REDUCTION OF CONDUCTIVE EMI NOISE RESULTED FROM THE COMMERCIAL POWER SUPPLY *

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Abstract

Almost every electronic equipment must be connected to power grid. Because of the complexity of power lines, the reduction of conductive electromagnetic interference (C-EMI) plays an important role in precise measurements. Electromagnetic interference (EMI) is a major problem for electronic equipment, especially for those sophisticated instruments using in TLS (Taiwan Light Source). Therefore, a lot of efforts have been made to minimize the electromagnetic noise between instruments and power grid [1]. In this paper, a line impedance stabilization network (LISN) was built up to get the power spectrum of various instruments from power grid. After measuring some commercial power supplies, it is found that some of these power supplies induce effectively C-EMI into power grid, even though a passive filter is bound in power line. These noises may influence numerous equipments in a local area near the sources. Therefore, how to choose a suitable filter to block off noise is a decisive factor to reduce the effects of C-EMI.

INTRODUCTION

As the popularization of electronic products increasing, more and more electromagnetic noises are surrounding our daily life. These noises may be too small to affect our health, but these unnoticed noises could enormously interfere with the performance of high precision instruments using in every laboratory. Generally speaking, electromagnetic interference is classified with two types; one is “Radiated Electromagnetic Interference” (R-EMI), which transfers in space by radiation form. The other type of noise is transferring through power grid, which is so called “Conducted Electromagnetic Interference” (C-EMI). Both R-EMI and C-EMI need coupling mechanism to transport. Radiated electromagnetic interference is induced at frequencies higher than radio frequency; therefore, we define the boundary of frequency between radiated electromagnetic interference and conducted electromagnetic interference is 30 MHz. In this paper, conducted electromagnetic interference is defined and measured between 0.45 MHz to 30 MHz. According to the FCC part 15, all commercial electronics equipments should emit a limited intensity of noise. They are class A: 60 dBμV in the frequency range from 0.45 MHz to 1.6 MHz、69 dBμV in the frequency range from 1.6 MHz to 30 MHz, and class B with a uniform intensity of 48 dBμV in the frequency ranging from 0.45 MHz to 30 MHz. (shown as Fig. 1)

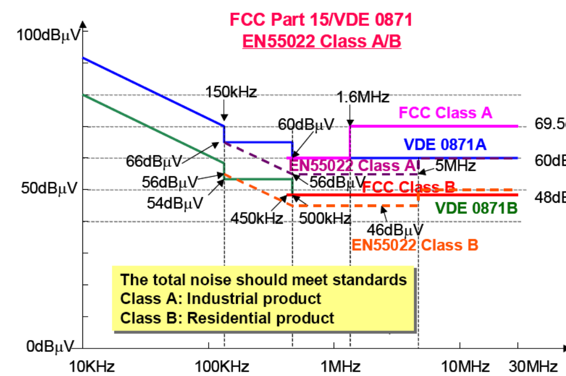

Figure 1: Conducted EMI standards [2-3].

Several kinds of power supplies commonly used in NSRRC have been tested in this paper. Switching power supply is widely applied and many of them are made up of high speed electronics nowadays. These high speed electronics induce lots of surges and high frequency noises. These noises could affect the instruments around the source through power grid. Besides, a large amount of cables and wires bounding to instruments provide the coupling paths. Without properly arrangement, bunches of wire not only increase the risk of fire disaster, but also induce annoying noises. In order to avoid this situation, we have testified some EMI filters and checked their efficiency. According to the measurement, conducted EMI could be suppressed obviously in some bands of frequency. Our objective is all of instruments should match the restriction of FCC part 15 class B [2].

EXPERIMENTAL METHODS AND APPARATUS

The experimental apparatus is set up as shown in Fig 2. A LISN (Line Impedance Stabilization Network) is used to separate “Common Mode” and “Differential Mode” noise from EUT (Equipment Under Test). The result is recorded as spectrum format by spectrum analyzer. A 2m × 2m sheet of copper is used as ground plane to prevent unnecessary electric disturbance. In our measurement, LISN plays an important role to separate the common mode and differential mode noise. There are mainly two functions for LISN. One is to supply clean electricity to EUT, the other is to provide stable 50 ohm for input impedance. By means of spectrum analyzer, we can

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acquire common mode and differential mode noise separately.

