

# Design Concept of the EMI Noises Surveying System for Transceivers Performance-Based Test

, Hsuang-Chung Ko<sup>2</sup>, Deng-Yao Chang<sup>2</sup>, and #Cheng-Nan Hu<sup>1</sup>

<sup>2</sup>*King Yuan Electronics Co. Ltd., Taiwan, R.O.C.*

<sup>1</sup>*CRC, Oriental Institute of Technology, Taiwan, R.O.C;*

<sup>1</sup>*E-mail: hu\_chengnan@yahoo.com.tw; fo011@mail.oit.edu.tw*

## 1. Introduction

Emerging wireless SOC and SIP technologies with highly integrated devices derive the development of today's low cost wireless mobile terminals with multi-standards, including GSM/EDGE, Bluetooth/WLAN, GPS, and UMTS/WCDMA system, on a single convergent platform [1]. When conducting the RF performance measurement, RF test development has always been torn between the request to be able to perform a large variety of sophisticated RF measurements in a productive environment and the restriction to keep cost of test as low as possible. Considering the ATE system, the most costly and complex components are those used in RF subsystem, which is usually configured to handle only one receiver per system. These receivers must handle a frequency range between 10 MHz and 6 GHz and have a very high dynamic range capable of measuring stringent two-tone signals such as Adjacent Channel Power Ratio (ACPR) or Third Order Intercept (IP3). These signals are difficult to measure because they consist of a primary high power frequency or tone at 900 MHz to 6 GHz, which is adjacent to a very low-level noise tones 10 MHz away under the requirement of the measured repeatable to 0.1 dB accuracy [2-4]. As a result, the high susceptibility of the Device-Under-Test (DUT) to electromagnetic noise from its immediate surroundings is a key issue. Thus, an approach to survey the surrounding electromagnetic interferences on wireless systems is essentially important to an ATE during performing the performance-based test to come out the repeatable and confident measured results. In this paper, we firstly propose a cost-effect test-bench design concept in which a PCB antenna system featured by the multi-band, dual-polarized radiated performance is utilized to measure the environment electromagnetic noises. Instead of the un-user-friendly metal-shielding environment or expensive chamber room solutions, by incorporating into this design concept, the novel ATE can be used to clarify the root-cause and to improve the low yields issue when performing RF testing suspected by EMI interferences.

## 2. Approach to RF Tester Design

### A. *Alternate Testing Method for Mixed-Signal/RF Circuits*

The call for a testable wireless device results in a conflict of interest between the degree of integration afforded by the design process and the level of testability achievable by an external tester. A viable solution is to place the ATE functionalities in close proximity of the device module to be tested. This improves the test-access speed, minimizes test signal degradation, and increases controllability and visibility of the signals internal to the device-under-test (DUT).

Fig. 1(a) shows the picture of the conventionally used ATE in which the surrounding metal shielding is employed to isolate the electromagnetic fields as possible as one can. To survey the achievable electromagnetic isolation, there are several test points, marked as A to G (see Fig 1 (b)), used to capture the electromagnetic fields locally. To this approach, it has inherent drawbacks as described here.

- 1) *The electromagnetic field is location dependency due to multi-path effect. Thus, the test points (A-G, see Fig. 1 (b)) shall be as close to the system-under-test as possible.*
- 2) *The electromagnetic noises either caused by outside interference signals or by system's switch transition noise are time-variant in nature. Thus, Synchronization between RF testing and noise surveillance is needed to find out the correlation between measured results and measurement error due to system noise.*
- 3) *How to come out the optimal number and location for the test points to this approach?*

To improve above-mentioned drawbacks, a PCB antenna is applied to the tester of ATE operating as an EMI noises surveying system so that the surrounding interference signals can be measured for properly calibration if needed. Fig. 2 shows the picture of the proposed ATE, showing the role of a load-board (see the inset of the Fig. 2) in a high-end conventional ATE environment. In this environment, the load-board shall include a low-parasitic socket to hold the DUT, power and ground planes, signal traces, switches/relays to multiplex external tester resources, resulting in susceptibility to the EMI noises. Thereby, and an on-board design of the PCB antenna system is used to measure the interference frequencies of interests. Another alternative is to utilize the PCB antenna system by placing directly above the load-board to capture the spectral content introduced by electromagnetic interference signals or switching noise due to high-speed circuits simultaneously. Fig. 3(a) shows the picture of the prototype ATE in which the load-board (see Fig. 3(b)) is dedicated to the tester head as the interface between tester head and DUT. Fig 3 (c) illustrates the layout of the PCB antenna system which can be extensively used in any kinds of testers. As a result, the highly frequency-/time-dependence interferences degrading RF performance or resulting measurement uncertainty can be measured simultaneously on almost the same location for pre-calibration or for de-embedding the measured characteristics

