Electromagnetic Field Analysis for Smart Key Antenna

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Abstract :
Currently, people are able to control a door lock from a distant point of the outside of a vehicle. Recently, a door lock system has been developed to detect an owner approaching and unlock when he/she grips a door handle. In this system, an antenna detects the existence of an owner with his electrical key within a 3000mm radius around the vehicle. As this performance of the antenna decides the operating area, it is essential to grasp directivity and confirm that there is the unoperating area. In this report, we will describe a case of which we have developed a technique to predict directivity of an antenna using the electromagnetic field analysis software, JMAG

JMAG Users Conference 2010

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AISIN SEIKI Co., Ltd.

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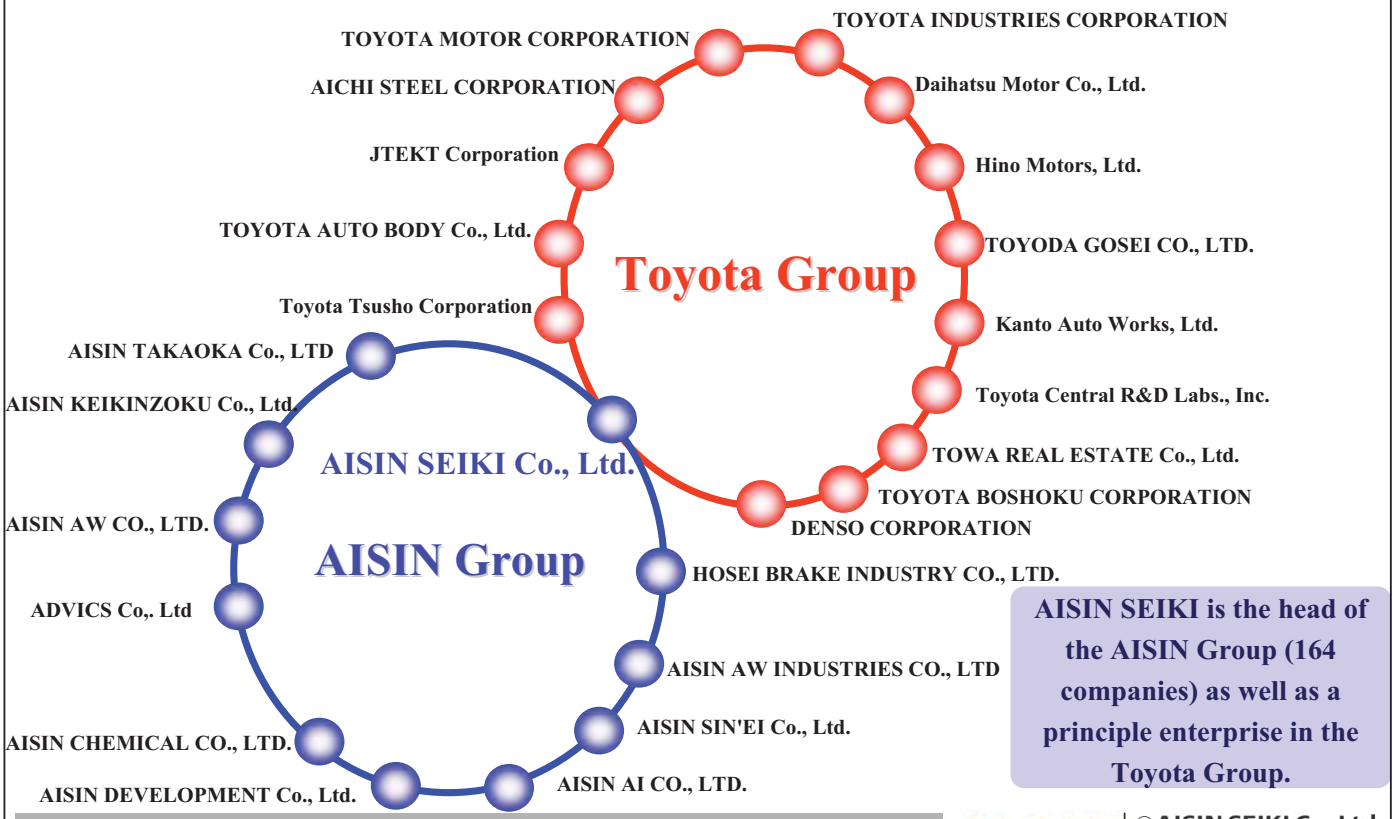
1-1. AISIN SEIKI



AISIN SEIKI is the head of the AISIN Group (164 companies) as well as a principle enterprise in the Toyota Group.

