Pre-EMC Testing in ATC versus an EMC Test Laboratory

Gilbert A. Diwa, Jaime M. Ebero, Harvey V. Naredo

Analytical Testing and Calibration (ATC) Laboratory – Integrated Micro-Electronics Inc. (IMI)
North Science Avenue, Laguna Technopark Special Economic Zone (LT-SEZ), Binan 2024, Laguna
gilbert.diwa@global-imi.com, jaime.ebero@global-imi.com, harvey.naredo@global-imi.com

ABSTRACT

Pre-EMC testing done in an EMC Test Laboratory (ETL) and in ATC is conducted emission, 150 kHz to 108 MHz and radiated emission, 30 MHz to 2.5 GHz using CISPR 25 Class 5 limits. The DUT is a commercial camera operating at 12 V and 355 mA. The conducted emission noise level of ATC is approximately higher by 20 dBuV. Conducted emission at 12 V measurement in ATC is approximately higher by 10 dBuV. The Radiated emission measurement at 150 kHz to 30 MHz between UL and ATC are comparable. From 30 MHz to 200 MHz, the ATC measurement of Radiated emission is approximately higher by 10 dBuV/m, however from 200 MHz to 2.5 GHz UL measurement is higher by 20 dBuV/m than ATC measurement. ATC and ETL detected conducted emission peaks at 1 MHz. Radiated emission peak at 40 MHz was both detected by ATC and ETL measurements. However, ATC has not detected peak at 70 MHz but detected by ETL. At about 750 MHz and 900 MHz and 2.3 GHz, ATC detected peaks but not detected by ETL.

1. 0 INTRODUCTION

Electrical and electronic devices inherently generate electromagnetic interference to other devices therefore it should be regulated. CISPR 25[1] contains limits and procedures for the measurement of electromagnetic interference of receivers used on board vehicles, boats, and on devices in the frequency range of 150 kHz to 2.5 GHz. In the conducted emission, the frequency range is 150 kHz to 108 MHz while the radiated emission frequency range is 150 kHz to 2.5 GHz.

Fundamental equations such as Ampere's law and Ampere-Maxwell law encompass the phenomenon of conducted emission and radiated emission.

Ampere's law[2]:

$$\oint \vec{B} \cdot d\vec{s} = \mu_0 i^{enc} \qquad (1)$$

Where $\vec{B}$, is the magnetic field, $d\vec{s}$ is the infinitesimal segment path along the Amperian loop, μ_0 is the magnetic constant and i^{enc} is the current enclosed by the Amperian loop.

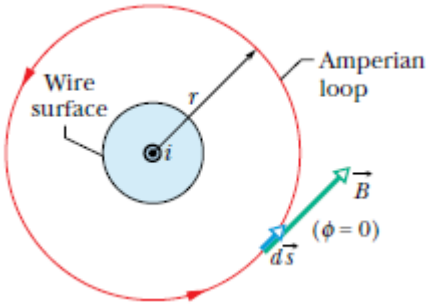

Fig. 1. Representation of variables in Ampere's law.

Ampere-Maxwell's law[2]:

$$\oint \vec{B} \cdot d\vec{s} = \mu_0 \varepsilon_0 \frac{d\Phi^{elec}}{dt} + \mu_0 i^{enc} \qquad (2)$$

Where Φ^{elec} is the electric flux, and ε_0 is the electric constant.

Conducted emission in power lines occur via electrical and magnetic coupling and electronic switching in a device under test (DUT). Measurement of conducted emission uses Voltage method or Bulk Current Injection method. Only the Voltage method was compared in this paper. In the Voltage method, the setup uses line impedance stabilization network (LISN) connected in series to the supply line and return line. The spectrum analyzer is connected to the LISN to plot the voltage level (dBuV) versus the frequency (Hz). LISN is a low pass filter connected between the AC-DC Power supply and the DUT. The setup is inside the semi-anechoic chamber.

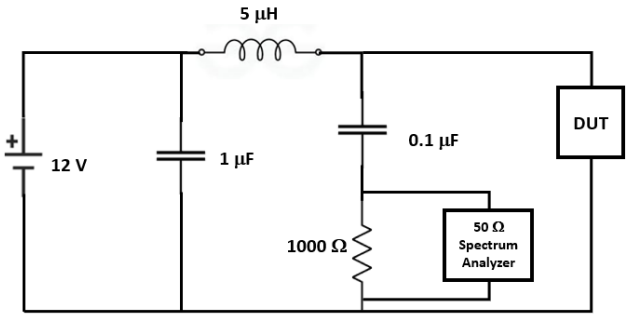

Fig. 1. Schematic Diagram of the LISN. The 5 µH LISN impedance, 100 kHz to 110 MHz[3].

