parameters and two constraints needed to completely draw a bond wire. These parameters and constraints are shown in figure 1.

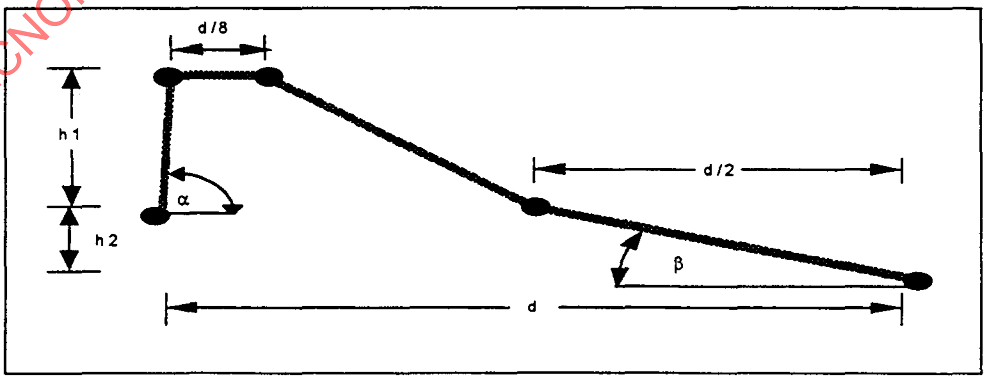


Figure 1 — Parameters and constraints

4 Parameter descriptions (cont'd)

The parameters are:

α = The angle between horizontal plane and the wire at the bond pad.

β = The angle between horizontal plane and the wire at the lead.

d = Total distance the wire covers in the horizontal plane.

h1 = The height between the bond pad and the top of the loop.

h2 = The height between the bond pad and the lead.

The two constraints are:

X_3 set at X_2 + d/8 and is the approximation for the location of the end of the loop.

X_4 set at d/2 and is the approximation for loop width.

(See figure 2 for coordinate locations)

The (X_3, Y_3) and (X_4, Y_4) positions are approximations based on observations of actual bond wires. When changes to the above constraints are required, the changes must be included in the report. The differences in X_3, X_4 and Y_3, Y_4 must be noted.

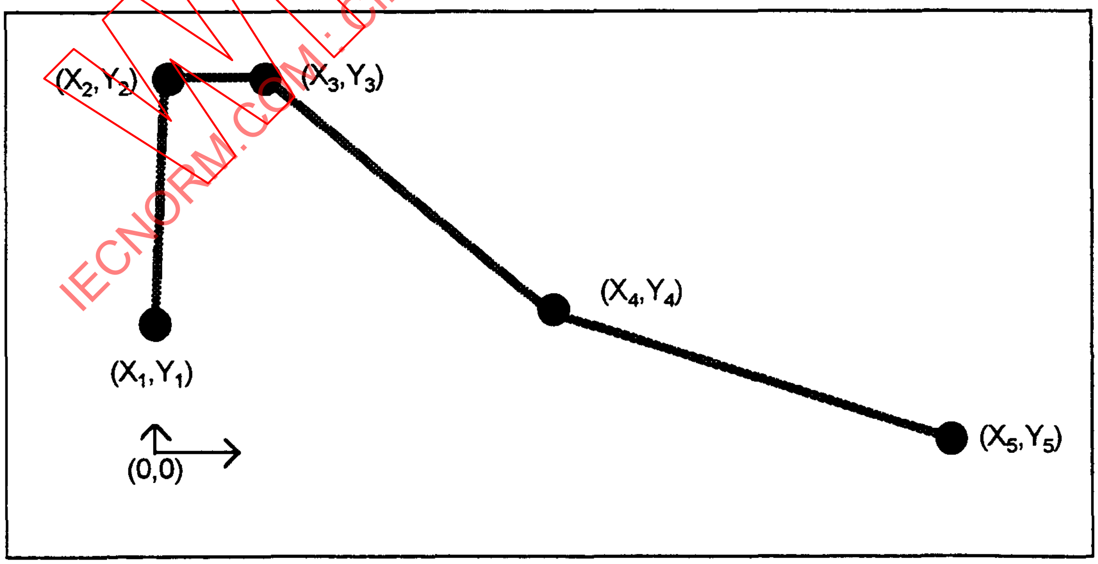


Figure 2 — Coordinates

5 Bond wire model

5.1 Preferred model

The bond wire model can be completely drawn as there are five points on an X - Y grid that can be determined from the parameters. These five points are shown in figure 2. The calculation of these points is shown in table 1. Figure 3 shows the parameters, constraints, and the coordinates combined. It can be seen in figure 3 that the top of the loop is 1/8 the distance of the wire along the horizontal plane, and the fourth point is 1/2 the distance of the wire along the horizontal plane.