Analysis and Control Logic Dept.

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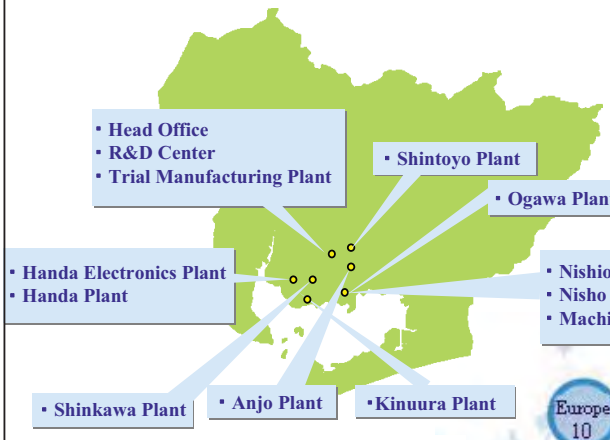
1-2 AISHIN SEIKI Locations



Head Office: 2-1, Asahi-machi, Kariya, Aichi, 448-8650 JAPAN
Capital: ¥45.0 billion (as of March 31, 2010)
Number of Employees: 12,775 (unconsolidated; as of March 31, 2010
Plants in Japan: 11 locations

- Business has expanded to 19 countries in North America, South America, Europe, and Asia
- Products are manufactured where there is demand

Analysis and Control Logic Dept.

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1-3 Main Products from the AISIN Group

Automotive Parts

Reliable products from the comprehensive solutions of the AISIN Group
Our concepts focus on "environmental friendly," "safe," and "light/compact" products

Drive Trains

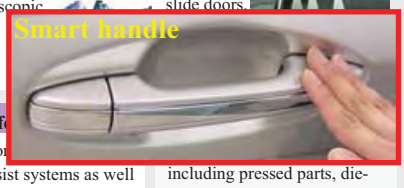
Transmission and hybrid systems such as AT、MT、AMT、CVT.

Breaks and Chassis

Systems furthering road safety including breaking systems such as ESC, suspension, and tilt and telescopic

Body Components

Body components increasing convenience and comfort including power slide doors.



Engines

Systems for engines such as O/P, W/P, VVT, and exhaust manifolds

Inf

Products for parking assist systems as well as front and side navigation systems.

including pressed parts, die-cast parts, as well as casted and molded parts.

Life/Amenities and Energy Systems

A wide variety of products are provided for life/amenities and energy systems by coupling the technology and know-how gained from automotive components with the independent technology of each product.

● **Life and Amenity**

Washlets

● **Energy System**

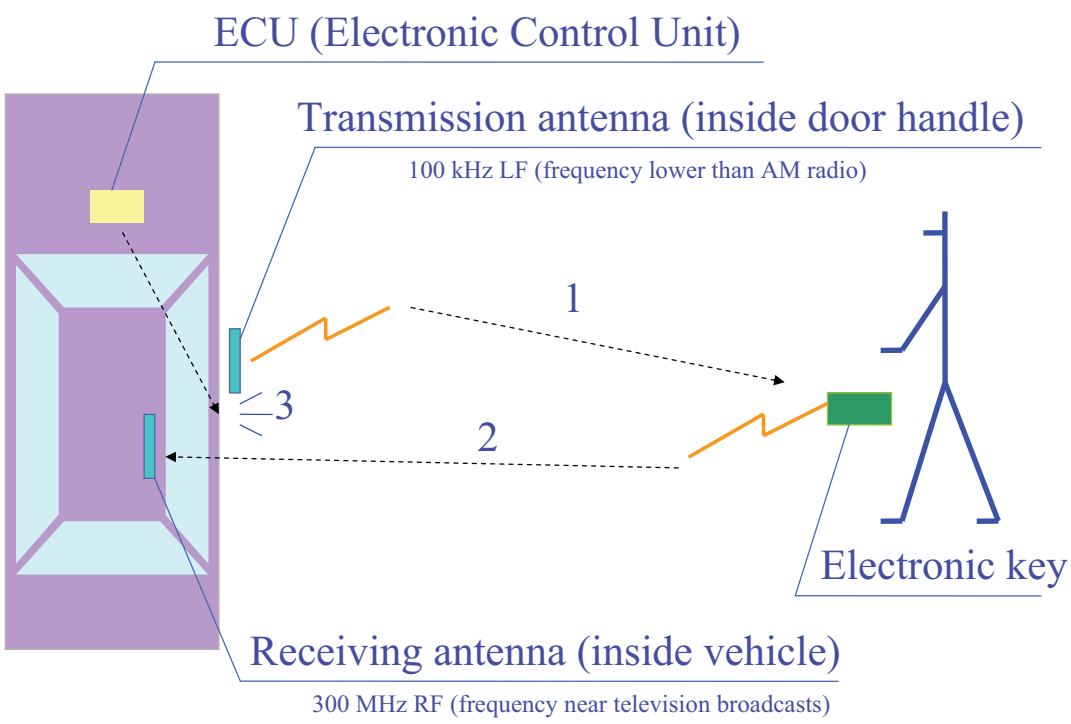
GHP (Gas Heat Pumps)

