

PLASTIC PACKAGES' ELECTRICAL PERFORMANCE: REDUCED BOND WIRE DIAMETER

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Abstract

The effects of different bond wire diameters and bond pad pitch on the electrical performance of a package are shown and explained. A detailed study of the simultaneous switching noise, crosstalk and ohmic drops is presented.

Introduction

The current trend in semiconductor towards sub-micron technology has increased the density of logic circuits in smaller die sizes [1]. The number of I/Os is increased. Consequently, the pad pitches have reduced. This reduction required thinner bond wires for proper bonding.

This paper presents the effect of different bond wire diameters and the impact of pitch reduction on the electrical performance of plastic packages. The trend represents a major challenge in package characterization because of the difficulty associated in measuring the complex electromagnetic interactions within a difficult to reach area of the package. Thus, an efficient approach is to create bond wire models with acceptable accuracy to predict their performance using a commercially available 3D electromagnetic field solver [2].

Bond Wire Modeling

The modeling and simulation were performed in presence of an ideal ground plane at 30 mil below bond wire. The bond wire modeling consisted of four sets of different wire diameters at 0.8mil, 1.0mil, 1.2mil, and 1.3 mil, employing two separate bond pad and bond finger pitches (Fig 1). Straight-line structure was used to model the gold bond wires. The bond wires embedded in a plastic mold compound with 4.3 dielectric constant. The simulation was performed in the presence of eleven bond wires. However, only the inner most seven within eleven are reported. Beyond these seven inner most seven bond wires accuracy suffers due to diminishing electromagnetic fields (Fig 2).

