Radiated Emission of a 3G Power Amplifier

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Abstract: This application notes presents a methodology of prediction the near-field emission of a power amplifier using the electromagnetic field solver of IC-EMC. The integrated circuit used as a case study is a 3G power amplifier for 1900 MHz UMTS band. The use of inductances as radiating dipoles is described. The structure of a near-field emission model of the power amplifier is detailed. An advanced model including vertical dipoles is also introduced for an improved matching between measured magnetic field.

This work has been conducted by C. Dupoux, PhD student from Freescale Semiconductor, S. Akue Boulingui, PhD student from IUT GEII Tarbes, and E. Sicard, INSA Toulouse France, in cooperation with

Keywords: near-field scan, circuit for 3G mobile platform

Files related to this case study may be found in "case_study\pa_3G"

1 Case study

This integrated circuit used as a case study includes a 3G power amplifier (PA) and a power detector. It works from 1920 MHz to 1970 MHz [1], with a maximum power around 1 Watt. Its detector allows measuring its output power with a high accuracy. It is designed in InGaP technology and it contains 2 amplification stages. Its input and output are single-ended, matched 50 Ω.

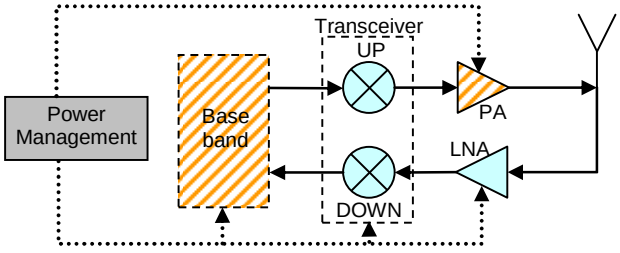


Figure 1: Generic diagram of a mobile phone

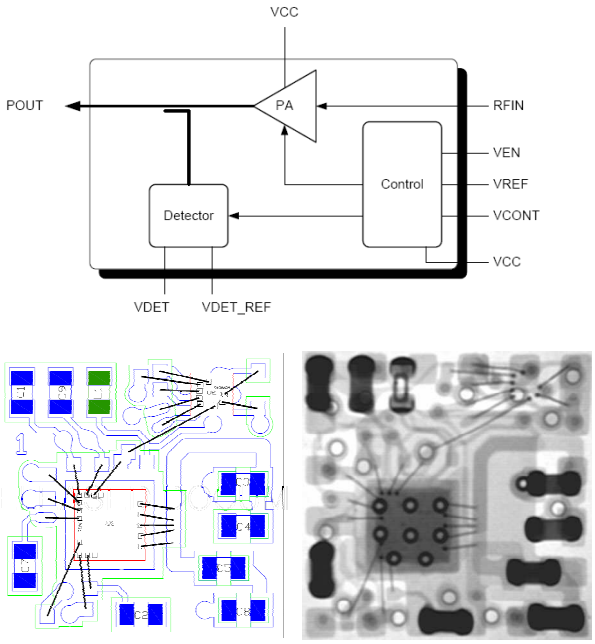


Figure 2: Schematic diagram of the PA (up), internal view of the PA Layout (left) X ray view (right)

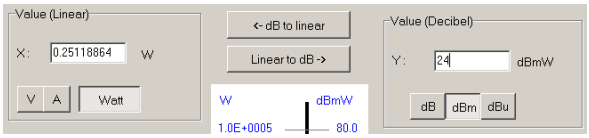


Figure 3: translating dBm into Watt using Tools > dB/Linear Unit Converter

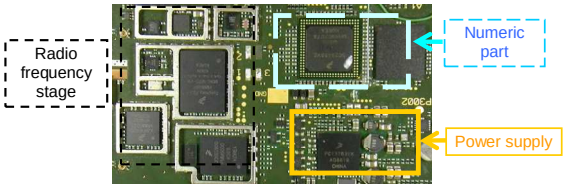


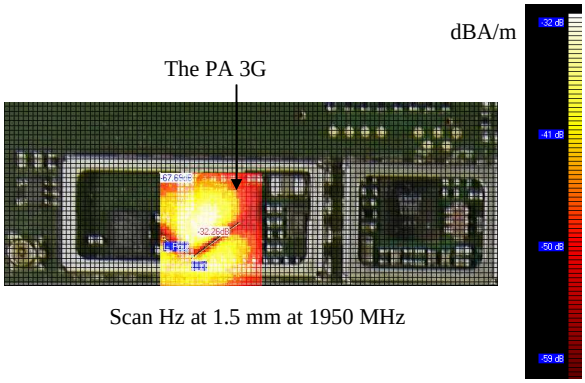
Figure 4: the Power Amplifier is part of a 3G platform developed by Freescale [1]