Radiated emission is the propagation of electromagnetic wave from a device. Monopole antenna is used for low frequency (150 kHz to 30 MHz), biconical antenna and LPDA for mid-frequency (30 MHz to 1 GHz, and horn antenna for high frequency (1 GHz to 2.5 GHz). The spectrum analyzer attached to the antenna is used to gather data. The setup is inside the semi-anechoic chamber.

The semi-anechoic chamber size used in ATC is about 5 m x 3 m x 3m while the chamber size of the test laboratory is 10 m x 10 m x 10 m x 10 m. Urethane absorber is used.

2. 0 REVIEW OF RELATED WORK

Refer to 1.0 INTRODUCTION

3.0 METHODOLOGY

The ATC semi-anechoic chamber shield performance is -80 dB from 30 MHz to 1 GHz and -60 dB from 1 GHz to 18 GHz. The radio wave absorber is urethane with dimensions 500 mm x 500 mm x 400 mm high. CISPR 25 test frequency range from 150 kHz to 2.5 GHz, Class 5 limit was used. Conducted emission voltage disturbance method test range is 150 kHz to 108 MHz while the Radiated emission test range is 150 kHz to 2.5 GHz.

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Fig. 2. Spectrum analyzer.

As shown in Fig. 2, the spectrum analyzer range of detection is from 9 kHz to 6.2 GHz. AC to DC power supply was used to supply 12 V and 355 mA to the DUT. Current consumption of the biased DUT setup is about 207 mA. The spectrum analyzer and the power supply are placed outside the semi-anechoic chamber. A 2 mm grounded copper plated wooden table was used as stage for the setup inside the semi-anechoic chamber. The wooden table is 2 m long x 1 m wide x 1 m high. The DUT and the power lines are placed on top of 50 mm thick insulating spacer.

The conducted emission setup is comprised of 2 LISN, an AC-DC power supply, and DUT with power cables as shown in Fig. 3.

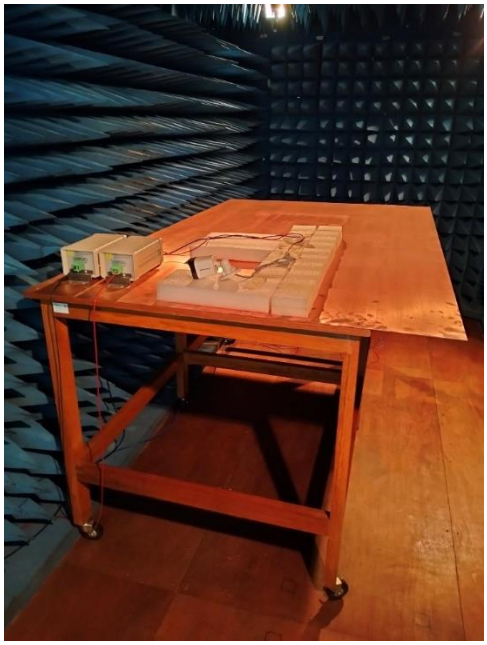

Fig. 3. Conducted emission setup 150 kHz to 108 MHz using 5 µH LISN.

The radiated emission setup is composed of 2 LISN, an AC-DC power supply, antenna, DUT and power cables as shown in Fig. 4 to Fig. 7.

The monopole antenna is positioned 1 m from the DUT as shown in Fig. 4. The monopole antenna is mounted on a tripod. The monopole antenna is connected to the spectrum analyzer using 50 Ω coaxial cable.

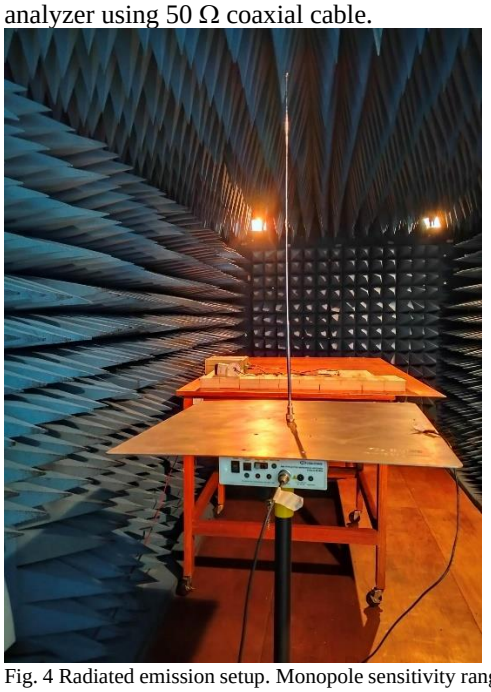

Fig. 4 Radiated emission setup. Monopole sensitivity range from 150 kHz to 30 MHz.