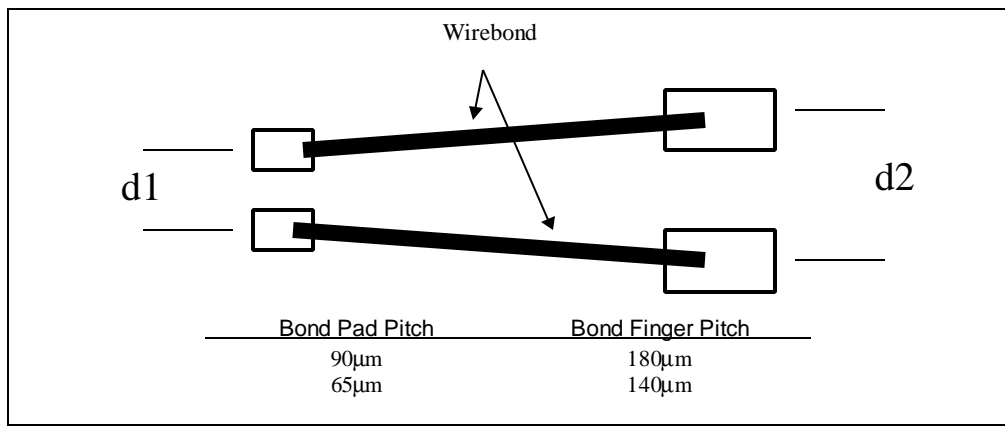


Figure 1: Bond Pitch

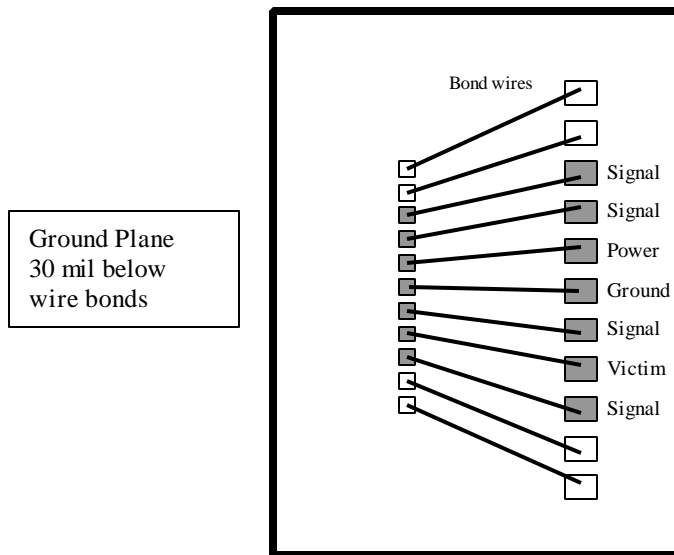


Figure 2: Bond Wires' Modeling Structure

Parasitic parameter for 90mm bond pad pitch and 180mm bond finger pitch

Length	Wire Length	Bond wire Diameter				Percentage change		
		0.8 mil	1.0 mil	1.2 mil	1.3 mil	1.3-1.2	1.3-1.0	1.3-0.8
Resistance (Ohm)	5 mm	0.383	0.257	0.198	0.180	9.60	42.34	112.71
	2 mm	0.154	0.103	0.079	0.072	9.65	42.58	113.24
Inductance (nH)	5 mm	6.103	5.869	5.668	5.576	1.65	5.25	9.45
	2 mm	2.089	1.996	1.915	1.879	1.92	6.23	11.18
Capacitance (pF)	5mm	0.202	0.242	0.279	0.299	-6.66	-19.20	-32.31
	2mm	0.104	0.122	0.140	0.149	-6.12	-17.74	-30.04
Mutual Inductance (nH)	5 mm	3.320	3.318	3.314	3.311	0.09	0.21	0.27
	2 mm	0.9798	0.9787	0.9770	0.9758	0.12	0.30	0.41
Mutual Capacitance (pF)	5 mm	-0.0374	-0.0488	-0.0602	-0.0698	-13.74	-30.10	-46.37
	2 mm	-0.0204	-0.0261	-0.0327	-0.0364	-10.06	-28.28	-43.89

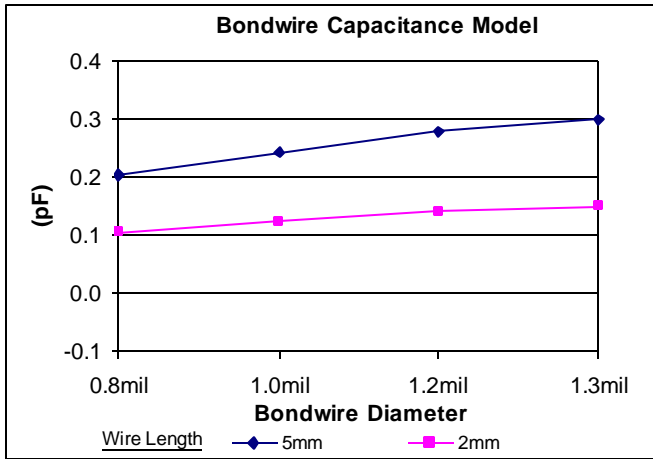
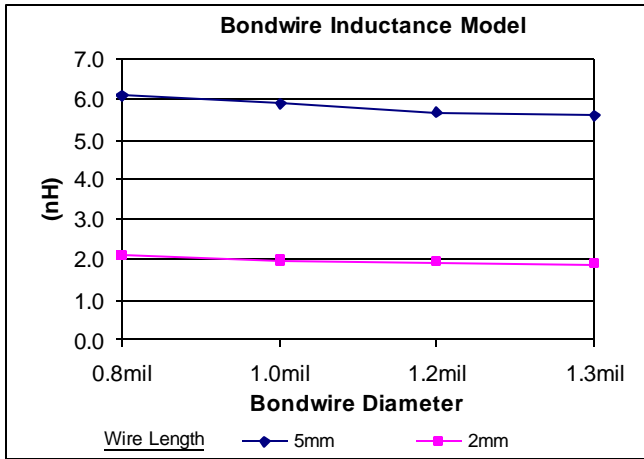


Figure3: Inductance and Capacitance of bond wire for 90um Bond Pad Pitch and 180um Bond Finger Pitch structure