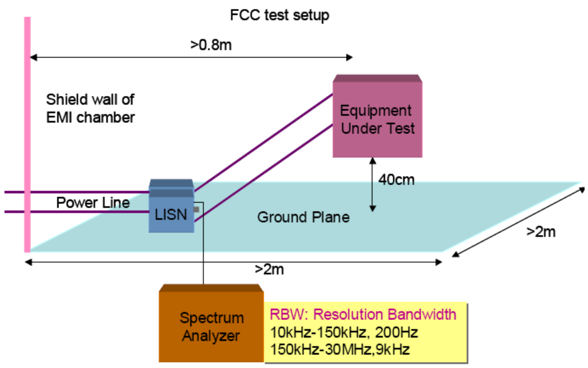

Figure 2. Experimental apparatus.

Several kinds of power supply commonly used in TLS (Taiwan Light Source), including quadruple magnet DC power supply, pulse magnet DC high voltage power supply have been measured. Also, regarding the number of vacuum pumps in beam storage system is numerous. We have measured couple of vacuum pumps, such as dry pump、turbo molecular pump and ionization pump. According to the measurement results, it is found that all power supplies and pumps under test are well designed to fit in FCC class A standard. However, one of EUTs, the DC high voltage power supply of ionization pump exceeds class B standard.

EXPERIMENTAL RESULTS

The first thing to reduce the conducted EMI should be a well designed electronic circuit, especially in modern electric device. Once the negligence or miss happened in the beginning of circuit design, the only thing we can do is adding filters to block off conducted EMI noise.

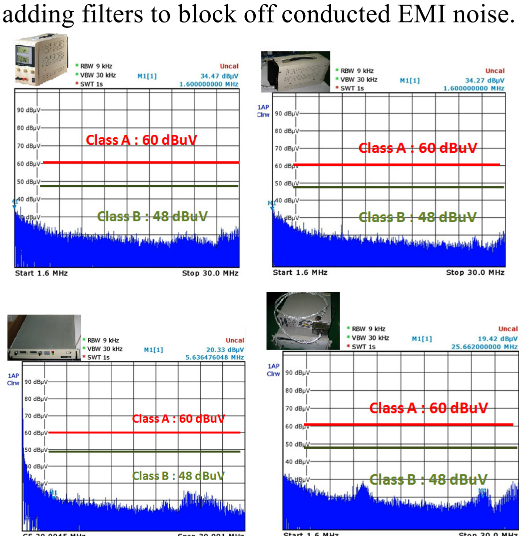

Figure 3. Conducted EMI spectrum of some qualified power supplies.

A linear power supply, which supposed to have less EMI noise, has been tested first. As our expectation, the spectrum shows this device emits unnoticeable conducted EMI noise (see Fig.3 upper left graph). Compare to the linear power supply, the upper right graph shows the spectrum of a switching power supply. Because of the built-in filter on power input end, it efficiently stops noise from flowing out to the power grid. It is observed that the high voltage DC power supply (the bottom left graph) and the quadruple magnet power supply (the bottom right graph) send out an acceptable noise level. We can see some peaks showing between 10 MHz ~ 30 MHz with the intensity less than 48 dBμV. That means the above devices conform to FCC class B standard.

We also measured the performance of different kinds of pumps. The dry pump and the turbo molecular pump under test emit a small intensity of conducted EMI noise. Both of them conform to class B standard without any filtering process (Refer to Fig. 4).

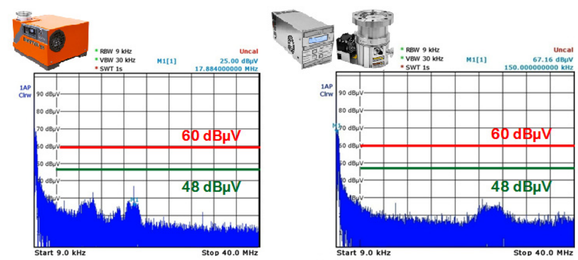

Figure 4: Conducted EMI spectrum of different kinds of vacuum pumps which conform to class B.

On the other hand, the spectrum of ionization pump shows a contrary result (Refer to Fig. 5). The dual controller of ionization pump emits a noise bigger than 48 dBμV, and slightly crosses over the 60 dBμV level while the controller outputs high voltage. To prevent the ionization pump affecting other devices, an EMI filter is added to the input end of the controller. From Fig. 5, it is observed the intensity of noise is 65 dBμV at 12 MHz and 60 dBμV at 4 MHz, which exceeds the class A standard. It implies the devices using the same power grid could be affect by conduction.

