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SERIES K: PROTECTION AGAINST INTERFERENCE

Electromagnetic field strength inside and outside of electric vehicles using wireless power transfer technology

ITU-T K-series Recommendations – Supplement 29

Supplement 29 to ITU-T K-series Recommendations

Electromagnetic field strength inside and outside of electric vehicles using wireless power transfer technology

Summary

In the near future, the electric vehicle may become the means of transport used most frequently by the general public. Electromagnetic field (EMF) exposure levels from electric vehicles causes some concern to the general public so they should be assessed for the various types of vehicles.

Supplement 29 to ITU-T K series Recommendations considers a particular electric vehicle using dynamic wireless power transfer (WPT) technology to charge its battery with the power delivered from the coils installed underground. In this case, passengers and drivers may be exposed to an EMF inside and outside the vehicle when it is stationary or moving. In each case, two different EMF measurement protocols need to be applied to evaluate human exposure levels to EMF. This Supplement includes the evaluation results of EMF exposure levels based on exposure limits inside and outside the electric vehicles known by the commercial name of OLEV (on-line electric vehicles) developed in the Republic of Korea.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
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Keywords

Electric vehicle, EMF strength, exposure level, WPT.

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Supplement 29 to ITU-T K-series Recommendations

Electromagnetic field strength inside and outside of electric vehicles using wireless power transfer technology

1 Scope

This Supplement contains the evaluation results of electromagnetic field (EMF) strength conducted inside and outside a specific electric vehicle known by the commercial name of OLEV (on-line electric vehicle) using dynamic wireless power transfer (WPT) charging technology.

Other electric vehicles using the same or similar charging technologies may exist in the market but do not fall in the scope of this Supplement.

2 References

[IEC 62110] IEC 62110:2009, *Electric and magnetic field levels generated by AC power systems – Measurement procedures with regard to public exposure*.

[IEC 63184] IEC PAS 63184:2021, *Assessment methods of the human exposure to electric and magnetic fields from wireless power transfer systems – Models, instrumentation, measurement and numerical methods and procedures (frequency range of 1 Hz to 30 MHz)*.

3 Definitions

3.1 Terms defined elsewhere

This Supplement uses the following terms defined elsewhere:

3.1.1 magnetic field strength (*H*) [b-ITU-T K.83]: The magnitude of a field vector in a point that results in a force (*F*) on a charge *q* moving with the velocity v:

$$F = q(v \times \mu H)$$

The magnetic field strength is expressed in the unit of amperes per metre (A/m).

3.1.2 electromagnetic field (EMF) [b-ITU-T K.91]: A field determined by a set of four interrelated vector quantities that characterizes, together with the electric current density and the volumic electric charge, the electric and magnetic conditions of a material medium or of a vacuum.

3.1.3 exposure [b-ITU-T K.52]: Exposure occurs whenever a person is exposed to electric, magnetic, or electromagnetic fields.

3.1.4 exposure level [b-ITU-T K.52]: Value given in the appropriate quantity used when to express the degree of exposure of a person to electromagnetic fields or contact currents.

3.1.5 exposure limits [b-ITU-T K.70]: Values of the basic restrictions or reference levels acknowledged, according to obligatory regulations, as the limits for the permissible maximum level of the human exposure to the electromagnetic fields.

3.1.6 reference levels [b-ITU-T K.70]: Reference levels are provided for the purpose of comparison with exposure quantities in air. The reference levels are expressed as electric field strength (*E*), magnetic field strength (*H*) and power density (*S*) values. In this Recommendation, the reference levels are used for the exposure assessment.

3.2 Terms defined in this Supplement

None.

4 Abbreviations and acronyms

This Supplement uses the following abbreviations and acronyms:

EMF Electromagnetic Field

EV Electric Vehicle

ICNIRP International Commission on Non-Ionizing Radiation Protection

OLEV On-Line Electric Vehicle

PAS Publicly Available Specification

WPT Wireless Power Transmission

5 Conventions

None.

6 Background

With the rapid development of WPT technology, the exposure levels of EMF to the human body radiated from WPT devices are becoming an issue of concern. In order to protect the environment and to cope with rapid climate change, electric vehicles operated by built-in batteries are widely used. Among various kind of electric vehicles, the dynamic electric vehicle charges its battery with the power transferred from the coils installed underground. As electric vehicles will be one of the most frequently used type of WPT devices in our daily lives, the EMF exposure level from electric vehicles is becoming a serious concern to many people.

