EXTRACTION OF PARASITIC PARAMETERS FOR QFN32

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ABSTRACT

The Quad Flat No Lead or QFN package, a near CSP lead frame, is a promising choice for portable wireless applications such as BluetoothTM and RF SoC. Excellent attributes of this advanced package include miniaturized footprint, good electrical performance and excellent thermal characteristics. In this paper, the parasitic parameters of one signal path for a typical 32 I/O (0.5 mm pitch)QFN package structure, were extracted precisely using Ansoft HFSS and ADS of the Agilent company.

Index Terms—Parasitic Parameters, HFSS, ADS, extraction, optimization

1. INTRODUCTION

Rapidly improving operation frequency of Integrated Circuit, development of wireless communication, along with an increasing demand for miniaturisation, are driving towards more functionality, faster performance, lower power consumption and lower operating voltages. The role of today's packages is becoming more and more important for their impact on signal integrity, insert loss etc. The QFN package, a near CSP leadfame, is strongly emerging as a promising choice for portable wireless applications . Key advantages of this advanced package are miniaturized footprint, good electrical performance and excellent thermal characteristics.

Due to the relatively high operating frequency, the impact of the chip package on IC performance should be considered seriously. A bad package design even leads to chip failure, therefore, the extraction of accurate package parasitic parameters for chip designers, to realize the collaborative design of chip and package, not only can optimize the performance of the chip, but also can greatly shorten the development cycle and reduce costs.

HFSS is a well-known high-performance full-wave electromagnetic(EM) field simulator for arbitrary 3D volumetric passive device modeling .It can solve 3D EM problems quickly and accurately . Because Ansoft HFSS employs the Finite Element Method(FEM), adaptive meshing to solve Maxwell equations, theoretically the calculation accuracy is not limited to frequency. So it can be used to calculate parameters such as S Parameters(scattering parameters), Resonant Frequency, and Fields.

In this paper we firstly model and simulate the QFN32 package in HFSS and get the precise full-wave S parameter results of a chosen signal path. And then put forward the T equivalent circuit of the signal path. To get the accurate component values of the equivalent circuit, we establish the T-equivalent circuit of the signal path in ADS and perform its S parameter simulation in the frequency band we are interested in .In the simulation, we tune and optimise the values of the resistance, inductance and capacitance and fit its S parameter to that obtained from HFSS, thus get the precise parasitic values.

2. QFN32 STRUCTURE DESIGN AND MODEL SIMULATION IN HFSS

In order to model and simulate the QFN32 package , we should firstly identify numerous physical parameters of the package. Since the bond wire is the most critical interconnect parameter, the parametric variation is focused on the die pad pitch which directly impacts the die size as well as bond wire length. The bond wire profile was based on the JEDEC 4-point guideline with a loop height of 0.15 mm and diameter of 25 um. The die size is 3x2.75x0.2 mm and the pad on the die is octagon with an area of 119x 78um ,while the distance between pads is 311um.Key parameters are shown in Table 1.

TABLE 1: QFN PACKAGE PARAMETERS

Dimension	Value
Body Size	5x5mm
Number of Pads	32
Lead Width	0.25mm
Lead Pitch	0.5mm
Paddle Size	3.5x3.5mm
Thickness	0.75mm

The electrical modeling of the QFN packages was based on the package structures, layouts, and materials of the real QFN packages. Fig. 1 shows the cross-section view of a typical QFN package. The materials used and their related physical parameters are shown in table 2.

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According to the above package size and all the used material information, we can get the HFSS model of QFN32, which is shown in figure 2.

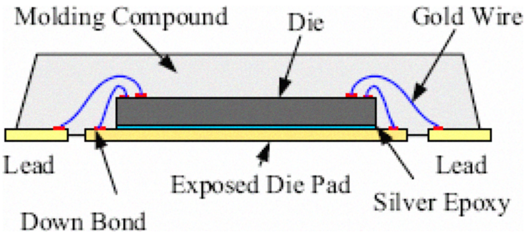

Fig.1.Cross-section view of QFN package.

