DESIGN OF ELECTROMAGNETIC FIELD (EMF) FOR A NOVEL ON-LINE ELECTRIC VEHICLE (OLEV)

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INTRODUCTION

Even though intensive researches have been performed on fully electric vehicles for a long time, still we are facing serious problems to be solved in the battery-powered electric delivery system. These issues are enlarged size, weight, and cost of battery, recharging time, and limited availability of charging service points. Moreover, diminished stocks of lithium could cost increasingly high prices and lead to electric vehicles pricing themselves out of the automotive marketplace.

Recently, KAIST has introduced the novel on-line electric vehicle (OLEV), in which the automotive vehicle constantly receive and recharge their power from the power lines embedded underneath the surface of the road. OLEV has the reduced battery capacity to about 20 percent compared to that of the conventional battery-powered electric vehicles, while it can consequently minimize the weight and the price of the vehicle and power station.

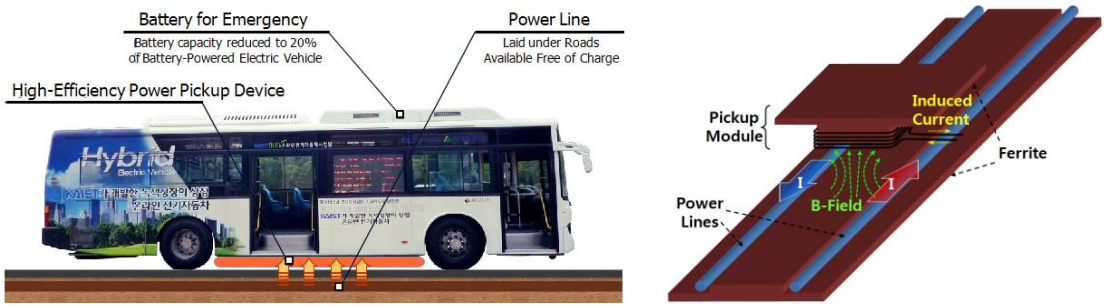

Figure 1: Photograph of OLEV and its main devices (left) and concept of contactless power transfer (right)

ACTIVE AND PASSIVE SHIELDING

One of the key design requirements of the OLEV system is the suppression of the leakage magnetic flux from power lines and pickup module while it maintains the power delivery efficiency and meets the total power needs of the OLEV. The EMF problem is concerned since the OLEV receives the main power from the rail underneath the road, and there should be a great amount of EMF leakage between the vehicle and the road. In order to guarantee the minimal EMF around the vehicle, we have proposed a hybrid design approach by combining the wiring and current control method in addition to active and passive shielding techniques in [2]. The suggested designs are devised to meet the EMF regulation level less than 62.5mG, while it is a regulation notified by Korea Communications Commission [3].

In the proposed design approaches, we have adopted metallic shield plate to reduce the magnetic flux inside of the vehicle. It is verified that the EMF level inside the vehicle is lowed to less than 30mG. In particular, we have applied vertical magnetic shielding plate underground as shown in Figure 2(top) to reduce leakage magnetic flux outside the vehicle and on the road. It is also noted that soft electrical connection between the metallic brush of the vehicle and the vertical ground plate under the ground significantly reduces EMF levels.

Furthermore, in order to further reduce the leakage EMF levels, we have employed active shielding techniques. It is confirmed that the active shielding method is the good solution for the reduction of magnetic field especially at the low frequency. Figure 2(bottom) shows the simulated effectiveness of the active shield method applied to the OLEV. As shown in Figure 3, it is found that the passive shielding is applied to the OLEV, and the EMF level is significantly reduced. The proposed design approaches are verified though 3D EM full-wave simulations and are verified by the EM field measurement.

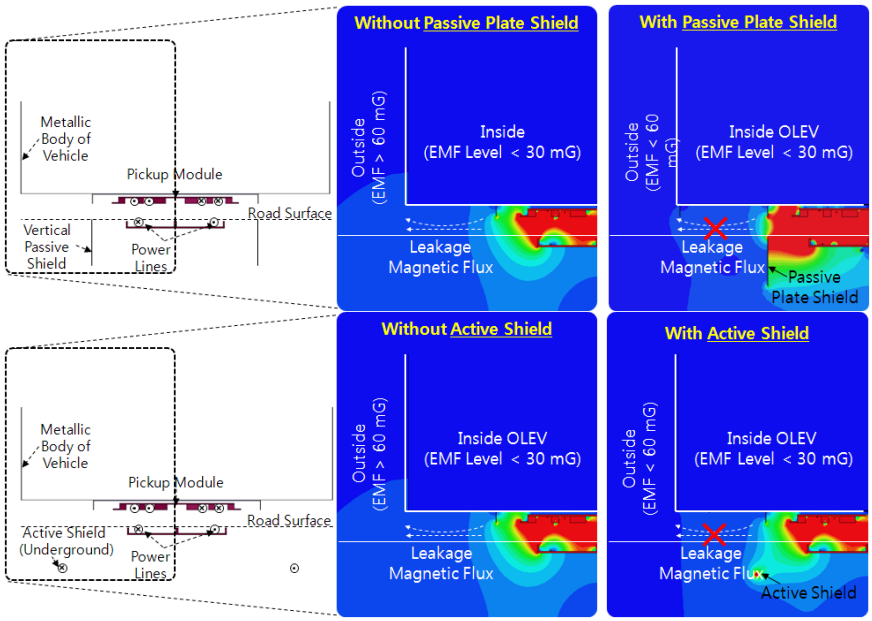

Figure 2: Simulated passive plate shield (top) and active shield (bottom). Both reduce EMF level significantly.

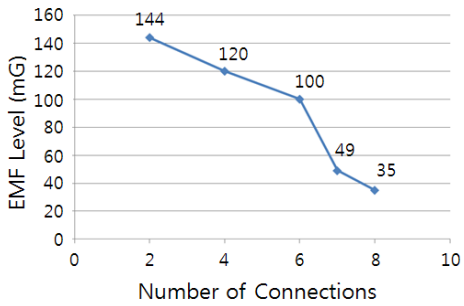

Figure 3: Measured EMF level of OLEV with vertical passive shield and brush connecting to chassis of vehicle.

CONCLUSIONS

We have introduced OLEV and its contactless power transfer mechanism. The suggested EMF design methods were successfully demonstrated by combining wiring, and current control as well as passive and active shield method to improve the power transfer efficiency and to suppress the leakage magnetic flux. The proposed design methodologies were well verified through a series of electromagnetic field simulation and measurement.

REFERENCES

[1] H. R. Ross, "Roadway for supplying power to vehicles and method of using the same," U.S. Patent no. 4007817, Feb. 15, 1977.

[2] S. Celozzi, "Active Compensation and Partial Shields for the Power-Frequency Magnetic Field Reduction," IEEE Int'l Symposium on Electromagnetic Compatibility, vol. 1, pp. 222-226, Nov. 2002.

[3] Notification no. 2008-37, Korea Communications Commission, May 2008.