The biconical antenna positioned horizontally is placed 1 m away from the DUT as shown in Fig. 5. The biconical antenna is mounted on a tripod. The biconical antenna is connected to the spectrum analyzer using 50 Ω coaxial cable.

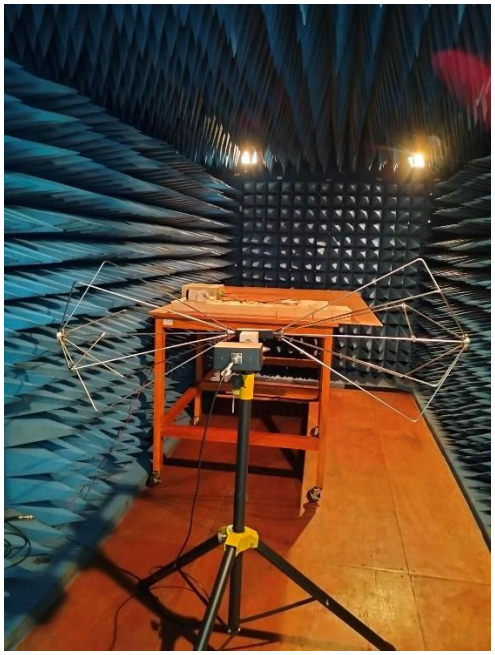

Fig. 5. Radiated emission using biconical antenna sensitivity range from 30 MHz to 300 MHz.

The Log Periodic Dipole Array (LPDA) antenna positioned horizontally is placed 1 m away from the DUT as shown in Fig. 6. The LPDA is mounted on the tripod. The LPDA antenna is connected to the spectrum analyzer using 50 Ω coaxial cable.

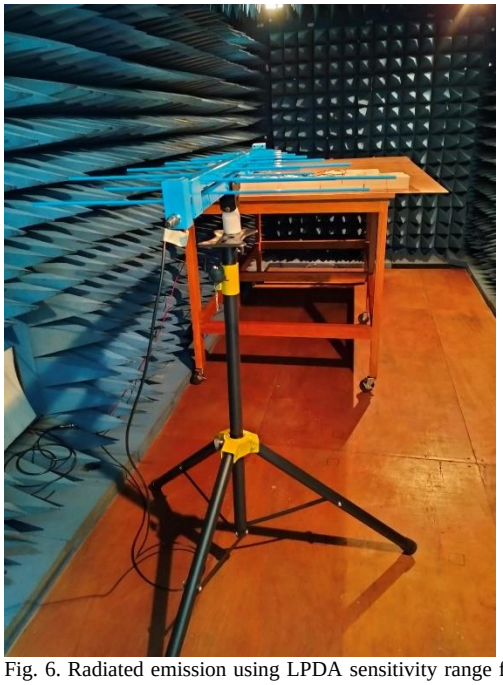

Fig. 6. Radiated emission using LPDA sensitivity range from 250 MHz to 1.3 GHz.

The double ridged horn antenna is placed 1 m from the DUT as shown in Fig. 7. The horn antenna is mounted on a tripod. The horn antenna is connected to the spectrum analyzer using 50 Ω coaxial cable.

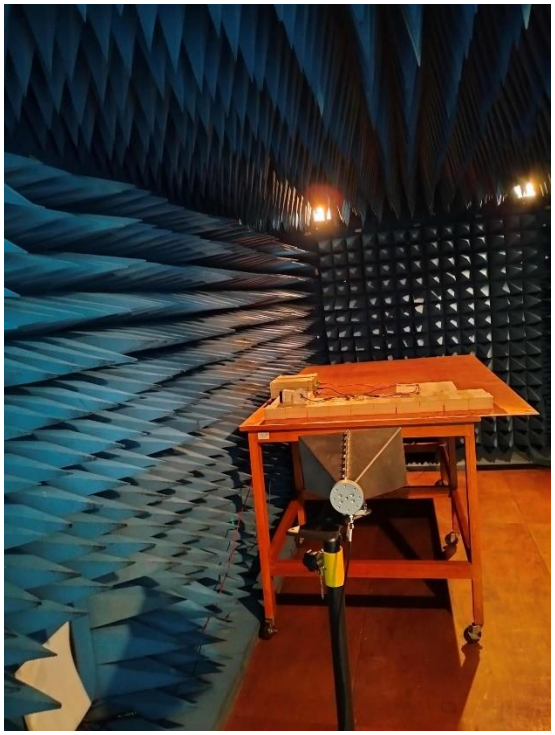

Fig. 7. Radiated emission using horn antenna sensitivity from 1 GHz to 8 GHz.