7 What is dynamic wireless electric vehicle charging?

The electric vehicle presented in this Supplement uses 20 kHz frequency band and a rated power of 75 kW. Figure 1 is a diagram of the electric vehicle under discussion, which was developed in the Republic of Korea. The primary coil is wired underground, and the electric vehicle receives electric power wirelessly from its pickup coil at the bottom of the vehicle, which is used to charge a battery or drive a motor.

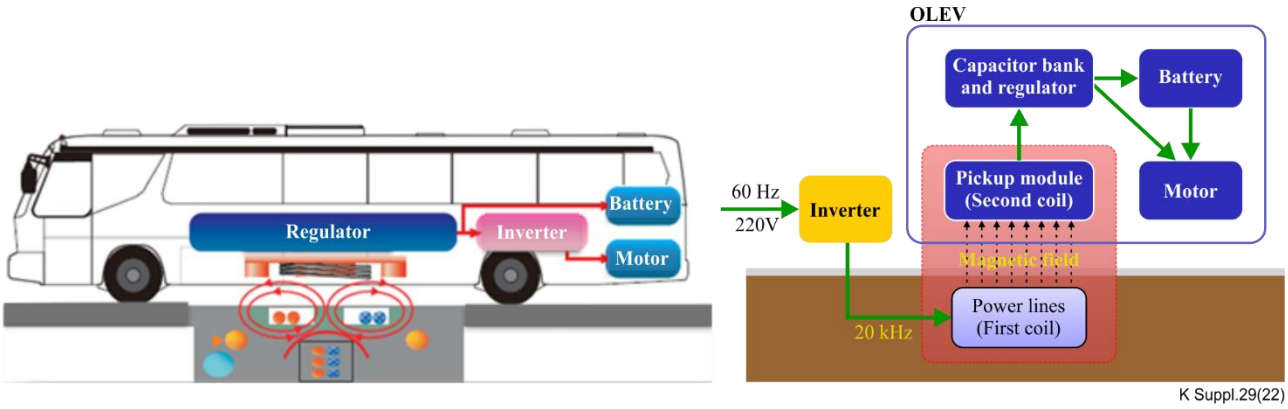


Figure 1 – Operational scheme of electric vehicle

8 EMF exposure conditions of electric vehicles

In the case of the electric vehicle, only whole-body exposure applies, which can happen in two types of exposure condition as shown in Figure 2.

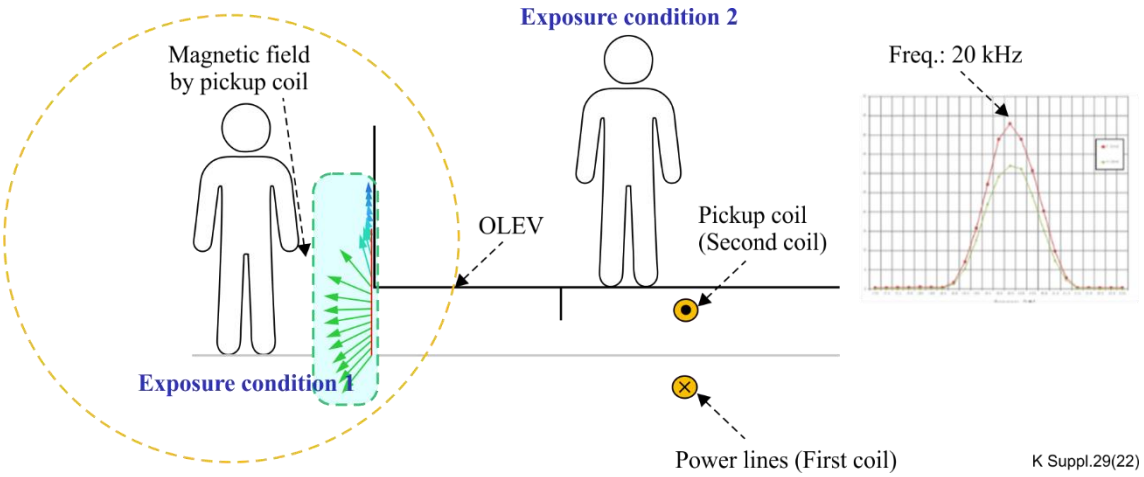
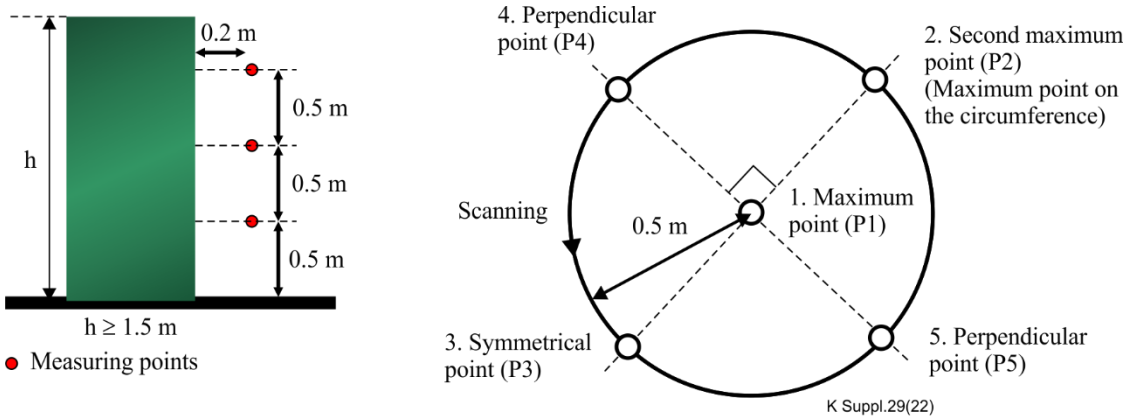