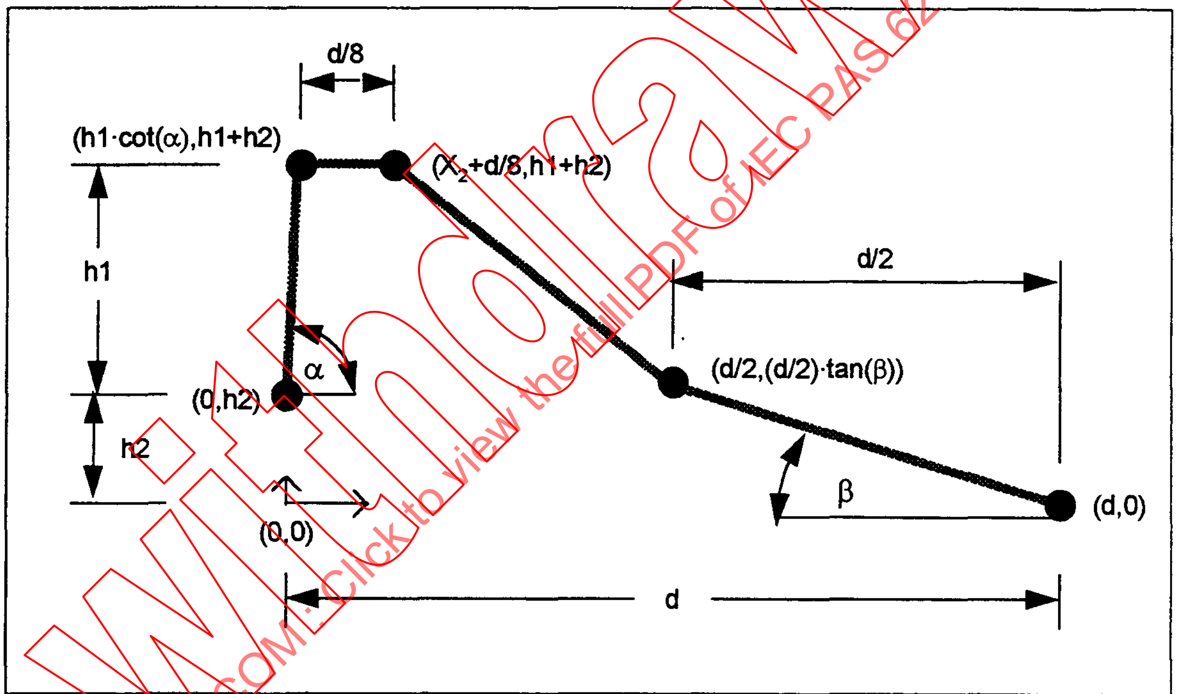


Figure 3 — Parameters and coordinates

Table 1 — Calculation of bond wire coordinates

X = Value	Y = Value
$X_1 = 0$	$Y_1 = h2$
$X_2 = h1 \cdot \cot(\alpha)$	$Y_2 = h1 + h2$
*$X_3 = X_2 + d/8$	$Y_3 = h1 + h2$
*$X_4 = d/2$	$Y_4 = (d/2) \cdot \tan(\beta)$
$X_5 = d$	$Y_5 = 0$
* Values of X3 and X4 may be some division of d other than d/8 and d/2 respectively, but these values have been found representative of most bond wire geometries.	

5.2 Model simplification

The exact bond wire profile may be unknown. If necessary the model in 5.1 may be simplified by setting α = to 90 degrees and eliminating coordinate (X_4, Y_4), constraint d/2 and parameter β. This simplified version is shown in figure 4.