### **B. *Prototype PCB Antenna Design***

Electromagnetic interference signals introduced by existed wireless standards include GSM/EDGE (900/1800/1900 MHz, Bluetooth/WLAN 802.11b (2450 MHz), GPS (1570 MHz) and UMTS/WCDMA (850/900/1700/1900/2100 MHz). We categorize the interference signals into two groups: one for GSM/WCDMA system, and the other for both GPS/WLAN bands. For each group, a dual-band antenna design can be utilized to cover the frequency regime of interests. Since the interference signals are random polarized wave in nature at multi-path environment, we use two identical dual-band antennas placed in perpendicular orientation to capture two-principal polarized waves induced on board. Fig. 3(c) illustrates a prototype PCB antenna design in which two antennas is designed at resonance of 900/1800 MHz bands and the other two antennas are designed at resonance of 1500/2400 MHz bands. Following by a combiner circuit equipped by three broadband combiners (Part No: Mini-circuits TCP-2-25) associated with four coaxial cables, most of the EMI noises of interest can be picked up by four antennas. The output of the combiner circuit is connected to a spectrum analyzer or programmable ATE on purpose) such that all of the surrounding interference signals can be monitored dynamically when tester performing the RF test.

## **3. Experimental Results**

By implementing the proposed prototype load-board to the ATE header and docking upon handler under surrounding system-under-test, we measure the background noises. The measured results corresponding to different scenarios are illustrated and discussed in detail as follows:

- (1) Test case I: We turn on the nearby tester, one of testers close to the proposed ATE side-by-side, to run the GSM TX measurement such that the radiated spurious emission signals

generated by power amplifier is present on the surrounding test environment. Then, we perform the measurement by using proposed ATE. The measured result as indicated by Fig. 4(a), showing two intentioned tones at frequencies ranging from 890-915 MHz, which are signals around the UL band of GSM, clearly observed above the system noise floor. Obviously, this results validate the proposed ATE system can survey the surrounding EMI noises of the system-under-test precisely.

- (2) Test Case II: To verify the high band performance, we turn on the nearby tester to run the PHS transceiver test. Measured result is indicated in Fig. 4(b), showing the interference signals at frequency ranging from 1880-1930 MHz observed which is exactly coincide with the operation frequencies at PHS system. Besides, in the Fig. 4(b), a weak signal with most likely GMSK modulation spectrum at frequencies around GSM 1900 band delivered from outside base-station is captured.
- (3) Test Case III: We turn-off all of the nearby testers but intentionally turn-on one GSM handset in the testing field, then perform the measurement. Fig. 4(c) plots the measured results, displaying obviously the interference signals at frequencies ranging at GSM UL and DL bands observed. This proves that the proposed test concept can be used to monitor any mobiles sneaking into the testing field, which is prohibited when doing the RF test.

## 4. Conclusion

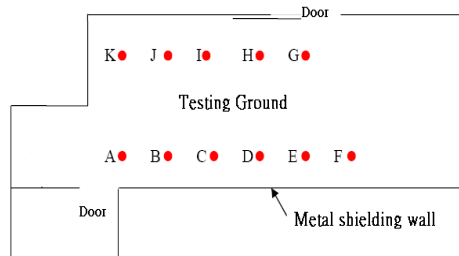
In this study, the proposed ATE test concept used to survey most of existed EMI noises dynamically is employed to improve the measurement uncertainty of RF testing performance due to IP3 or ACPR issues, for example. With the knowledge of background noise, one can analyze the correlation between the tested report and background noise to find out the root-causes. Thus, a smart ATE can be programmed to perform the RF test accord with system-under-test form TDMA or FDMA perspective to improve the yields loss in the future study.

## REFERENCES

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(a)



(b)

Figure 1. (a) Picture of the conventionally used tester; (b) Layout of the conventional tester in which the metal shielding is used to improve the electromagnetic isolation and test points, marked by A-G, are used to measured the interference signals.

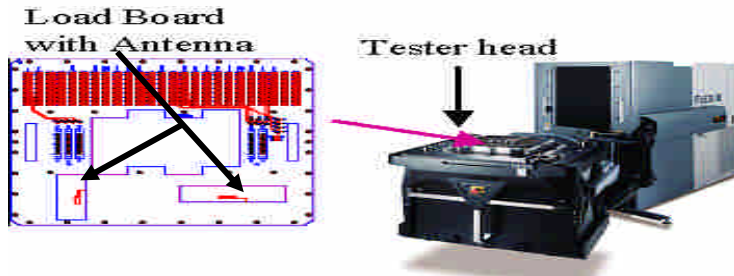


Figure 2. Picture of the proposed tester; the inset of the figure illustrates the load-board design concept in which the embedded PCB antennas are built on board