Gas engine cogeneration systems

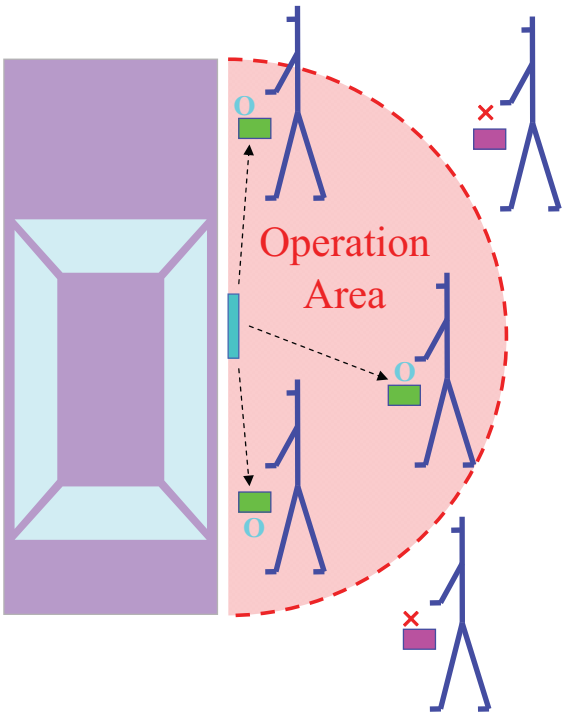
● **New Business**

Femto-second fiber lasers

2-1 Smart Key Systems



2-2 Operation Area of Smart key Systems



The operation area is determined by the transmission antenna in the door handle and the reception performance of the antenna in the electronic key.

Measuring the operation area is vital.

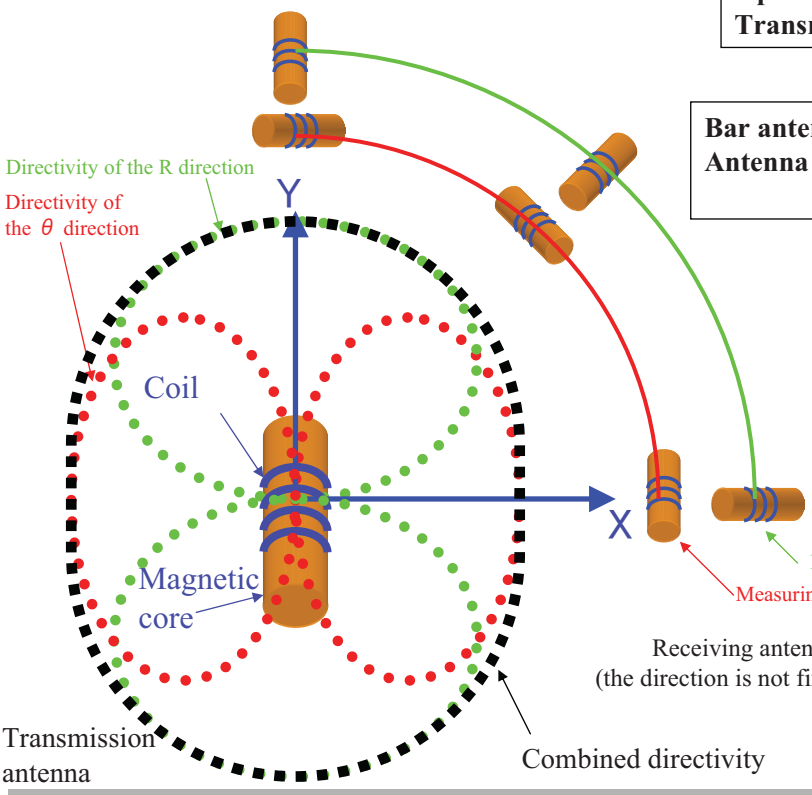
3-1. Antenna Principles

Operating range of the smart key system: 1 m
Transmission frequency of the smart key: 100 kHz

