The RF Immunity Characteristics Analysis of SSD Performance due to Wireless Communications Emission in Proximity

Han-Nien Lin[1], **Po-Yan Wang**[1], **Hung-Yun Tsai**[1], **and Yung-Chi Tang**[2]

[1]Department of Communications Engineering, Feng-Chia University
No. 100 Wen-Hua Rd., Taichung 40724, Taiwan, R.O.C.
[2]Section of EMC, Bureau of Standards, Metrology and Inspection, M.O.E.A
No. 4, Sec. 1, Jinan Rd., Zhongzheng Dist., Taipei City 100, Taiwan, R.O.C.

Abstract— To facilitate the high speed data access/storage with vibrating and swaying proof, the Solid State Drive (SSD) is now commonly integrated with mobile or portable device like Ultrabook with its compact size. Besides RFI noise generated from such high speed digital device is observed imposing an inferior impact on RF wireless communications performance, it is also possible that the SSD storage module might be failed for data accessing caused by high level RF transmitted power from various transmitters of wireless communications systems. In addition, when WiFi tethering is used for cloud applications with the 3G/4G WWAN network through smart phone, the transmitted RF power from mobile phone might also affect the data access/storage of SSD memory. Because when we use WWAN network for Internet surfing, we would usually place the mobile phones by side of ultrabook/notebook computer with built-in SSD and thus the high level output signal from nearby mobile phone might cause memory mapping error of SSD. To analyze the EM immunity characteristics of SSD and related memory module, we will categorize the coupling mechanism of RF power between SSD and RF transmitter into antenna coupling, circuitry coupling, and cavity resonance coupling. With the help of dedicated near-field RF signal generator and stripline [1] for closely located digital modules like SSD and flash memory in this study, we can identify the location and root cause of data accessing and storing degradation to benefit the manufacturers for proper SSD integration with mobile or portable device with compact design form limitation. We also evaluated the pass/fail EM immunity characteristics for SSD storage module, and hope to apply the IEC 63132 [2] series IC-EMS measurement techniques on the component level to help solving the problem and further improve the integrating design to meet the EMC/performance requirement in the future study.

1. INTRODUCTION

Cloud computation and always-connected Internet service attracts the most industrial attention for the past few years. Therefore, the Solid State Drive (SSD) and flash memory is now commonly integrated with mobile or portable device with its inherent vibrating and swaying proof characteristic. Owing to its compact size and fast processing speed, the Solid State Drive (SSD) is also commonly found installed in Ultrabook and similar devices. Besides such high speed digital module has malignant impact on RF receiving performance of wireless communications, the digital components or modules might also suffer functional degradation due to near field electromagnetic interference. For instance, when WiFi tethering is used for cloud applications with the 3G/4G WWAN network through smart phone, the transmitted RF power from mobile phone might also affect the data access/storage of SSD memory. Because when we use WWAN network for Internet surfing, we would usually place the mobile phones by side of ultrabook/notebook computer with built-in SSD and thus the high level output signal from nearby mobile phone might cause memory mapping error of SSD. The scenario of WiFi tethering with mobile phone placed aside of SSD is illustrated in Figure 1, which explains the RF output signal of mobile phone might cause the bit error of SSD memory access.

2. RF TRANSMITTED POWER COUPLING MECHANISM FOR EM IMMUNITY ANALYSIS

To quantify the RF power impact on SSD functionality from transmitters of various wireless communication systems via embedded or integrated antennas as shown below in Figure 2, we conduct the 1000 times test for data bit read/write/erase operation to validate the SSD module.

From the analysis of above illustration, it indicates the major RF coupling being circuitry coupling and direct antenna coupling. The circuitry coupling means that the SSD suffers noise coupling from the mini-coaxial cable connecting WLAN/WWAN antennas and WLAN/WWAN

Figure 1: Scenario of WiFi tethering with mobile phone placed aside of SSD.