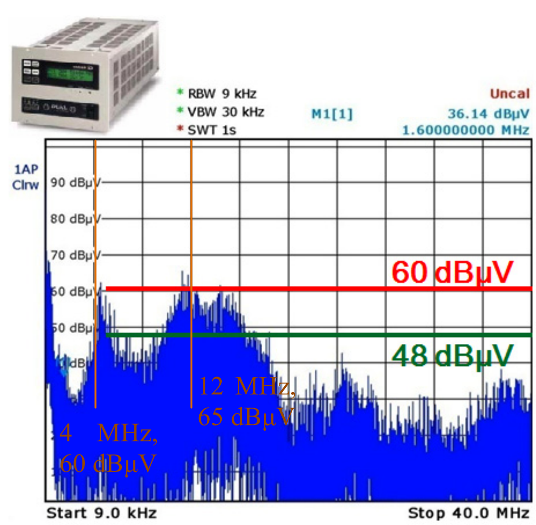

Figure 5: Dual controller of ionization pumps emits obvious noise.

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In order to suppress the noise level, an EMI filter is added to the input end of the dual controller. After the installation, we can see a distinct reduction, especially around 4 MHz - 15 MHz (Refer to Fig. 6). Comparing these two spectra, the intensity at 4 MHz reduces 23 dBμV, and 30 dBμV at 12 MHz frequency. The result fits the FCC class B standard then.

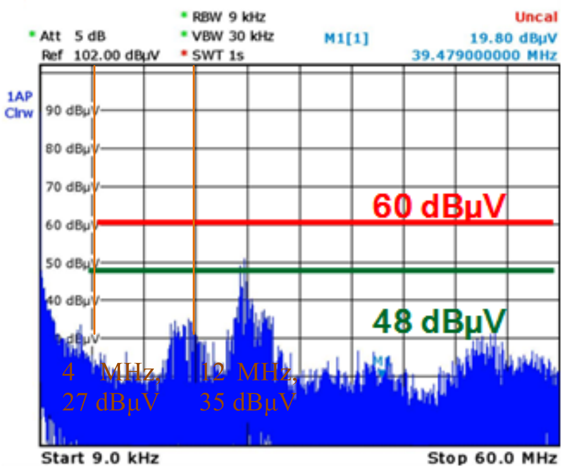

Figure 6: Reduction of EMI intensity after filter added.

In addition to add filter, the installation of UPS (Un-interruptible power supply) also reduces the conducted EMI noise. Refer to Fig. 7, the intensity at 4 MHz is slightly bigger than adding filter, however, at 16 MHz, the intensity reduces from 57 dBμV to 41 dBμV. The overall intensity by adding UPS is smaller than adding filter. It seems reasonable that the performance of UPS is better than filter. The UPS rectifies electricity and then converts the filtering current to alternating source. The process eliminates the high frequency noise coming from power grid. There is no other noise unless the UPS switches its source. When power failure, the UPS switches its power source and a surge will be generated.

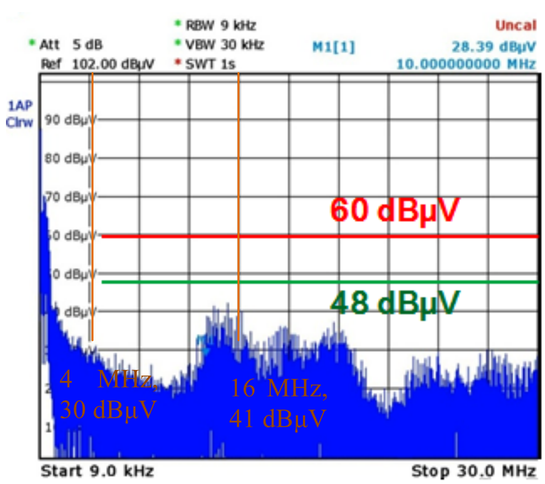

Figure 7: Reduction of conducted EMI intensity after off-line UPS installation.

CONCLUSIONS

After testing several cases, the reduction of conducted EMI from some commonly used devices had been confirmed. By adding EMI filter or UPS system, the noise level would be obviously suppressed by the amount of 20 dBμV ~ 35 dBμV. By means of these processes, all equipment under test will conform to the FCC class B standard. The remedy helps us to deal with the existing problems even without the modification of the instruments.

REFERENCES

[1] Y.-H. Liu et al., “Conductive EMI Test of Magnet Power Supply in NSRRC”, IPAC10, 2010.

[2] “The Federal Code of Regulation”, FCC Part 15.

[3] “The European Standard”, EN 55022.