Bar antenna: Magnetic field type antenna
Antenna proximity: Main component of magnetic field

Magnetic field calculation of the proximity field

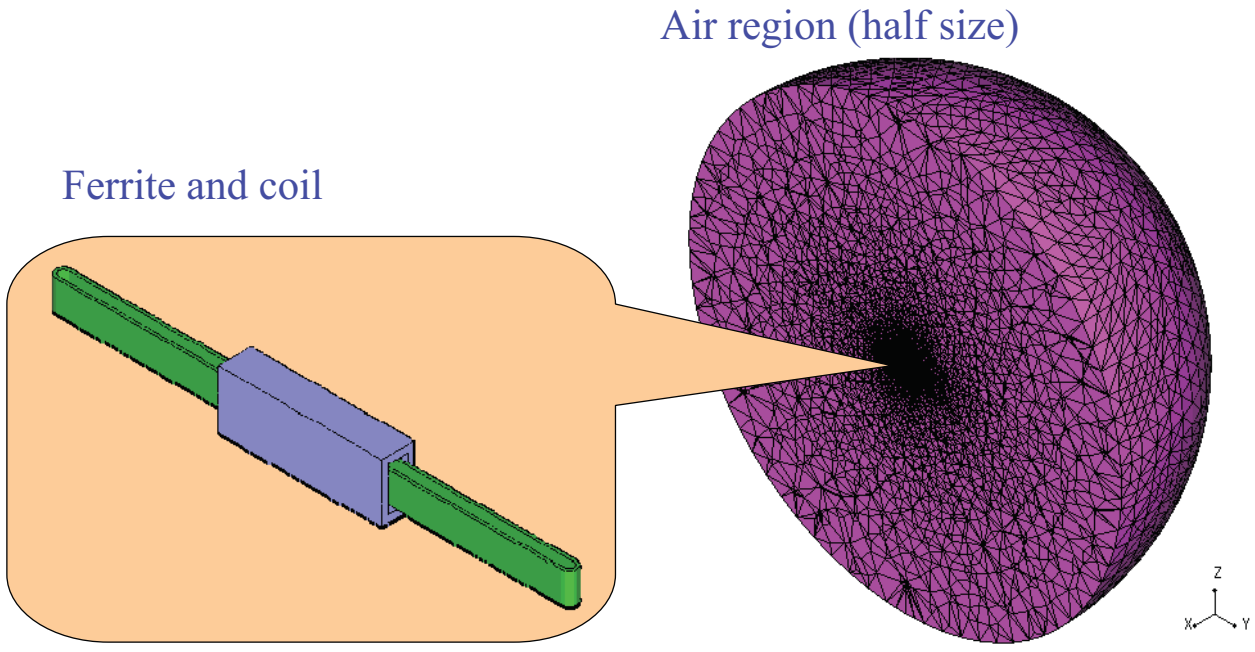
Frequency response magnetic field analysis (FQ)



3-2. Furthering Established Technology

- Confirming the Magnetic Field Calculation Accuracy
- Directional Calculation validity of Magnetic Fields in Doors
- Understanding the Effects on Directional Magnetic Fields of Conductive Plating
- Confirming Dead Areas When Building Vehicles

4. Confirming Magnet Field Calculation Accuracy
Spatial freedom of calculation models

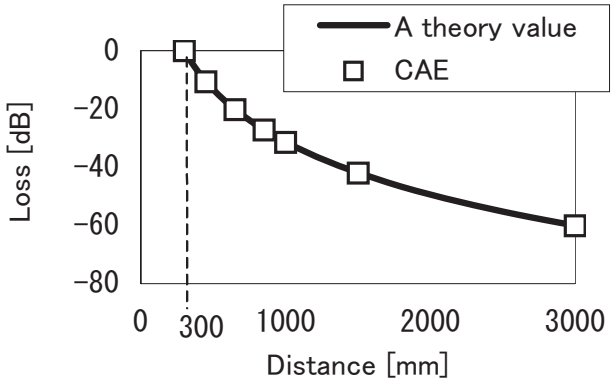


4. Confirming Magnet Field Calculation Accuracy
Spatial freedom of magnetic field calculations

The theoretical and calculated values of field attenuation match

$$H_\theta = j\omega\ \mu_0\left\{\frac{1}{r^3}+\frac{jk}{r^2}-\frac{k^2}{r}\right\}$$