TABLE 2: MATERIAL PARAMETERS OF QFN32

	permittivity	permeability	Conductivity (S/m)
Molding compound	3.6	1	1e-9
Lead and Exposed Die pad	1	0.999991	34.8e6
Silver Epoxy	1.06	1	2e6
Gold wire	1	0.99996	42.57e6

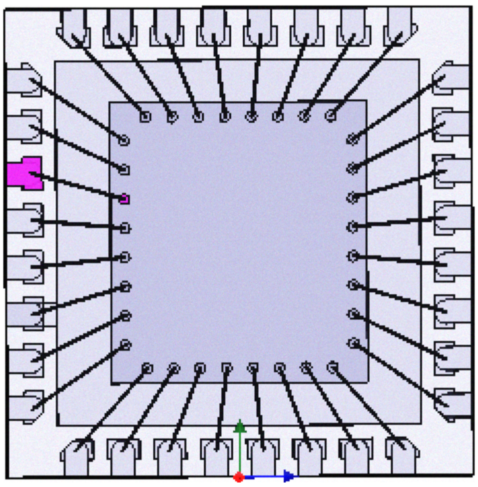

Fig.2.HFSS model of QFN32 package

In this work, extraction of two-port scattering parameters for the chosen signal path, which is highlighted in figure 2, was performed. Unlike in traditional three-dimensional full-wave simulations where there is a requirement of port extensions such as microstrip, internal or lumped ports were used instead for analysis of two-port scattering parameters for signal path. These ports were attached at die pads and solder joint pads, respectively. Each internal port was set to an impedance of 50Ω, a standard value for network measurement in the simulation of any individual signal path consisting of two ports. Now we assume that the model is used in the package of Beidou navigation RFIC of China and the operating frequency band of the signal through the signal path is 1268.52 ± 10.23MHz with a bandwidth about 20.5MHz, so we can get the insertion loss and return loss characteristics of the signal path in the frequency band we concern , which are shown in figure3 (a) and 3(b).

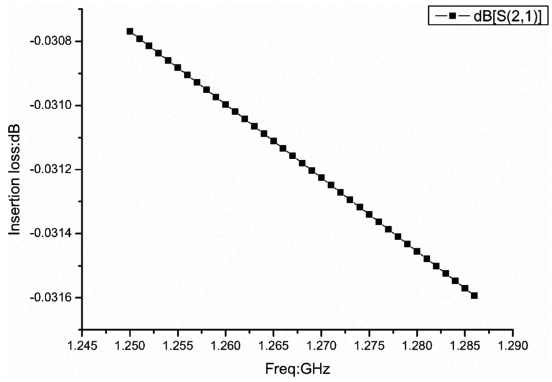

Fig. 3(a) insertion loss

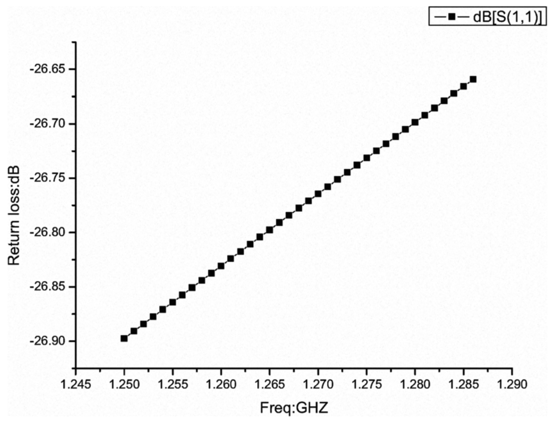

Fig. 3(b) return loss

3. EQUIVALENT CIRCUIT OPTIMIZATION

In the free-space, a circular bonding wire with a length of l and diameter of d , the inductance L_0 and series resistance R can be obtained from equation (1), (2). In addition, distributed capacitance exists between the gound and the wire, so it can be equated as a T –equivalent circuit network.

$$L_0 = (\mu_0 l / 2\pi) \times [\ln(4l/d) + \mu_r \tanh(4\delta_s / d)/4 - 1] \quad (1)$$

$$R = 1/(\pi d \sigma \delta_s) \quad (2)$$

Where σ and μ_r are the material's Conductivity and Relative permeability of the wire,and δ_s is the skin depth of the wire.

