Measurement of magnetic fields originating from electric vehicle charger system

Japan EMF Information Center

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Introduction

Electric vehicles have gradually become more common in recent years; there were 62,686 electric vehicles in Japan as of March 31, 2013. Some people are concerned over the possible health effects from such vehicles. Experimental data of the magnetic field intensity showed for below demonstrating the reference values of ICNIRP guidelines which was presented at BioEM 2013. This year, we measured the magnetic fields originating from the electric vehicle charging system under various conditions.

Methods

➢ Measurement instrument

····In order to measure the generated magnetic field level and its frequency

【Sensor】
- 3-D fluxgate magnetometer
- Bartington, UK, model Mag-03
- Frequency range ; 0Hz ~ 3kHz
- Measurement range ; -1mT ~ +1mT

【Spectrum analyzer】
- Bartington, UK, model Spectramag-6
- Sampling interval ; 100μs ~ 10s
- Battery life ; 8 hours

The confirmation of the use propriety of sensor ; Mag-03.

→ It confirms that the frequency of the magnetic field which generated from electric vehicle charger system is less than 3 kHz.

【Sensor】
- 3-D coil magnetometer
- NARDA, Germany, model EFA-300
- Frequency range ; 5Hz ~ 32kHz
- Measurement range ; 100nT ~ 31.6mT

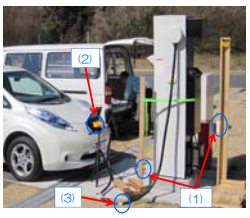
Measurement result

We confirmed that there were no major magnetic fields sources of electric vehicle charger system in the frequency range of 3 kHz to 32 kHz.

➢ Measurement object

Four types of chargers, two for quick charging and two for normal charging, were subjected to the measurement.

- main electric charger bodies --- (1)
- vehicle charging inlets --- (2)
- charging cables ---(3)



➢ Measurement condition

Measurements were conducted at three states of charge (SOC) against the full charge amount at the start of charging, for a maximum of 60 minutes.
If the charging was completed before 60 minutes elapsed, we finished the measurement at that point.

- ◆ quick chargers : 20% / 40% / 60%
- ◆ normal chargers : 20% / 50% / 90%

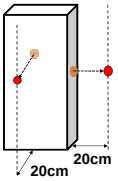
Before starting charging the background magnetic field at each measurement position was measured, and while charging the current flowing through the charging cable was also measured with clamp CT (9278) and power high tester (3193) made by Hioki E.E. Corporation).

➢ Measurement position

At all of the measurement positions, the measuring points are fixed with wooden jigs.

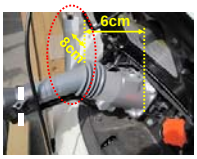
● main charger bodies

We scanned around the main electric charger body panels with the magnetic field sensor placed on their surfaces (distance: 0 cm).
First, we chose two panel surfaces that showed higher magnetic fields, and then identified a point on each surface that showed the maximum magnetic field.
After that we measured the magnetic fields at a distance of 20 cm from the identified points by changing the height of the sensor



● vehicle charging inlets

Magnetic field was measured at a horizontal distance of 6 cm from the charging inlet, which was assumed to be the position of the hand of a person holding a charging connector with their other hand on the vehicle.



● charging cables

Magnetic field was measured on the surface of a charging cable (distance: 0 cm).

Measurement cooperation
: Japan Automobile Research Institute

Table.3. The maximum low frequency magnetic field of indivisual measurement position during normal charging

Type of charger	Magnetic flux density		
	Charger body	Vehicle charging inlet	Charging cable
A	2.7	0.5	34.8
B	0.8	0.2	48.0

The measured values are lower than the magnetic field reference level provided in the ICNIRP Guidelines (200 μT for the general public) at all measurement positions.

Results

Static magnetic field during quick charging

Since the measured static magnetic field during charging was the summation of the geomagnetic field and the magnetic field created by the charging current, we subtracted each axis component of the geomagnetic field from each axis component of the measured magnetic field.