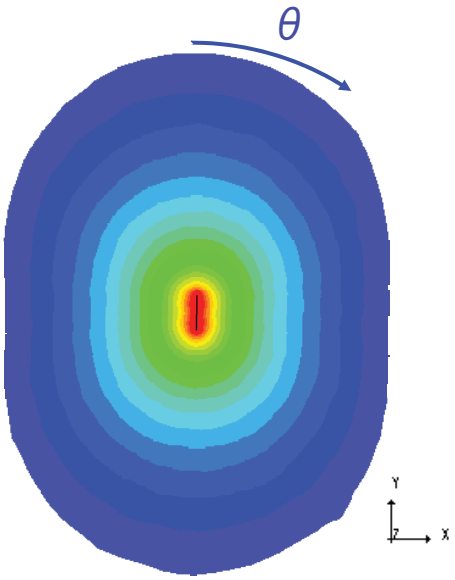
Static field | Conductive field | Radiated field

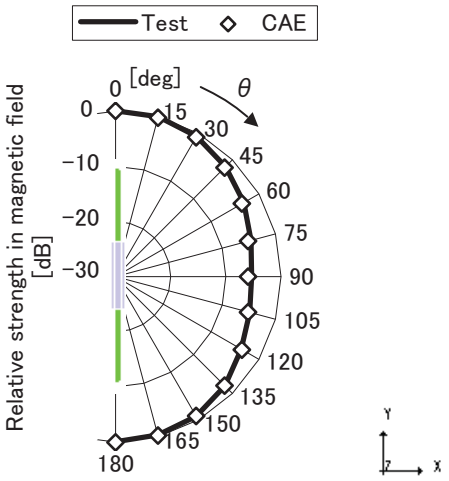


Normalizes at 300 mm

4. Confirming Magnet Field Calculation Accuracy
Spatial freedom of directivity calculation

The directivity in the analysis and actual testing matches



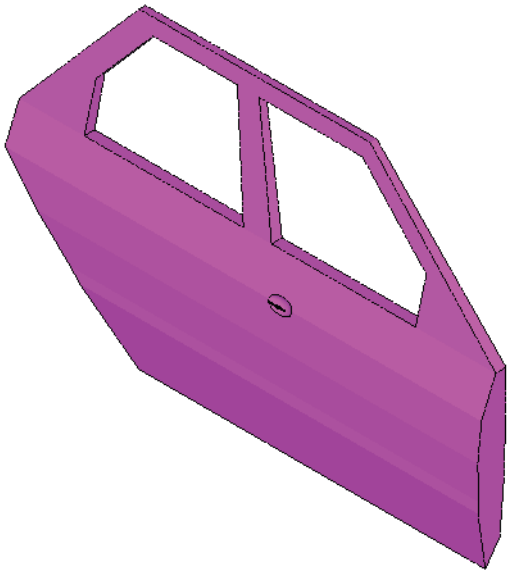


Measured radius 3000 mm

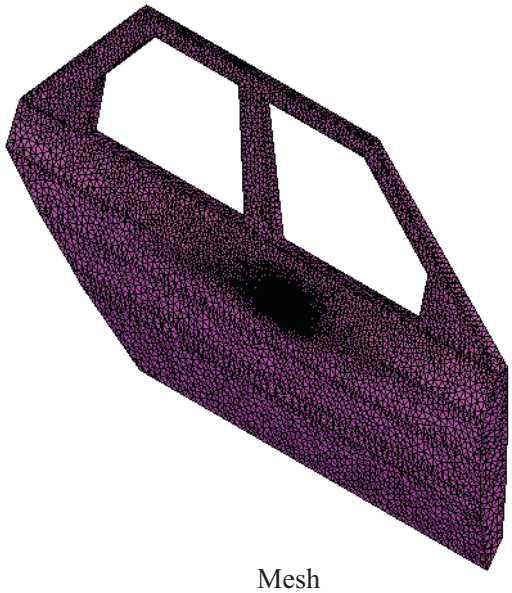
5. Validity of Directional Calculations for Magnetic Fields Including the Door