Fig. 1 describes the principle of the used PA. Fig. 2 presents two internal views of the power amplifier.

The UMTS power amplifier (PA) amplifies the signals from the transceiver to the antenna. It is able to send RF power signals up to 24 dBm. Using *Tools → dB/Linear Unit Converter*, this is equivalent to 0.25 W (fig. 3). We use a complete mobile phone platform shown in Fig.4, instead of a dedicated EMC test board. Therefore, the near field scan is the only method that may be used for EMC characterization as electric contact with the platform is not allowed.

2 Near-Field Scan of the Power Amplifier

The PA near-field scans are performed at an equivalent altitude of 1.1 mm. The measurement area is 6.2 x 6.4 mm with X and Y steps of 0.2 mm. During these measurements, the center frequency of the UMTS power amplifier is fixed to 1950 MHz. Its output power is 20 dBm distributed on a 5 MHz bandwidth. Fig. 5 presents the Hz magnetic field of the PA near-field scan at 1950 MHz. At the altitude of 1.5 mm, the PA radiates up to -30 dBA/m [2].



Scan Hz at 1.5 mm at 1950 MHz

Figure 5: example of near-field scan with IC-EMC (Scan_Hx_PA_1950_1_5mm / Scan_Hz_PA_1950_1_8mm_PA.xml)

3 Simulation of the radiated near-field

3.1 Inductance-based model

Fig. 6 details the schematic diagram of the PA. It includes the supply network, the PDN of the PA, the pre-amplifier stage and the power stage itself, connected to a 50 Ω through a transmission line. Note that the PA itself is mainly a current source. Fig. 6-25 details how the package lead inductances are assigned physical coordinates to enable the IC-EMC simulator to compute the radiated field.

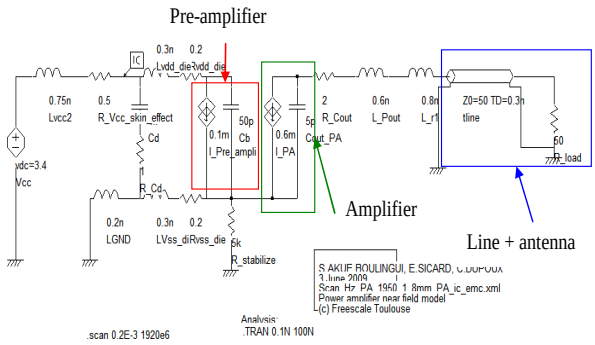


Figure 6: The schematic diagram of Prometheus used for near-field scan prediction (PA_scan_V_8_1950MHz.sch)

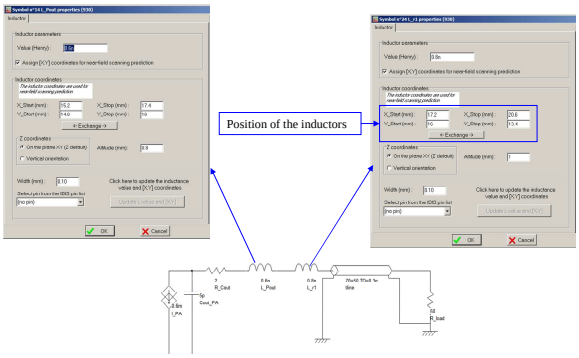


Figure 7: the inductance coordinates in X,Y,Z will be considered as radiating dipoles in IC-EMC EM solver

3.2 Near-Field Prediction

Differences between measurement and simulation (Fig. 7) are summarized in Table 1. The mismatch mainly comes from the fact that two inductances are not efficient to reproduce the near field at the boundaries of the PA current dipoles.