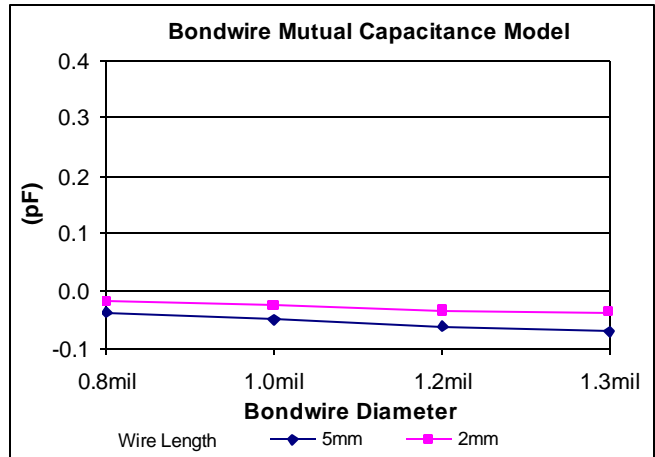
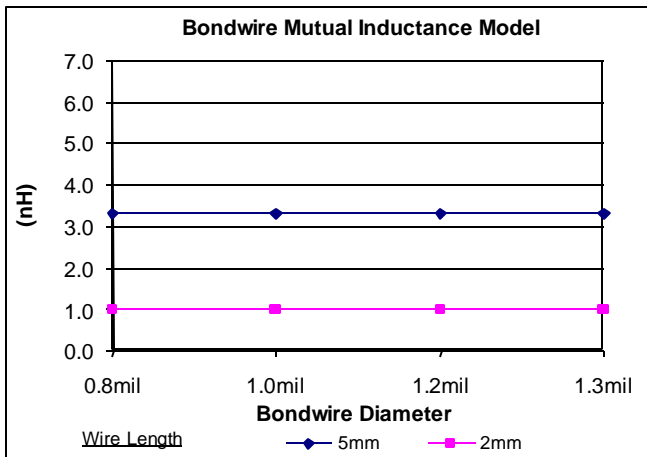


Figure 4: Mutual Inductance and Capacitance for 90um Bond Pad Pitch and 180um Bond Finger Pitch structure

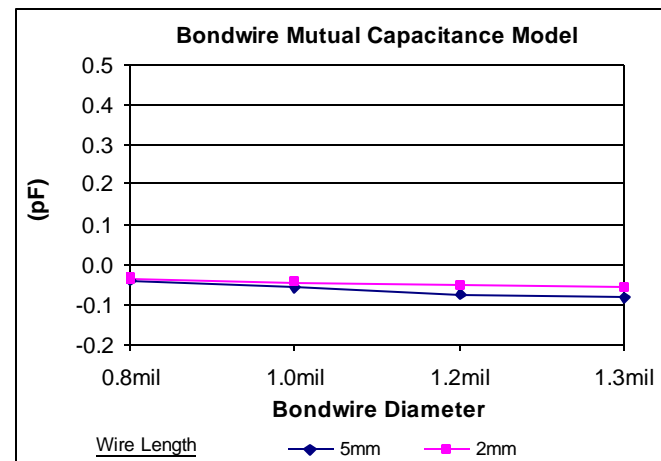
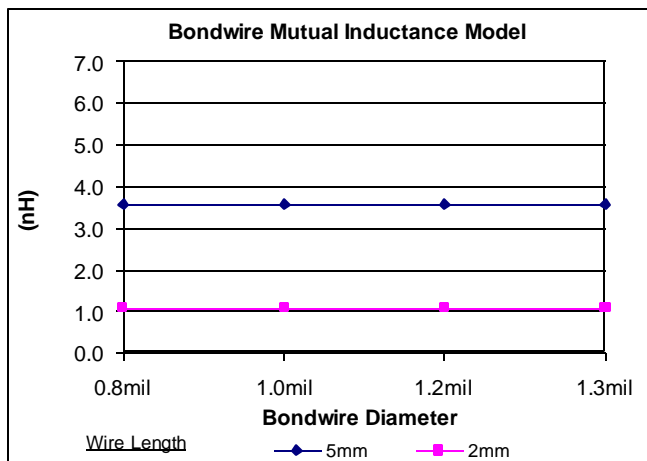


Figure 5: Mutual Inductance and Capacitance for 65um Bond Pad Pitch and 140um Bond Finger Pitch structure

The results indicate significant increase in wire resistance and up to 10% increase in the wire inductance with reduction of bond wire diameter from 1.3mil to 0.8 mil. The bond wire capacitance decreased by 30% with the same reduction of the bond wire diameter. Capacitance and inductance coupling changes were insignificant. Also, by reducing bond pad pitch from 90 μ m to 65 μ m and bond finger pitch from 180 μ m to 140 μ m increased the capacitance coupling by 15% and inductance coupling by 10%.

