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Radiated emission measurement of a cell phone processor module using TEM cell

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Abstract. In this paper, a radiated emission measurement of a cell phone integrated circuit using TEM cell. A hybrid which can identify the main coupling mechanism is used to measure, where consequent results have been compared with the one using the industry standard measurement method. A data analysis method, which is so called Short Time Fast Fourier Transform (STFFT) is presented to help to analyze the results, and show acceptable performance.

Keywords: Electromagnetic compatibility (EMC), processor module , radiated emission, short time fast Fourier transform (STFFT).

1 Introduction

Billions of cell phones have been purchased every year in the world. They are widely used in people's daily life. Though there is no direct evidence, people doubts its influence on health [1-2]. They are also emission source that could influence the safety of airplane. Several airplane accidents are found caused by electromagnetic interference (EMI) [3]. One of the main EMI sources in airplane is the cell phone. That's why the Federal Communications Commission (FCC) [4] and Federal Aviation Administration (FAA) [5] regulations prohibit the use of cell phones on airplane.

Many electromagnetic compatibility (EMC) organization and countries define the standards that the cell phones must satisfy if the cell phone companies want to sell them on the market. The cell phones need to pass the radiated emission test to ensure that they won't cause any problem to other equipment. The main emission source in the cell phone is the processor. It contains both analogue and digital components which radiate emission greatly. The radiated emission normally causes problems to other nearby equipment. The radiated emission couples to the cable of other equipment and enters into the inner of equipment, make the equipment stop to run or

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pause of communication, both of them are dangerous. Thus, the radiated emission test of the processor is necessary. There are several measurement methods to do the radiated emission measurement of integrated circuit [6-8]. Two popular methods are defined by IEC 61967 part 2 [9] and BISS paper [10] respectively.

The previous work [6-8, 11] on the radiated emission test using TEM cell only focuses on the measurement itself, and compares the result to the defined limit line. The analysis of the data is not sufficient. This paper talks the difference between the two methods through analysis of the measurement result using several data analysis method, such as STFFT [12], also the main coupling mechanism can be obtained using a hybrid [13].

This paper is organized as follows: two test bench setups are compared in section 2, while the radiated emission measurement result is presented in section 3. The data analysis method is shown in section 4.

2 Methodology comparison and test setup

2.1 Measurement Methodology

A TEM cell (FCC TEM JM1) was used to capture the coupling. The method described in [9] and the other methods defined in the BISS paper [10] are both used during these investigations. The principle of the TEM cell method is that the radiated emission of the IC couples to the septum of the TEM cell, and through the septum, the interference is conducted to the spectrum analyzer (HP 4396A).

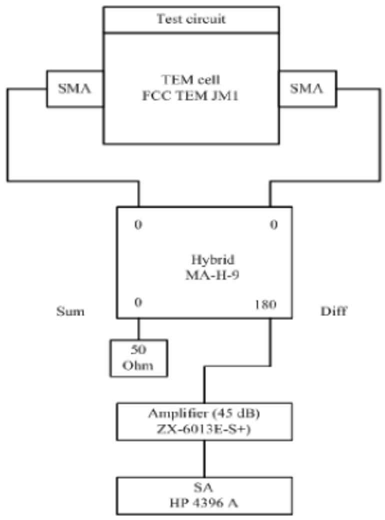
The method used in this paper is different from the IEC 61967 standard method [9], a hybrid is used in this measurement method [13]. The method described in the standard does not use a hybrid, thus, it cannot distinguish between E and H field coupling.

2.2 Test setup

The diagram of the setup is shown in Figure 1. The hybrid gives the sum and the difference of the TEM cell outputs. The sum of the two output voltages is proportional to the electric field coupling. If the DUT is located in the center of the TEM cell, the E-field coupling generates two responses that are in phase and the magnetic field coupling generates two out-of-phase responses. Similarly, the difference of the voltages is proportional to the magnetic field coupling [14].

As the radiated emission is small, three amplifiers (ZX-6013E-S+) are used to overcome the noise figure of the spectrum analyzer, thus to improve the signal to noise ratio. The measurement is divided into four parts with different fields and different orientations (E_ field (0 degree), H_field (0 degree), E_ field (90 degree), H_field (90 degree)).

The BISS paper test setup is shown in Figure 2.



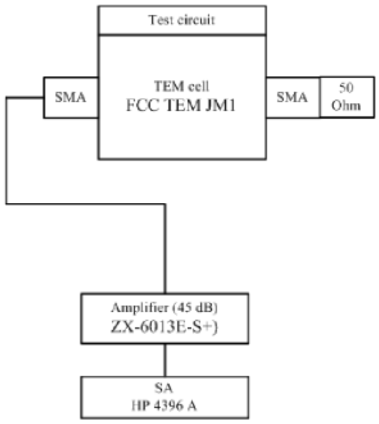


Fig. 1. Diagram of the test bench.

Fig. 2. BISS method to measure the radiated emission.

3 Test data

Besides the spectrum analyzer, STFFT is also used to analyze emissions of different field components (E and H), and different position of the processor board. The STFFT requires to capture real time data. Being interested in data up to 1 GHz, a sampling rate of 5GS/sec and 2Meg sample points allows capturing 400us of data. A low pass filter with a stop frequency of 1.2 GHz is used to avoid aliasing [12]. The test setup for using STFFT is shown in Figure 3.