4.0 RESULTS AND DISCUSSION

Conducted emission noise level was determined from 150 kHz to 108 MHz. ETL Return line is lower by 10 dBuV as compared to ETL Supply line. ATC Return line is lower by approximately 5 dBuV with respect to the Supply line from 150 kHz to 7 MHz. At approximately 30 MHz to 108 MHz, the difference between the ATC Return line and Supply line is about 20 dBuV. ATC noise level is approximately 20 dBuV while ETL is approximately 0 dBuV. The peak at 70 MHz in ATC Supply line can be attributed to current harmonics.

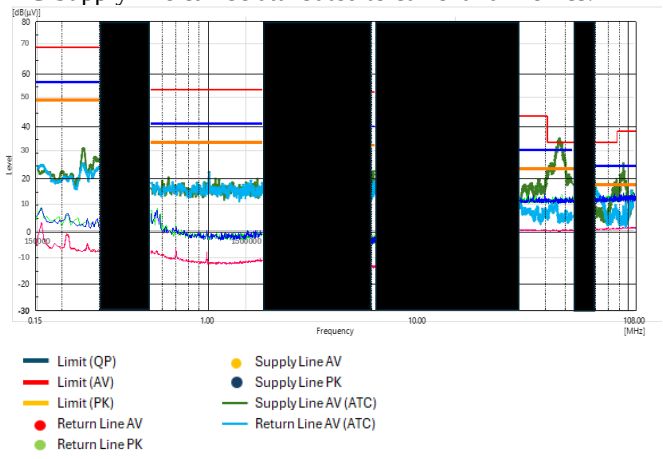

Fig. 8. Plot of Conducted Emission Noise Level. 150 kHz to 108 MHz. CISPR 25 Class 5 limits.

The conducted emission level, after applying 12 V and 355 mA, ETL Supply and Return line level increased by approximately 20 dBuV. ATC Return line increased by 1 dBuV while the Supply line increased by 4 dBuV. ETL's Return and Supply line exhibited a peak at around 1 MHz while only ATC's Supply line exhibited at 1 MHz region. No peak was detected on ATC's Return line. This is attributed to the high noise level, interference of the common mode current and differential current.

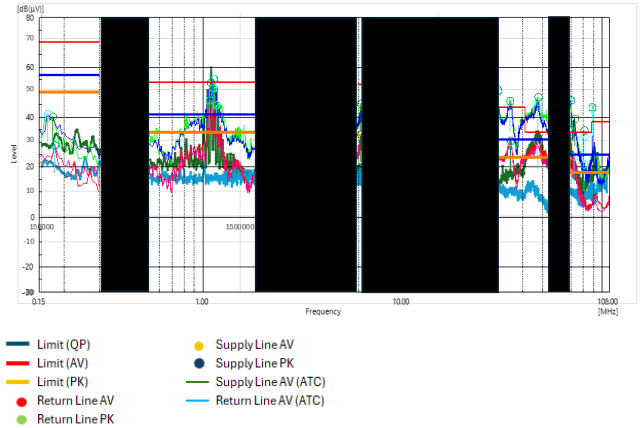

Fig. 9. Conducted emission 150 kHz to 108 MHz, 12 V, CISPR 25 Class 5.

The radiated emission average (AV) level at 150 kHz to 30 MHz of ETL and ATC are comparable as shown in Fig. 10. No peak (PK) level determined in ATC.

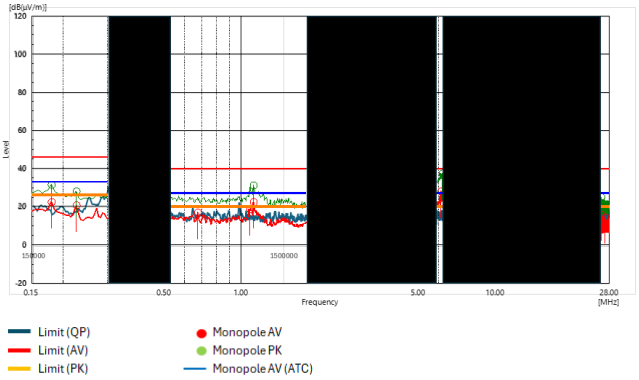

Fig. 10. Radiated emission Monopole, 150 kHz to 30 MHz, 12 V, CISPR 25 Class 5.