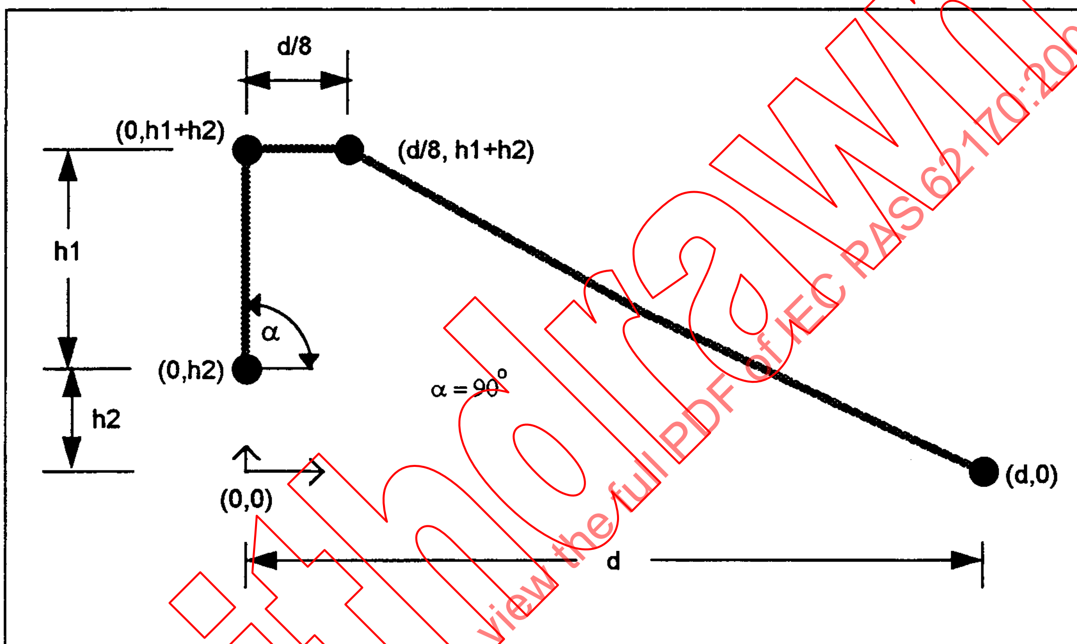


Figure 4 — Simplified bond wire model

Table 2 — Calculation of simplified bond wire coordinates

X = Value	Y = Value
$X_1 = 0$	$Y_1 = h2$
$X_2 = 0$	$Y_2 = h1 + h2$
$X_3 = d/8$	$Y_3 = h1 + h2$
$X_4 = NA$	$Y_4 = NA$
$X_5 = d$	$Y_5 = 0$

6 Electrical parameter approximations

Once the bond wire parameters have been defined and the coordinates calculated, the overall length of the bond wire can be calculated. First order approximations for the inductance and resistance can then be calculated.

6.1 Length determination

The bond wire is broken up into four sections: L1, L2, L3, and L4 as shown in figure 5. The length of each section of the bond wire can be calculated, and then summed to find the overall length. Each section can be calculated as shown in table 3. For the simplified model, the bond wire lengths are shown in figure 6 and calculated in table 4.