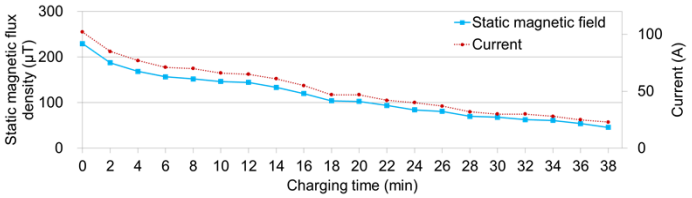


Fig.1. Time variation of magnetic field during quick charging
(ex. Type A, SOC 20% , in contact with charfing cable)

The static magnetic field is the largest at the start of charging and decreases over time.

A correlation was observed between the measured magnetic field and the current supplied to the vehicle.

Table.1. The maximum static magnetic field of individual measurement positions during quick charging

Type of charger	SOC (state of charge)	Magnetic flux density (μT)			Charging time (min)
		Charger body	Vehicle charging inlet	Charging cable	
A	20%	9.8	44.8	229.6	34 - 38
	40%	11.5	46.2	229.6	20
	60%	11.9	49.9	289.3	8
B	20%	5.9	39.4	278.3	32 -50
	40%	5.5	41.6	279.3	12 - 18
	60%	5.5	41.1	143.7	8

The largest value was measured on the charging cable, followed by that at the vehicle charging inlet and that at the charger body.

The maximum static magnetic field characteristics depend approximately on the distance between the magnetic field source and the sensor position.

The measured values are lower than the static magnetic field reference level provided in the ICNIRP Guidelines (40 mT for general public) at all measurement positions.

Low frequency magnetic field during normal charging

The quick electric charger converts commercial frequency current into direct current; the low-frequency magnetic field has multiple frequency components other than 50 Hz.

Table.2. The maximum low frequency magnetic field levels and their frequencies for individual measurement positions during quick charging

Type of charger	SOC (state of charge)	The maximum low frequency magnetic flux density / Frequency		
		Charger body	Vehicle charging inlet	Charging cable
A	20%	7.2μT / 50Hz	0.1μT / 50Hz	0.6μT / 50Hz
	40%	6.6μT / 50Hz	0.1μT / 50Hz	0.4μT / 50Hz
	60%	6.0μT / 50Hz	0.1μT / 50Hz	0.3μT / 100Hz
B	20%	0.9μT / 50Hz	0.1μT / 50Hz	0.8μT / 300Hz
	40%	1.1μT / 50Hz	0.1μT / 200Hz	0.9μT / 200Hz
	60%	1.1μT / 50Hz	0.1μT / 50Hz	0.7μT / 300Hz

The maximum magnetic field was observed at 50 Hz for the charger body for all measuring conditions.

Some results for the vehicle charging inlet and the charging cable showed that the field levels at frequencies higher than 50 Hz

We also calculated the ratio against the ICNIRP Guidelines for simultaneous exposure to multiple frequency magnetic fields using (Eq.1).
The maximum value was 4.7%, which is much lower than the level provided in the Guidelines.

$$f(x) = \sum_{j=1Hz}^{500Hz} \frac{H_j}{H_{Rj}} \qquad (\mathrm{Eq.1})$$

Where,
H_j : Magnetic field strength at frequency j
H_{Rj}: Reference level of magnetic field strength at frequency j

Low frequency magnetic field during quick charging

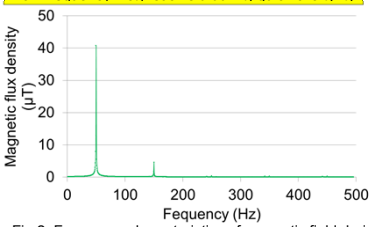


Fig.2. Frequency characteristics of magnetic field during normal charging
(ex. Type B of the normal charger, SOC (state of charge), cable placed in a loop)

Multiple frequencies exist in the low frequency magnetic field.

The maximum level was observed at 50 Hz and also under different measuring conditions.

The ratio of simultaneous exposure to multiple frequency magnetic fields against the level of the ICNIRP Guidelines is 27.3% at maximum, which is below the Guidelines level.

Conclusion

- The static magnetic field generated by chargers during quick charging is the largest at the start of charging, and then decreases as charging time increases.
- The low frequency magnetic field generated by chargers during “normal” charging has multiple peak frequencies, and the maximum level of the magnetic field was observed at 50 Hz.
- All of the strengths of the static and the low frequency magnetic fields generated by chargers during “quick” charging, and the low frequency magnetic fields generated by chargers during “normal” charging, are all lower than the magnetic field reference levels provided in the ICNIRP Guidelines.