ETL measured the radiated emission level (dBuV/m) from 30 MHz to 2.5 GHz using Biconical, LPDA and Horn antenna in horizontal (H) and vertical (V) mode while ATC used the horizontal (H) mode only. The plot of radiated emission shown in Fig. 11 shows ETL's H-AV, H-PK, V-AV and V-PK while ATC detected only AV-H.

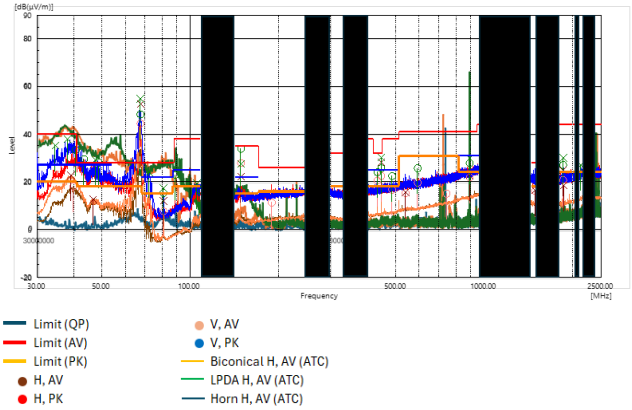

Fig. 11. Plot of Radiated Emission using Biconical, LPDA and Horn antenna, 30 MHz to 2.5 GHz, 12 V, CISPR 25 limits Class 5.

ATC's Biconical measurement level is approximately at 40 dBuV/m and has peak at approximately 40 MHz. ETL's H-AV and V-AV level is lower by approximately 20 dBuV/m than ATC's H-AV level. This is attributed to the higher noise level of ATC. Peak at 40 MHz is detected by both ETL and ATC measurements. Notice that the ETL's V-AV is higher than H-AV. It can be deduced that the amplitude of polarization along the vertical is greater than the horizontal polarization. At approximately 70 MHz, ETL detected a peak of about 50 dBuV/m. However no peak was detected by ATC's biconical antenna, which is attributed to the weak horizontal wave polarization. ATC's LPDA antenna detected peak at about 750 MHz and 900 MHz which is not observed

from ETL's measurement. ATC's horn antenna detected a peak at around 2.3 GHz which is not observed from ETL's measurement.

5.0 CONCLUSION

Pre-EMC radiated emission and conducted emission has been demonstrated in a 3 m x 3 m x 5 m. ATC's pre-EMC set-up can detect conducted emission peaks from 150 kHz to 108 MHz and radiated emission peaks from 150 kHz to 2.5 GHz based on CISPR 25 standard. Although ATC has a higher noise level than ETL, ATC setup can still detect peaks as compared to ETL.

6.0 RECOMMENDATIONS

Radiated emission testing at vertical orientation of the antenna is recommended to further characterize the capability of the ATC pre-EMC setup. Further analysis of the source of noise detected at conducted emission and radiated emission test.

7.0 ACKNOWLEDGMENT

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8.0 REFERENCES

1. CISPR 25, 2nd Edition 2002-08
2. K. Cummings et.al. **Understanding Physics**, John Wiley and Sons Inc. **2004**, pp 872-873, 906.
3. 5 uH Line Impedance Stabilization Network, TEKBOX Digital Solutions, v 1.2, p.2.

9.0 ABOUT THE AUTHORS

GILBERT A. DIWA, Ph.D. Photoscience, MS. Physics, BS Computer Science. Project Engineering Head, Failure Analysis Principal Engineer in Integrated Microelectronics Incorporated – Analytical Testing and Calibration since 2018

JAIME M. EBERO Jr. A licensed ECE from Mapua Institute of Technology. He has more than 15 year experience in reliability engineering and failure analysis. He is currently with Integrated Micro-Electronics serving in the Analytical Testing Laboratory as a Reliability Engineer focused on mechanical stress tests for advanced products.

HARVEY V. NAREDO, Graduated from the University of Perpetual Help Calamba with a Bachelor's Degree in Electronics Communication Engineering. Has a 2-year experience as a process engineer and is currently working at Integrated Micro-Electronics Inc. since 2022

10.0 APPENDIX

NOT APPLICABLE