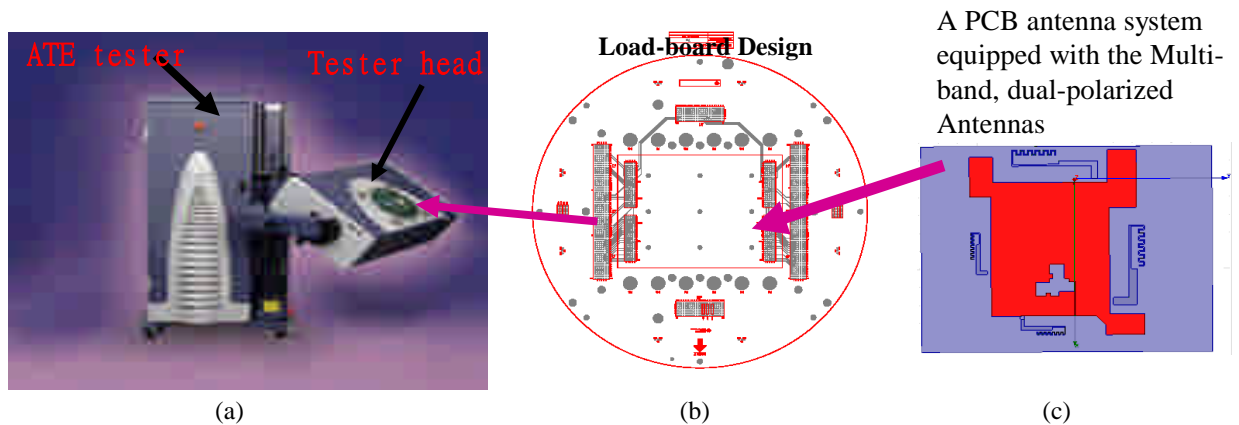


Fig. 3, (a) Picture of the proposed tester ; (b) Layout of the load-board in which a PCB antenna is mounted above the ground plane to measure the electromagnetic signals; (c) PCB layout in which two GSM/DCS dual-band antennas incorporating with two GPS/WCDMA dual-band antennas. are built to form a PCB antenna system.

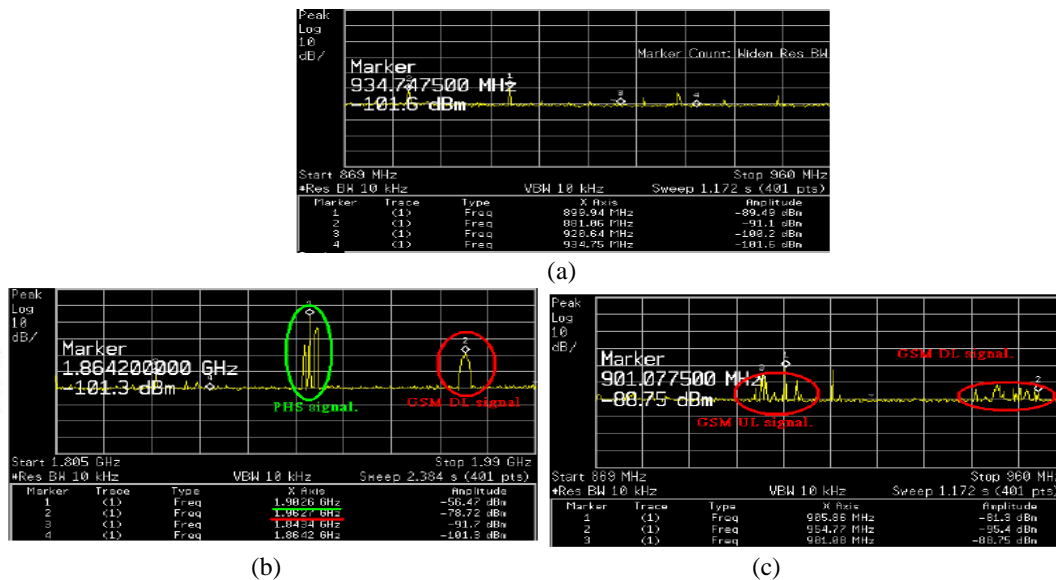


Fig. 4, (a) Measured spectrum context when GSM TX measurement run by the nearby tester, showing two intended tones observed at frequency ranging from 890-915 MHz which is coincided with GSM UL bands; (b) Measured spectrum context when PHS measurement run by the nearby tester, showing two intended interference signals observed at frequency ranging from 1880-1930/1843-1846 MHz which is coincided with PHS/GSM DL bands; (c) Measured spectrum context when one GSM handset is sneaking into test environment, showing GSM UL and DL spectrum observed