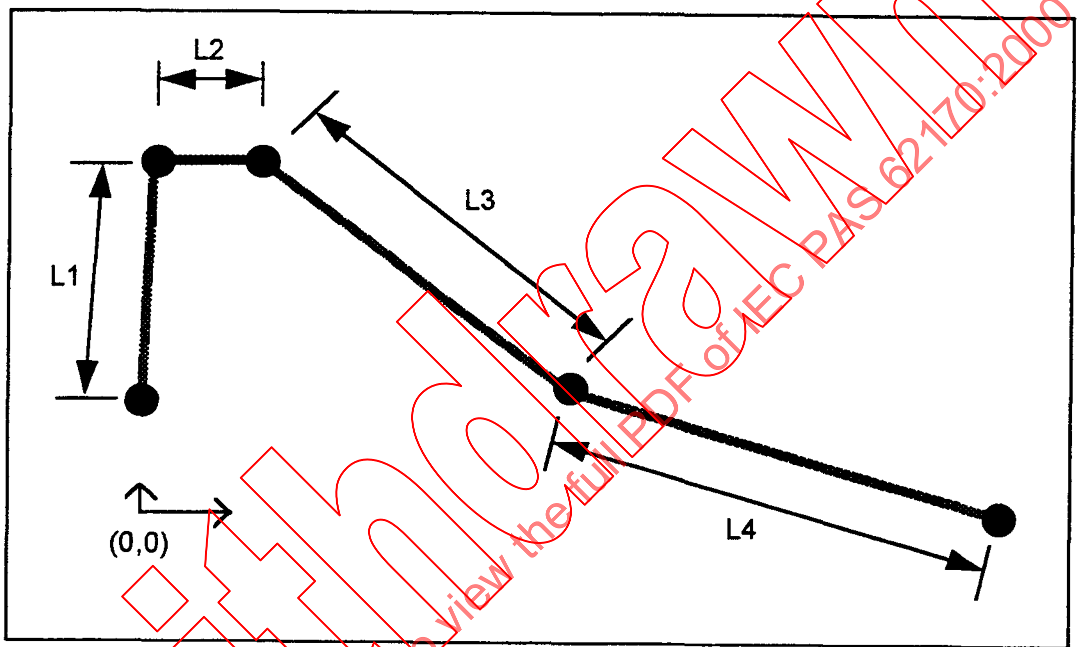


Figure 5 — Bond wire sections for the preferred model

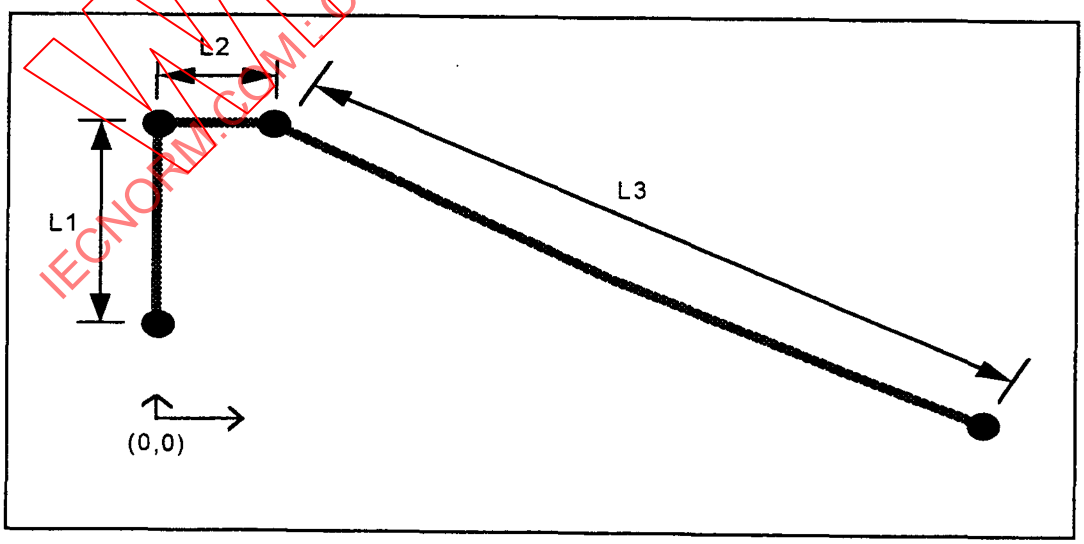


Figure 6 — Bond wire sections for simplified model

6.1 Length determination (cont'd)

Table 3 — Bond wire length calculation

Section = Value
$L1 = \sqrt{(X_2)^2 + h1^2}$
$L2 = X_3 - X_2$
$L3 = \sqrt{(X_3 - X_4)^2 + (Y_3 - Y_4)^2}$
$L4 = d/2 \bullet \sec(\beta)$
$Length = L1 + L2 + L3 + L4$

Table 4 — Simplified bond wire length calculation

Section = Value
$L1 = h1$
$L2 = X_3 - X_2$
$L3 = \sqrt{(X_3 - X_5)^2 + (Y_3 - Y_5)^2}$
$Length = L1 + L2 + L3$

6.2 Inductance approximation

The first order self inductance can be approximated by the closed form expressions in table 5.

6.3 Resistance approximation

The dc resistance can also be approximated if the diameter of the wire is known. The dc resistance is given by R_{dc} (in ohms):

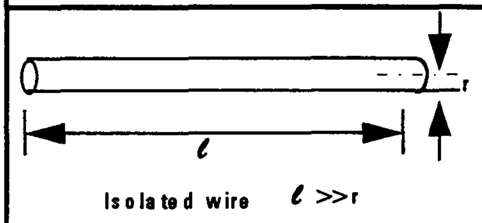
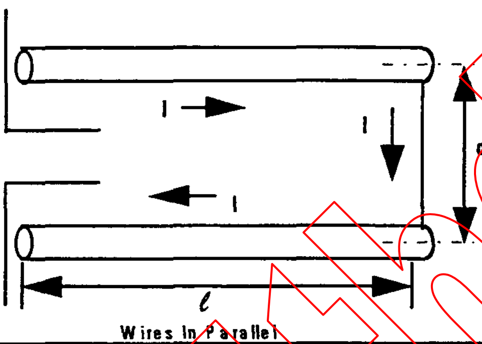
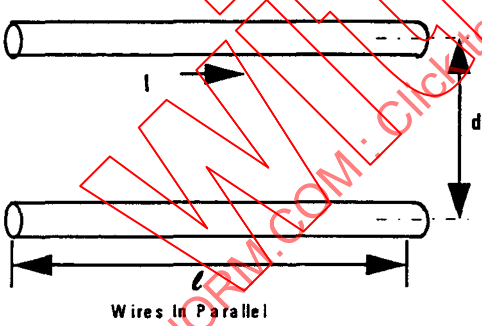
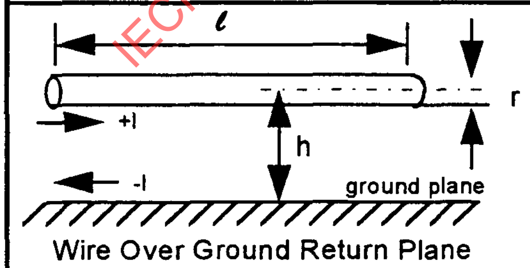
$$R_{dc} = \frac{Length}{s \cdot A}$$