Figure 2 – The exposure conditions of electric vehicles

'Exposure condition 1' describes an outdoor whole-body exposure when the electric vehicle is stationary. In this case, the EMF source is located on the side of the human body. 'Exposure condition 2' is an indoor exposure condition when the vehicle is stationary or moving, and the source of EMF is located under the feet of the human body.

9 EMF exposure evaluation protocol for electric vehicles

In order to evaluate the EMF exposure levels from the electric vehicle, the 3-point average measurement and the 5-point measurement method (adopting a maximum of 3 points and averaging them) were applied for measurement and numerical analysis. The 3-point measurement method is used for 'exposure condition 1' and the 5-point measurement method is used for 'exposure condition 2'.



a) 3-point method

b) 5-point method (point 1 at 0.2 m above ground)

Figure 3 – Measurement points

Regarding exposure condition 2, the level of magnetic field was scanned at a height of 0.2 m above the floor of the vehicle to find the position of the maximum value. The value and position of the second maximum field was determined by scanning along the circle with a radius of 0.5 m away from the centre of the maximum position. Another measurement was conducted at the point that is symmetrical to the second maximum point. Additional measurements were carried out at two points located along the circle perpendicular to the line passing the former three measurement points. Detailed measurement methodologies are described in [IEC PAS 63184] and [IEC 62110].

10 Evaluation results

10.1 Outside the electric vehicle (exposure condition 1)

To prove the validity of the 3-point measurement method, which is a whole-body exposure evaluation method applied at the outside of the electric vehicle, the spheroidal human model (relative permittivity: 15521, loss tangent: 2.939, electrical conductivity: 0.32288 S/m, mass density: 1090.4 kg/m^3) was used as shown in Figure 4.

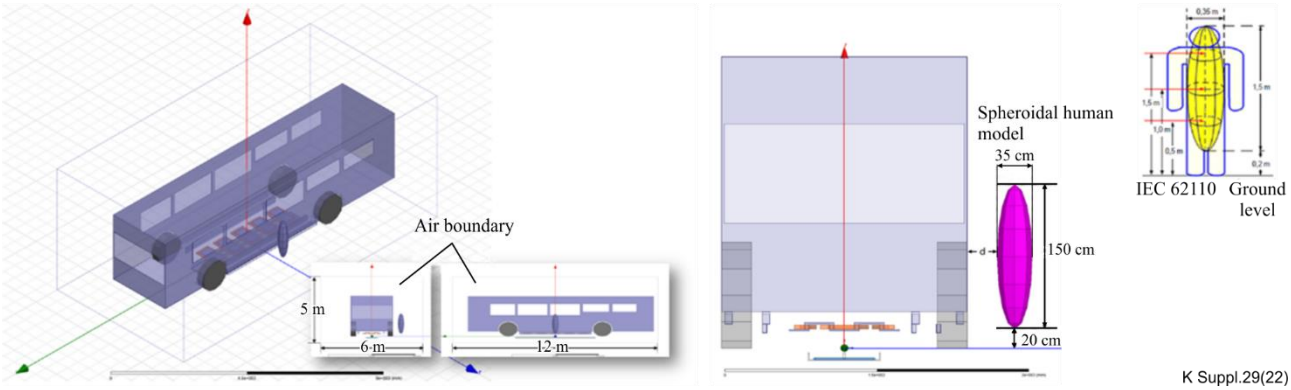


Figure 4 – Numerical analysis model of the electric vehicle and human body

As a result, as shown in Figure 5, the difference between the spatial average value using the numerical analysis human model and the 3-point average value of measurement data was a maximum of 4% at a distance of 0.5 m and 2% at a distance of 1 m from the electric vehicle, respectively.