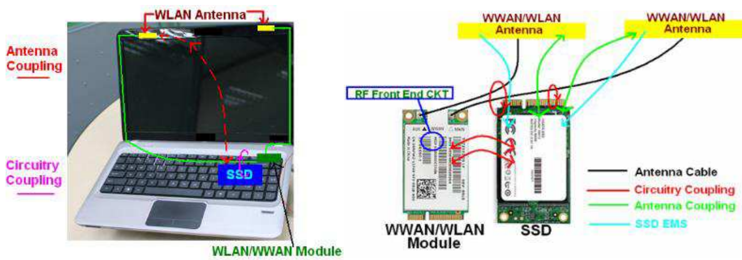
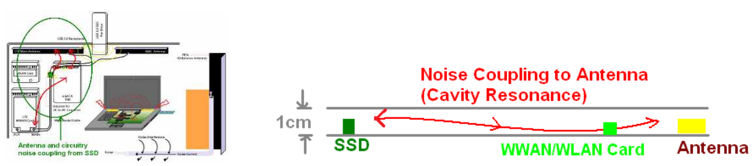


Figure 2: SSD module suffers WLAN/WWAN antennas and cable coupling.



(a) (b)

Figure 3: (a) Detailed coupling mechanism between WLAN/WWAN antenna and SSD module. (b) Cavity resonance coupling between WLAN antenna and SSD module.

module. If the antennas are further moved down to ultrabook computer base due to the shrinking lid form limitation design, the SSD will even suffer direct RF power coupling from those transmitting antennas which is categorized as "Antenna Coupling". The possible coupling mechanism between WLAN/WWAN and SSD module is detailed in Figure 3(a).

We also found out that even the SSD is moved away from the transmitting antenna, as shown below in Figure 3(b), high level transmitted RF power might still couple to the SSD module and cause functional failure. Since the chassis of Ultrabook is normally made of Al-Mg alloy and forms a cavity structure, we therefore call such phenomenon as "cavity resonance" coupling. From the possible coupling mechanism mentioned above, it could provide designers the solution for RFI problems by modifying the components placement layout for better isolation between SSD and transmitted antennas to enhance the EM immunity capability.

3. IMMUNITY CHARACTERISTICS REQUIREMENT FOR SSD INTEGRATED WITH RF RADIATORS

Before SSD is integrated or installed into Ultrabook or similar portable device, the SSD manufacturers should take the following issues into consideration.

1) The SSD should remain its normal operation when the antennas of wireless communications transmits and radiates RF power. Because the near field magnetic field from antennas might cause strong coupling to SSD, and therefore it is necessary to conduct SSD EMS test with dedicated portable generator.
2) The SSD should remain its normal operation when the antennas of wireless communications transmits and radiates RF power, which the RF current from main PCB or mini-coaxial cable might also couple the magnetic flux to SSD. Therefore it is necessary to conduct SSD EMS test with stripline fixture.

3) With more and more programing and erasing activities for SSD accessing/storage, the "wearing" effect decreases the isolation property of dielectric and changes its tunneling effectiveness as shown in Figure 4. The effect will ultimately result in the following consequences.
    a) Incorrect reading from the NAND cell after relatively short retention times.
    b) Program/erase failure.

Therefore, it is required for SSD EMS test that should also pass the test and remain functional operation after 1000 times Read/Write activities.

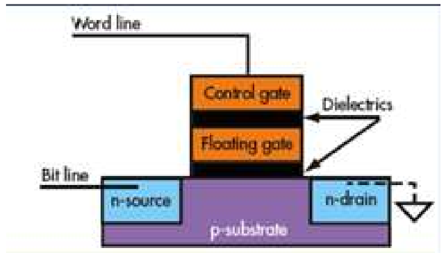
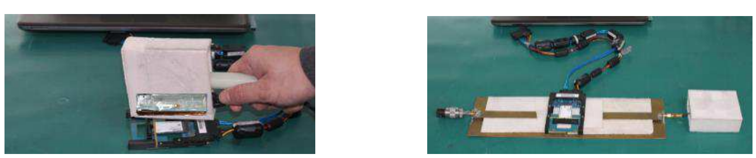


Figure 4: Isolation property of dielectric and tunneling effectiveness of NAND cell.