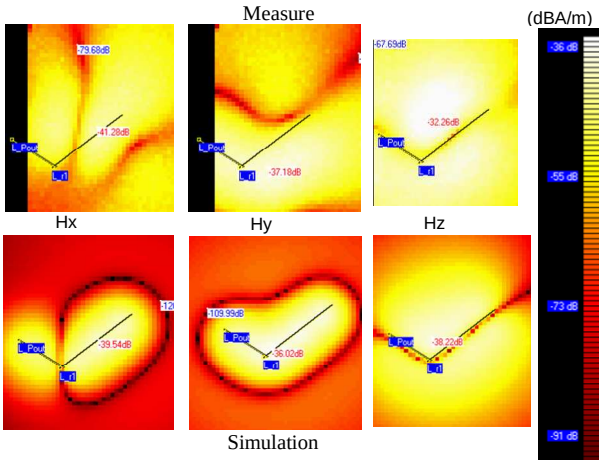


Figure 8 :Comparison between measured and simulated magnetic fields

Measure	**Hx**	**Hy**	**Hz**
	-41 dBA/m	-37 dBA/m	-32 dBA/m
Simulation	**Hx**	**Hy**	**Hz**
	-39 dBA/m	-36 dBA/m	-38 dBA/m

Table 1 : Peak magnetic field (measurement and simulation)

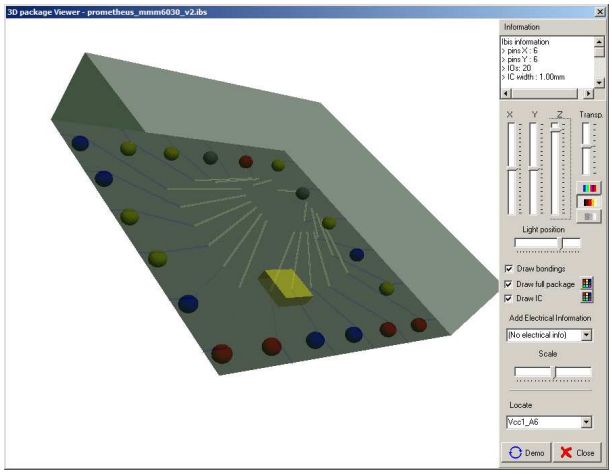


Figure 9: 3D view of the PA package (based on prometheus_mmm6030_v2.ibs)

3.3 Vertical current dipole model

In the IBIS description of the PA, we add hidden keywords which define the geometrical characteristics of the IC.

```
| Keywords added by E. Sicard for IC-Emc
| Data given by Freescale
[Package model] bga
|pack_width=4.0e-3
|pack_height=4.0e-3
|pack_ball=0.1e-3
|ic_width= 1e-3
|ic_height= 1e-3
|ic_xstart= 1.5e-3
|ic_ystart= 1.5e-3
|lead_alt = 0.2e-3
|pack_pitch=0.68e-3
|pack_cavity=2e-3
|ic_altitude=0.3e-3
|ic_thickness=0.4e-3
|
```

Table 2: Adding hidden keywords in the [package_model] section to generate realistic 3D views of the PA (prometheus_mmm6030_v2.ibs)

The IBIS description of the PA enables the 3D reconstruction of the IC (Fig. 9), where we can see that some part of the current may flow vertically, and not only horizontally.

To influence the field structure at dipole band rise we add vertical dipoles (Fig. 10) [3]. These new elements account for the metal leads on the package in the Z direction. Details of the X,Y, Z coordinates are given in Fig. 11.

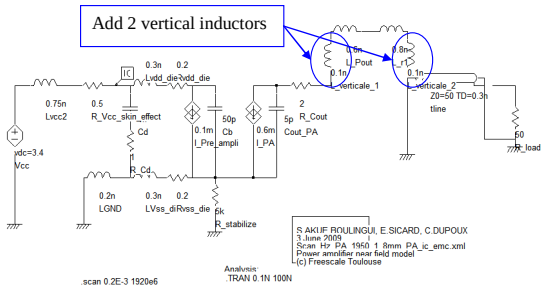


Figure 10: Model with vertical inductors (Scan_Hx_PA_1950_1_5mm\PA_scan_V_add _vertical_1950MHz.sch)