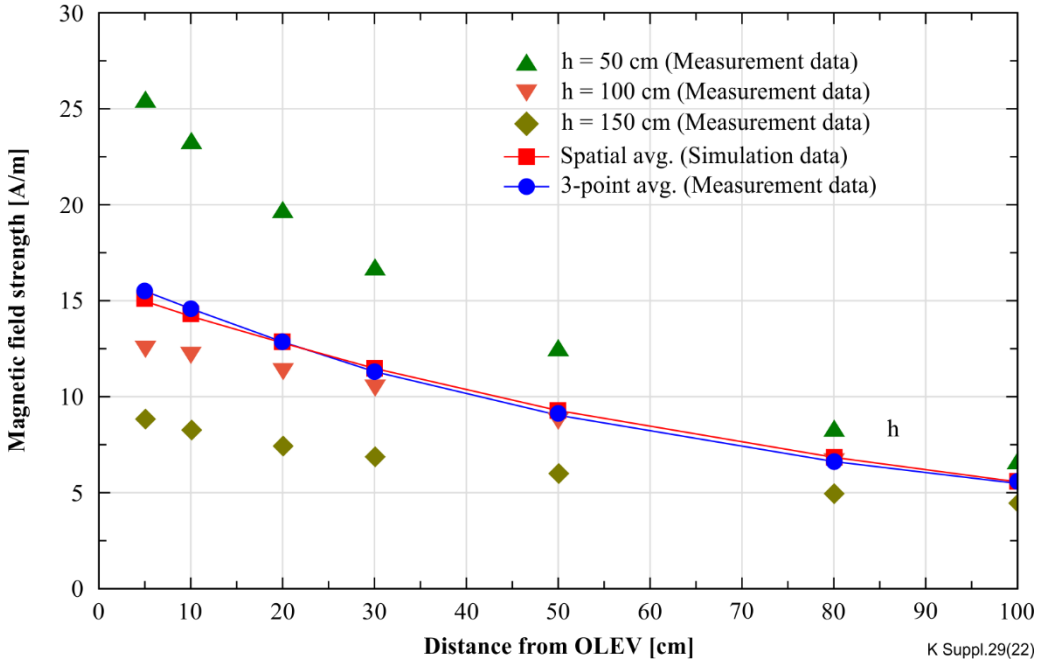


Figure 5 – EMF Exposure levels outside of the electric vehicle (whole-body average, 3-point average)

In a real-life situation, the minimum separation distance that a person can approach to the side of the electric vehicle is about 1 m. As a result of averaging the magnetic field strength at a height of the 3 points, namely 0.5 m, 1.0 m, and 1.5 m, the whole-body exposure to the EMF was 2.1 A/m as shown in Figure 6. The value is about 10% of the reference levels of International Commission on Non-Ionizing Radiation Protection (ICNIRP) guidelines [b-ICNIRP].