4. IMMUNITY TEST PROCEDURES AND MEASUREMENT SETUP

To help the SSD manufacturers identify the level of SSD's RF immunity from high level nearby radiators, we propose the RF testing procedure for SSD immunity diagnosis.

1) Use the self-developed dedicated SG module (for GSM/WCDMA) to impose RF power on SSD module for electromagnetic susceptibility test as shown in Figure 5(a). The portable SG device for this EMS test is used to simulate whether the SSD is in normal operation or not when nearby WWAN antennas radiate the RF power.
2) Put the SSD on stripline to observe whether the SSD is abnormal or not when RF power is injected into the terminated stripline as shown in Figure 5(b). The stripline is used to simulate the RF current flow either from main PCB or from mini-coaxial cable in ultrabook/notebook PC. During the test SSD is placed on top of the stripline which is transmitting signal and couples the magnetic flux to SSD to observe whether the SSD operation is abnormal or not.
3) Use WWAN (like GSM/WCDMA) transmitting antennas built in PNS (Platform Noise Scanner) to execute SSD EMS test. This test case simulates the condition for mobile phone being placed beside the SSD module, as shown below in Figure 6(a).



(a) (b)

Figure 5: (a) Portable SG device for SSD EMS test. (b) Configuration of Stripline for SSD EMS test.

(a) (b)

Figure 6: (a) Test condition for mobile phone placed beside the SSD. (b) The PNS setup for EMS test using mobile phone simulator.

We place the SSD under the GSM/WCDMA transmitting antenna and observe if the SSD operates abnormally or not. It should be noted that E_x, E_y, H_x, H_y of horizontal components be taken into account, where E and H denotes the electric field and magnetic field respectively. The PNS test setup is illustrated in Figure 6(b).

4) Finally, we will evaluate SSD endurance under EMS Test. After 1000 times Read/Write operation, the SSD should also pass the EMS test of step 1 and 2 in order to ensure sufficient life time of SSD.

The EMS test plan and procedure described above is totally based on the actual applications, and it can provide manufacturers an efficient diagnosis to solve the EMS problems and improve the quality of product. On the other hand, if the SSD fails some of the SSD near field EMC test criteria described above, then the ultrabook/notebook PC manufacturers will refuse to utilize such SSD from system crashing.

5. ESTIMATION OF IMMUNITY LEVEL AND CORRESPONDING FREQUENCY RANGE FOR SSD EMS TEST

The power level and frequency range for immunity test against transmitters of WWAN system depends on communication band the rated transmitting power. The maximum Tx power level for EMS test in each band is estimated first as shown below in Table 1, and then the test is executed to validate the proper function.

Table 1: Maximum Tx power level for EMS test.

Band	Radio Channels	TX Frequency Range MHz	Max TX power level Note: With GSM(1/8 pulse ratio) And with GPRS(pulse ratio 2/8)
GSM850	128. 190.251	824-849	2.0 W(33 dBm)
GSM900	975.38.124	880-915	2.0 W(33 dBm)
GSM1800	512.699.885	1710-1785	1 W(30 dBm)
GSM1900	512.661.810	1850-1910	1 W(30 dBm)

Table 2: SSD near field EMS test by SG module.