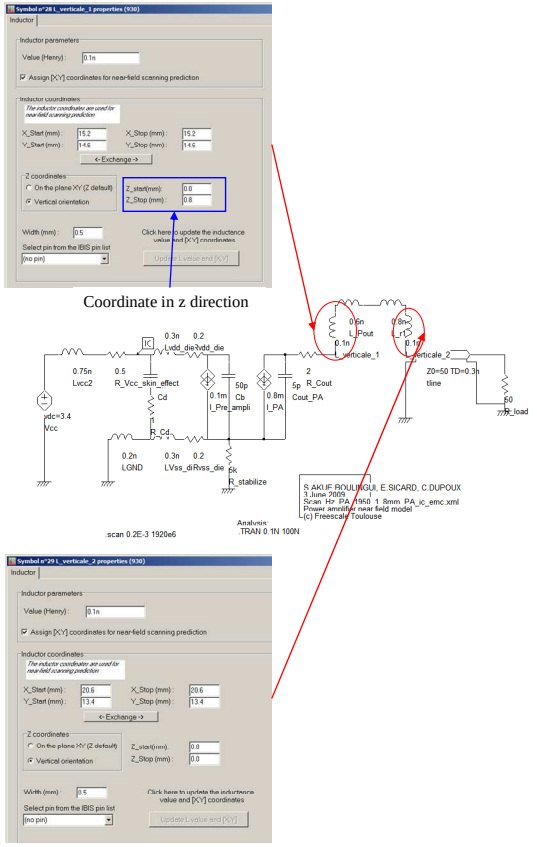
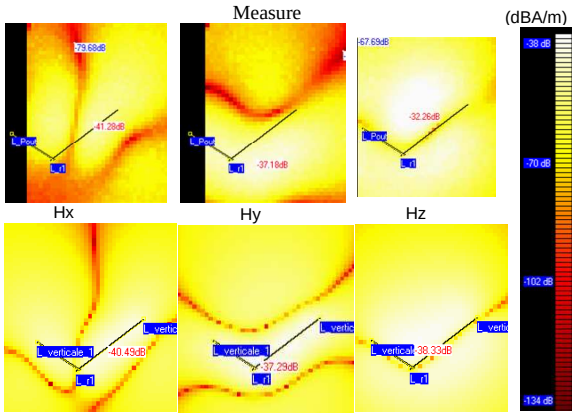


Figure 11:The schematic diagram of Prometheus used for near-field scan prediction (Scan_Hx_PA_1950_1_5mm\PA_scan_V_add _vertical_1950MHz.sch)



Simulation with vertical current dipoles

Figure 12:Comparing measurement and simulation with vertical dipoles (Scan_Hx_PA_1950_1_5mm\PA_scan_V_add _vertical_1950MHz.sch)

Measurement	**Hx**	**Hy**	**Hz**
	-41 dBA/m	-37 dBA/m	-32 dBA/m
Simulation	**Hx**	**Hy**	**Hz**
	-40 dBA/m	-37 dBA/m	-38 dBA/m

Table 3: Peak magnetic field with vertical current dipoles (measurement and simulation)

The matching between measurement and simulation is improved as can be seen in simulations shown in Fig. 12. Table 3 summarizes the values of the maximum magnetic field for Hx, Hy and Hz components, both for measurements and simulations.

4 Summary

We have detailed a near-field emission model related to a power amplifier used for 3rd generation mobile platform, and highlighted the effect of vertical current dipoles for improved matching with measurements.

References

[1] MMM6007 W-CDMA Transceiver Module, document n°: MMM6007/D, rev. 2.4, 2006, Internal document Freescale

[2] S. Akue Boulingui, C. Dupoux, S. Baffreau, E. Sicard, N. Bouvier, B. Vrignon, "An Innovative Methodology for Evaluating Multi-Chip EMC in Advanced 3G Mobile Platforms", IEEE EMC Symposium Austin, Texas, USA, 2009

[3] Céline Dupoux, Samuel Akue Boulingui, Etienne Sicard, Stéphane Baffreau, Nicolas Bouvier, “Measurement and Simulation of Electromagnetic Interference in 3G Mobile Components”, EMC Compo 09, Toulouse, Nov 2009