Simultaneous Switching

Ground Bounce is the noise generated in high speed components by simultaneous switching of multiple device outputs [3]. The package is usually the biggest contributor to this noise, even though it is actually generated in all parts of the power distribution interconnect between the power supply and the Integrated Circuit. As a general rule 70%-90% of the power path inductance is concentrated in the bond wire for PBGA packages, and 30%-70% of the power path inductance is concentrated in the bond wire for lead frame packages. The entire package parasitic except for the bond wire was ignored during Simultaneous Switching analysis for the purpose of identifying and visualizing the bond wire effects (Fig 2). Five high current driver (-32mA I_{OH} , 64mA I_{OL}) from Texas Instruments CMOS LEVEL 13 (ABT125N) I/O Model buffers were used for the simultaneous switching and switched at 500 ps. The non-linear drivers were attached to 1.4 inch ideal Transmission Line with a 5.0 pF capacitive load.

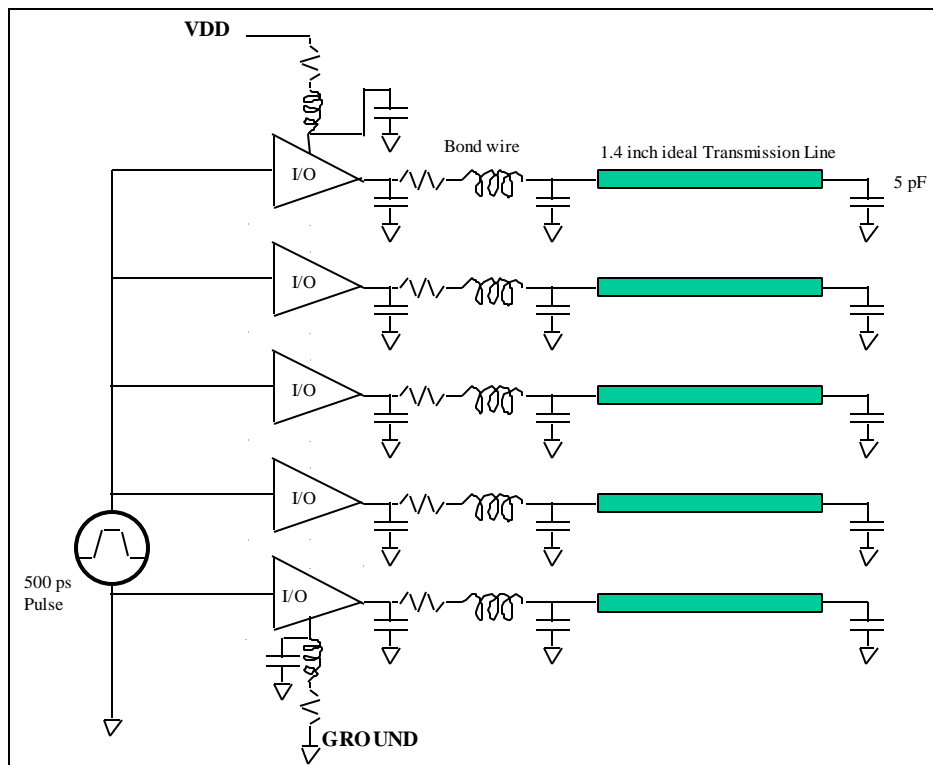


Figure 6: Simultaneous Switching SPICE Circuit

- Reducing wire diameter from 1.3 mil to 1.2 mil increased SSN Percentage by = 2.6%
- Reducing wire diameter from 1.3 mil to 1.0 mil increased SSN Percentage by = 3.6%
- Reducing wire diameter from 1.3 mil to 0.8 mil increased SSN Percentage by = 6.4%

Percentage increase in the SSN noise due to bond wire diameter reduction is negligible at 1ns or higher switching rates.