where

L is the total length of the wire
σ is the conductivity of the wire
A is the cross sectional area of the wire

6.3 Resistance approximation (cont'd)

Table 5 — Inductance formulas for calculations

Configuration	Formulas (All dimensions in cm, inductance in nH.)
	DC: $Ls = 2\times\ell\left[\ln\left(2\times\frac{\ell}{r}\right)-0.75\right]$ nH (1) [1] AC: $Ls = 2\times\ell\left[\ln\left(2\times\frac{\ell}{r}\right)-1.0\right]$ nH (2) [1]
	Loop Inductance of two parallel wires: $L = 2Ls - 2M$ (3) [1]
	Mutual inductance of two parallel wires is the number of flux lines surroundng both wires due to a unit current in one wire: $M = 2\times\ell\left[\ln\left(\frac{2\ell}{d}\right)-1+\frac{d}{\ell}\right]$ nH (4) [1] Assumption: Non-magnetic material, $\ell >> d$
	Self inductance per length of a wire over a ground plane: $Ls = 2\left[\ln\left(\frac{2h}{r}\right)\right]$ H/cm ; (5) [2] [3] $R_r << h << \ell$

7 Implementation

7.1 Package interpretation

Each bond wire in a package will have its own set of five parameters. The bond wire starts in the middle of the bond pad and contacts the center of the lead at distance d as shown in figure 7.

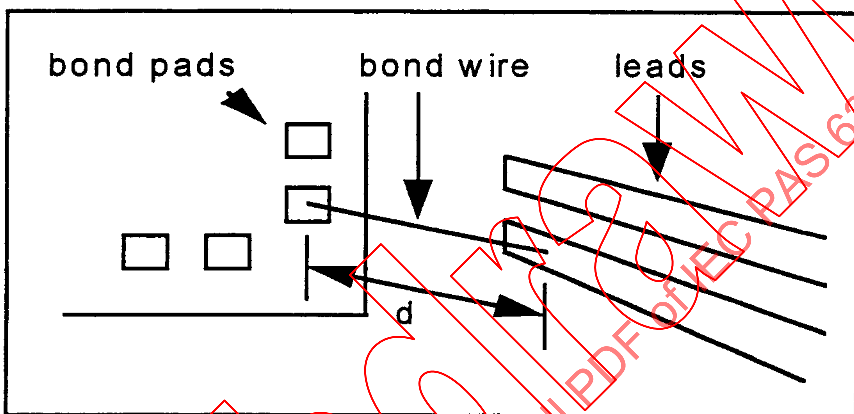


Figure 7 — Top view of bond wire

7.2 Implementation in a three dimensional field solver

The implementation of the bond wire geometry in a three dimensional field solver should be accomplished by the translation of a polygon, representing the cross-section of the bond wire, along the one-dimensional path specified earlier. This polygon should have at least four sides and should have the same cross-sectional area as the wire itself. The number of sides the polygon contains should be included in the final report along with the five parameters.

8 Report on models and results

The report should describe the five parameters for each bond wire. Tables 1 and 3 (preferred model) or tables 2 and 4 (simplified model) should be reported along with the values of the parameters and constraints listed in table 6. If the electrical parameters were calculated, they should also be reported, along with the calculated lengths, cross-sectional area, and conductivity of the material. If the model was done using a three dimensional field solver, the number of sides of the swept polygon should be reported.

8 Report on models and results (cont'd)

Table 6 — Parameters and constraints

Parameter and Constraints	Value (units)
h1	
h2	
d	
d/8	
d/2	
α	
β	