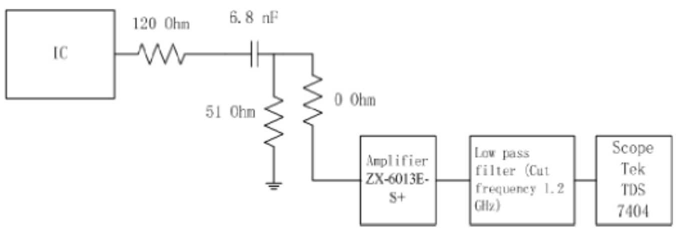


Fig. 3. Test setup for STFFT.

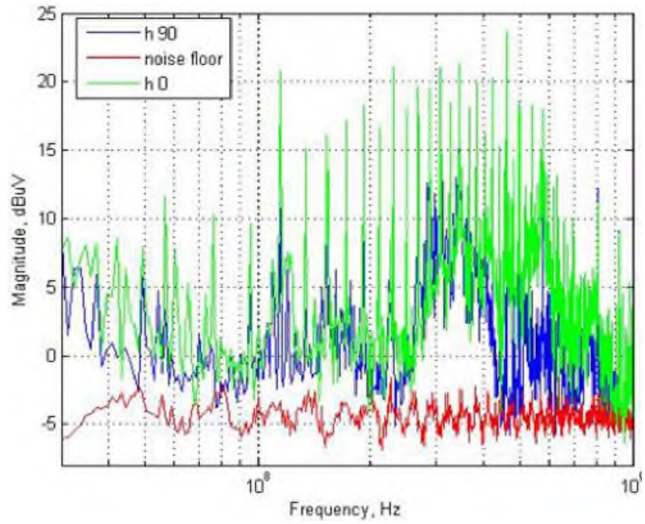


Fig. 4. Comparison result of emissions in H field 0 degree position and 90 degree position.

The cell phone board is put in 0 degree and then turn to 90 degree; the radiated emission is shown in Figure 4. For 0 degree configuration, the signals are below 600 MHz and appear to be periodic and harmonically related by 19.2 MHz. For 90 degree configuration, there are only few peaks in the whole measurement frequency range. It is quite different from the emission captured using the 0-deg configuration. At this moment, the peak emissions cannot be identified as time dependent or time independent. The emission of H-field in 0 degree orientation is worse than in 90 degree position and the difference is about 9 dB. This indicates a current flow in 0-deg direction.

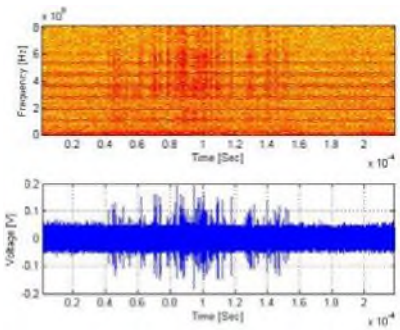


Fig. 5. STFFT result for the H field 0 degree configuration (NFFT 5000 points, Noverlap 1250).

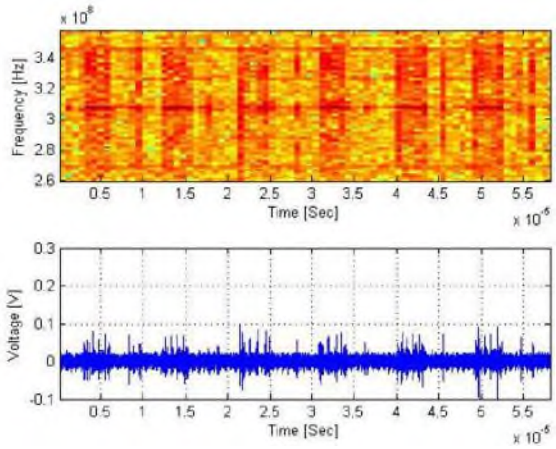


Fig. 6. STFFT result of H field at 90 deg orientation (NFFT 5000 points, Noverlap 1250).

The STFFT analysis result of H field 0 degree is shown in Figure 5. The narrow band signals are observed below 600 MHz. Besides the narrow band signals, there is also some time dependent signal from 300 MHz to 700 MHz. The STFFT gives the possibility to analyze the time dependent and independent signal, using only the spectrum analyzer one cannot obtain this information in the same clarity.

The STFFT analysis result of H field 0 degree is shown in Figure 6. Three narrowband signals are observed, their frequencies are not changed but the amplitudes vary with time. They are amplitude modulated signal. The wideband signals are also found.

The wide band signal covers the complete frequency range. The center frequency is around 300 - 500 MHz.

The harmonic frequencies of the clock aren’t observed neither on spectrum analyzer nor on the STFFT result.

4 Conclusions

Advantages of the TEM cell measurement are that it is relatively simple to perform [6-7] if a 10x10 cm board is available. The drawbacks are, the TEM cell method provides no insight into the reasons of the coupling, the near field scan method would yield this important information. Further, the TEM cell method cannot measure conducted emissions, this is covered by other test methods. The strongest emission measured using the BISS method is below the Class I limit as defined in the BISS paper. Narrow band signals and wide band signals are found using STFFT. Using a hybrid a differentiation between electric and magnetic field coupling was performed, showing that the coupling is mainly magnetic.

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