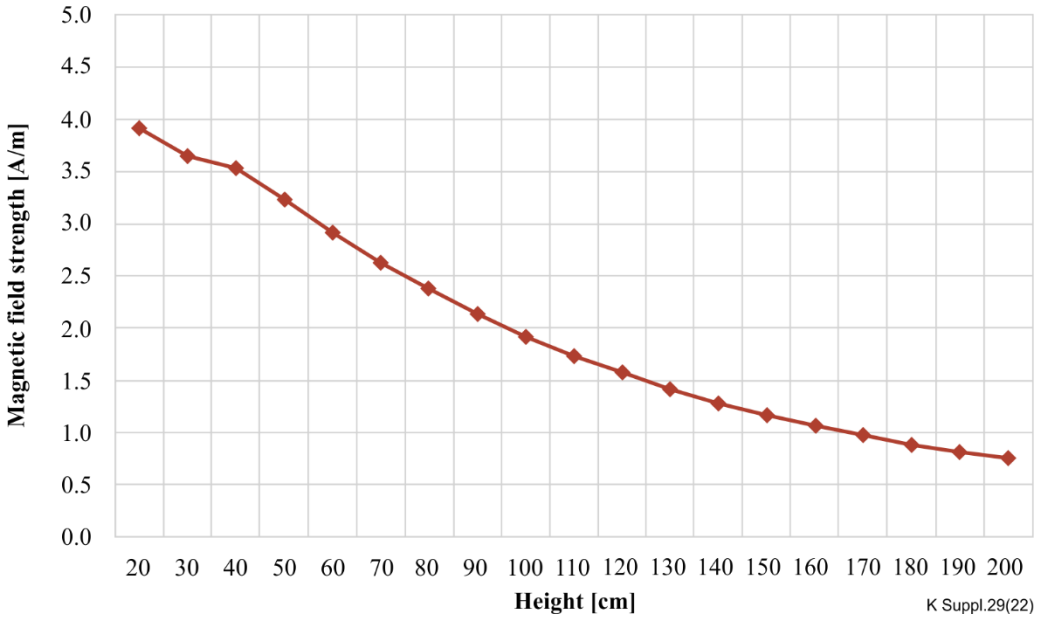
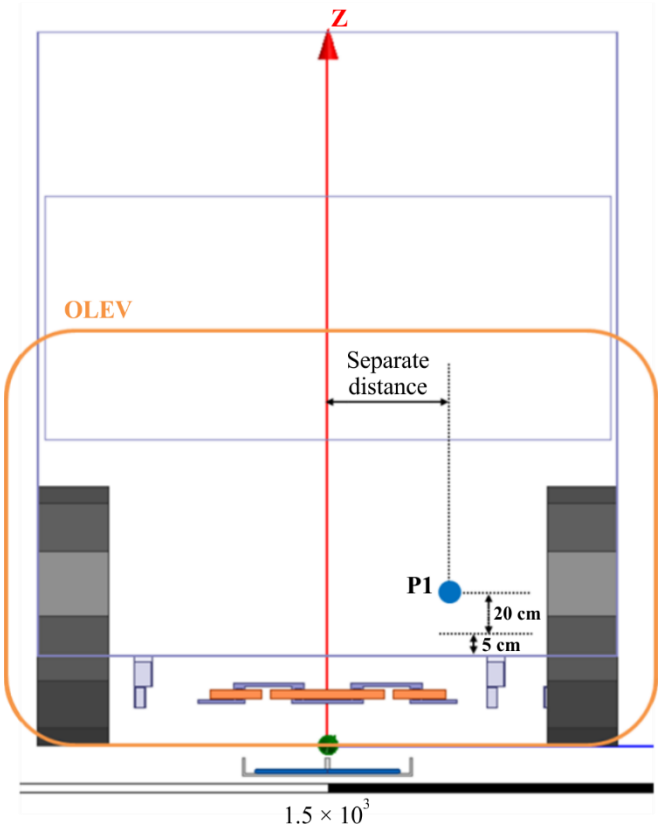


Figure 6 – Measured magnetic field strength at various heights at a distance of 1 m from the electric vehicle

10.2 Inside of electric vehicle (exposure condition 2)

In order to verify the evaluation method of the electric vehicle indoor exposure level shown in Figure 7, it was confirmed through measurement and numerical analysis using the 5-point evaluation method, giving the simulated and measured results of 3.36 and 3.06 A/m, respectively. The value is about 15% of the reference levels of ICNIRP guidelines.



< Simulated data >

Points	Computed values	Adopted values
P1	3.98	○
P2	3.96	○
P3	2.12	○
P4	1.06	
P5	1.93	

< Measured data >

Points	Computed values	Adopted values
P1	3.82	○
P2	3.40	○
P3	1.95	○
P4	0.89	
P5	1.07	

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Figure 7 – Magnetic field strength inside the electric vehicle (unit: A/m)

11 Conclusion

WPT technology will be widely used in various industrial fields. Currently, various WPT devices are being developed and the electric vehicle is one of its application areas. In the near future, the electric vehicle will be the WPT device most frequently used by the general public in their daily lives. The EMF exposure levels from the OLEV type of electric vehicle was investigated in a couple of exposure conditions. The levels were confirmed to comply with the exposure limits and reference levels of the ICNIRP guidelines.

Bibliography

[b-ITU-T K.52] Recommendation ITU-T K.52 (2021), *Guidance on complying with limits for human exposure to electromagnetic fields*.

[b-ITU-T K.70] Recommendation ITU-T K.70 (2020), *Mitigation techniques to limit human exposure to EMFs in the vicinity of radiocommunication stations*.

[b-ITU-T K.83] Recommendation ITU-T K.83 (2022), *Monitoring of electromagnetic field levels.*

[b-ITU-T K.91] Recommendation ITU-T K.91 (2022), *Guidance for assessment, evaluation and monitoring of human exposure to radio frequency electromagnetic fields*.

[b-ICNIRP] International Commission on Non-Ionizing Radiation Protection (2010), *ICNIRP Guidelines for Limiting Exposure to Time-Varying Electric, Magnetic and Electromagnetic Fields (1Hz to 100 kHz)*, Health Physics, Vol. 99, No. 6; pp. 818–836. <http://www.icnirp.de/documents/LFgdl.pdf>

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