Crosstalk

The inductance of the signal path can generate simultaneous switching noise. Additional inductance and capacitance coupling among the network elements can cause crosstalk on the bus line. The noise appears on the output of an idling circuit that connects to the same network elements. This will lead to a latch or false signal to the idle line if the coupling noise becomes greater than the voltage threshold. Peak to peak voltage for Near end and Far end crosstalk have been compared as follow:

Near end crosstalk:

Reducing wire diameter from 1.3 mil to 1.2 mil increased crosstalk Percentage by = 02%

Reducing wire diameter from 1.3 mil to 1.0 mil increased crosstalk Percentage by = 04%

Reducing wire diameter from 1.3 mil to 0.8 mil increased crosstalk Percentage by = 12%

Far end crosstalk:

Reducing wire diameter from 1.3 mil to 1.2 mil increased crosstalk Percentage by = 01%

Reducing wire diameter from 1.3 mil to 1.0 mil increased crosstalk Percentage by = 05%

Reducing wire diameter from 1.3 mil to 0.8 mil increased crosstalk Percentage by = 10%

Bond Wire Resistance and Fusing Current

The increases in bond wire resistance was the most significant among other parasitic parameters. The bond wire diameter reduction from 1.3 mil to 1.2 mil, 1.0 mil and 0.8 mil increased the wire resistance by 10%, 40%, and 110% respectively. The increase in resistance will impose a limitation on fusing current see Fig 6 [4]. In addition, the increase in the resistance will act as dumping resistance, and it will improve quality of the signal.

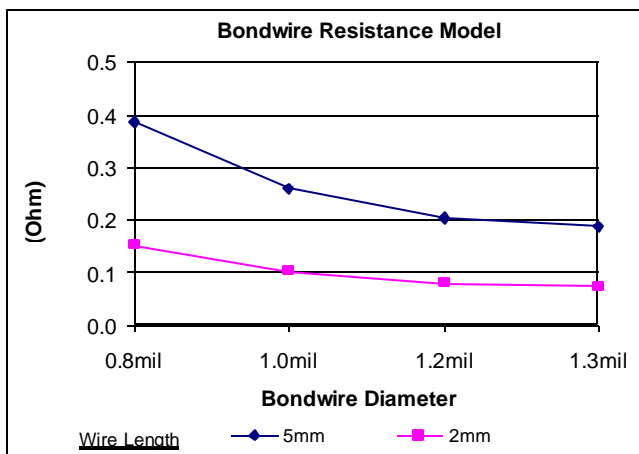


Figure 5: Bond wire resistance in Ohm

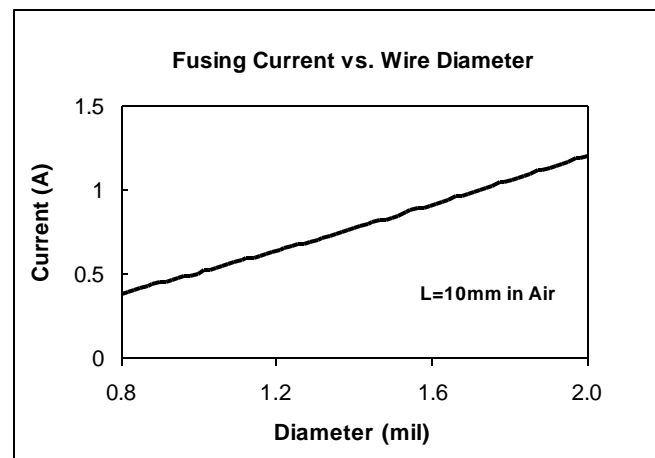


Figure 6: Bond wire diameter effects on Fusing current

Conclusion

The bond wire diameter reductions increase the inductance of the bond wire by 2-11%, and decrease the capacitance by 6-30%. The inductance and capacitance change have a moderate effect on the ground/power bounce and the crosstalk. A resistance increase will affect the current density of the power distribution system of the package. This problem can be dealt with by grouping two to three bond wires for ground and power connections. Careful design and understanding noise budget may permit the package to migrate to smaller diameter bond wires and bond pad pitch.

References

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3. E.Kurzweil et al " Catch ground bounce before it hits your system" IEEE International Test Conference 1993, pp. 574-584
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