Idle			
Band	*Tx Frequency*	*Max Tx Power Level*	*Pass(P) or Fail (F)*
GSM850	824.2MHz	32dBm	P
GSM900	880.2MHz	32dBm	P
GSM1800	1710.2MHz	29dBm	P
GSM1900	1850.2MHz	29dBm	P
WCDMA850	826.4MHz	23dBm	P
WCDMA1900	1852.4MHz	23dBm	P
WCDMA2100	1922.4MHz	23dBm	P
Read/Write			
Band	*Tx Frequency*	*Max Tx Power Level*	*Pass(P) or Fail (F)*
GSM850	824.2MHz	32dBm	P
GSM900	880.2MHz	32dBm	P
GSM1800	1710.2MHz	29dBm	P
GSM1900	1850.2MHz	29dBm	P
WCDMA850	826.4MHz	23dBm	P
WCDMA1900	1852.4MHz	23dBm	P
WCDMA2100	1922.4MHz	23dBm	P
Comments for test result: Passed			

Table 3: SSD near field EMS test by stripline.

Idle			
Band	*Tx Frequency*	*Max Tx Power Level*	*Pass(P) or Fail (F)*
GSM850	824.2MHz	32dBm	P
GSM900	880.2MHz	32dBm	P
GSM1800	1710.2MHz	29dBm	P
GSM1900	1850.2MHz	29dBm	P
WCDMA850	826.4MHz	23dBm	P
WCDMA1900	1852.4MHz	23dBm	P
WCDMA2100	1922.4MHz	23dBm	P
Read/Write			
Band	*Tx Frequency*	*Max Tx Power Level*	*Pass(P) or Fail (F)*
GSM850	824.2MHz	32dBm	P
GSM900	880.2MHz	32dBm	P
GSM1800	1710.2MHz	29dBm	P
GSM1900	1850.2MHz	29dBm	P
WCDMA850	826.4MHz	23dBm	P
WCDMA1900	1852.4MHz	23dBm	P
WCDMA2100	1922.4MHz	23dBm	P
Comments for test result: Passed			

6. TEST RESULTS

After performed the EMS tests mentioned earlier for sample SSD module for various operating modes, the results are summarized as following.

7. CONCLUSION

The SSD EMS test against RF power from WWAN transmitters is conducted to evaluate the immunity level and shielding effectiveness needed for SSD integrated with nearby RF transmitting module. For the Ultrabook and notebook PC manufacturers, they can benefit the SSD failure analysis against WWAN/WLAN systems and further utilize the isolation techniques from this study. As to the SSD related manufacturers, they can also benefit from this study about failure mode from EM susceptible test to identify their SSD design weakness for future improvement.

ACKNOWLEDGMENT

The authors would like to thank TRC (Training and Research Company) Taiwan for technical support, measurement assistance and test fixture for this study. We would also like to sincerely express appreciation to BSMI (Bureau of Standards, Metrology and Inspection) and NSC (National Science Council) for their financial grants support to this study. The original research work presented in this paper was made possible in part by the BSMI under Contract grant from BSMI Taiwan.

REFERENCES

1. Helttula, J., "Display and touch module electromagnetic verification specification," 6–15, Nokia SD NWP Product Quality, Feb. 2012.
2. IEC 62132-8, "Integrated circuits — Measurement of electromagnetic immunity 150 kHz to 3 GHz — Part 8: Measurement of radiated immunity — IC stripline method," 2012.
3. Lin, H.-N., C.-H. Lin, T.-J. Cheng, and M.-C. Liao, "Antenna effect analysis of laptop platform noise on WLAN performance," *PIERS Proceedings*, 585–590, Beijing, China, March 23–27, 2009.
4. Lin, H.-N., C.-H. Lin, M. C. Chang, and Y.-Y. Shih, "Analysis of platform noise effect on WWAN performance," *2010APEMC*, 12–16, TH-PM-A1-2: SS-13, Apr. 2009.
5. Lin, H.-N., J.-L. Chang, and C.-W. Kuo, "Radiated EMI coupling analysis between high-speed modules and receiving antennas of mobile devices," *2012 Asia-Pacific Symposium Electromagnetic Compatibility*, WE-AM-MS-1, May 2012.