However, it’s not enough if you just consider the parasitic parameters of the bonding wire, because the pin has parasitic parameters too, which can be obtained from simulation. So we can assume that the pin is part of the bonding wire, the total parasitic attributes still can be seen as a T circuit.

Based on the above discussion, an equivalent circuit of parasitic parameters was established in ADS, which was shown in figure 4, and then the S parameter simulation of the circuit was performed. We can see the insertion and reflection difference between ADS simulation and HFSS simulation in the concerned frequency band in figure 5(a) and figure 5(b).

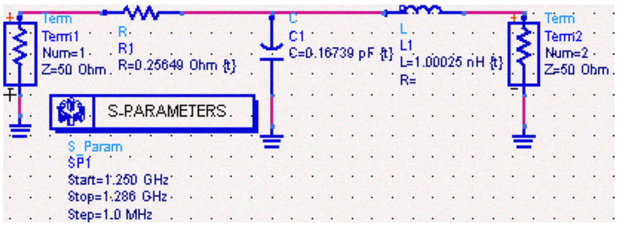

Fig. 4 equivalent circuit of parasitic parameters

TABLE 3: OPTIMIZED PARASITIC VALUES

Resistance(Ω)	Inductance(nH)	Capacitance(pF)
0.25649	1.00025	0.16739

According to figure 3(a) and figure 3(b), the insertion loss of the signal path is a little more than 0.03 dB, and the return loss is about 26.8 dB. Subsequently, we tune and optimize the R, L and C in ADS, thus parasitic parameter values were obtained , which were shown in table 3. Meanwhile the insertion and return loss S parameter differences between the tuned circuit and the HFSS simulation results were given in figure 5(a) and figure5(b).

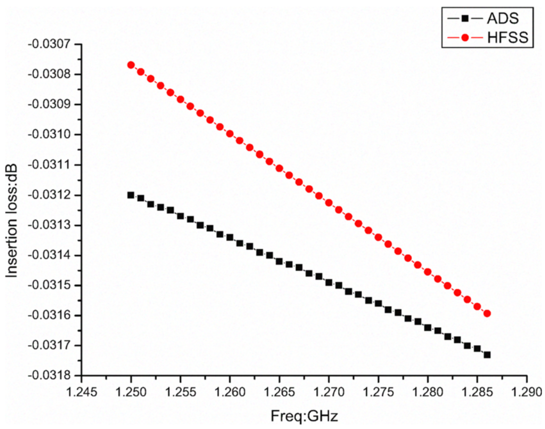

Fig. 5(a) insertion loss difference after optimization

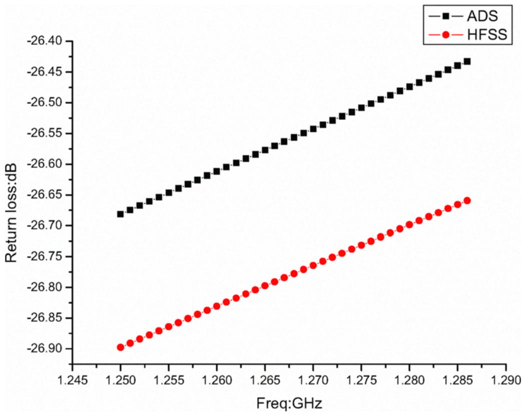

Fig. 5(b) return loss difference after optimization

4. CONCLUSION

As can be seen from figure 5,from 1.25 GHz to1.286 GHz, the maximum insertion loss difference between the tuned circuit and the HFSS simulation results is less than 0.01 dB, whereas the reflection difference is about 0.35 dB, So we can see that it is workable to get more precise parasitic parameters of QFN32 using HFSS, and ADS. Besides, this method can be used in differential signal path , which would makes a lot of sense in chip and package co-design, RF measurement techniques .

5. REFERENCES

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