Magnetic field calculation results of the model with a door

Calculation model of the door



Solid



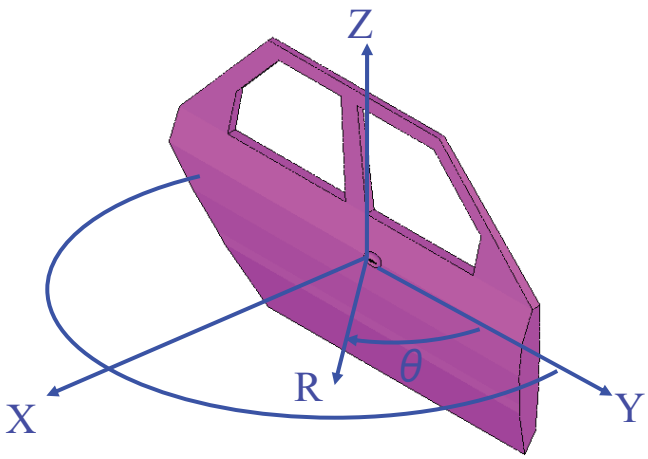
Mesh

5. Validity of Directional Calculations for Magnetic Fields Including the Door

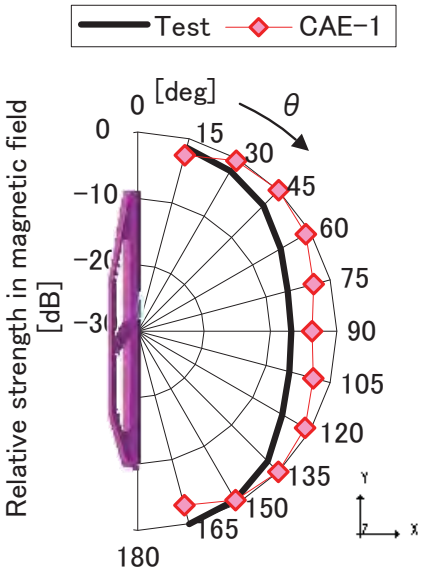
Calculation results for the directivity of the antenna with a door

test: Actual values

CAE-1: Calculation not accounting for eddy currents



Measured radius: 3000 mm

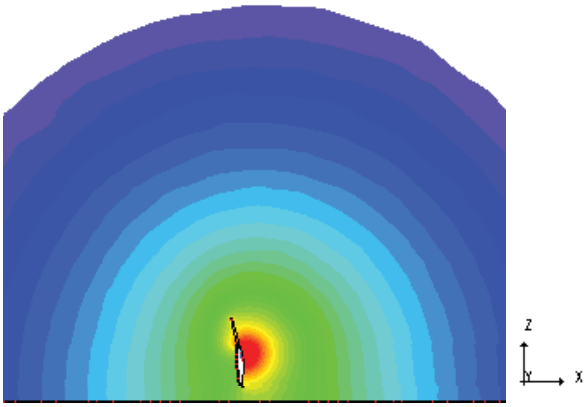


The maximum value is fixed to compare the directivity

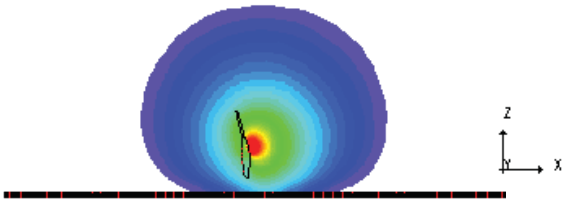
5. Validity of Directional Calculations for Magnetic Fields Including the Door

Contour plot for the vertical cross-section of the magnetic field

Comparing results to the eddy current calculation



Calculation accounting for eddy currents

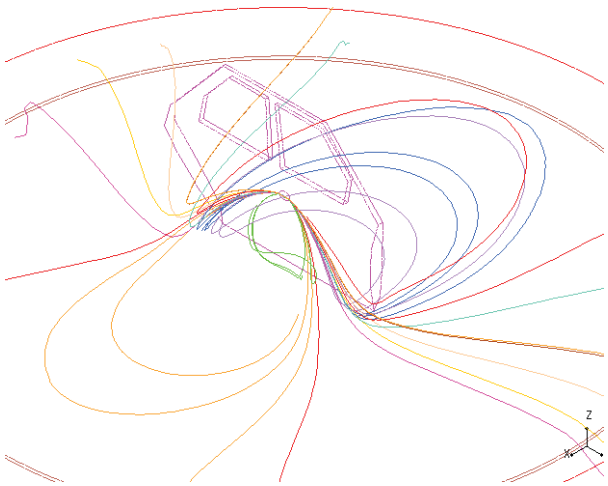


Calculation not accounting for eddy currents

5. Validity of Directional Calculations for Magnetic Fields Including the Door

Effects of shielding

Displays the lines of flux and electrical force produced by shielding



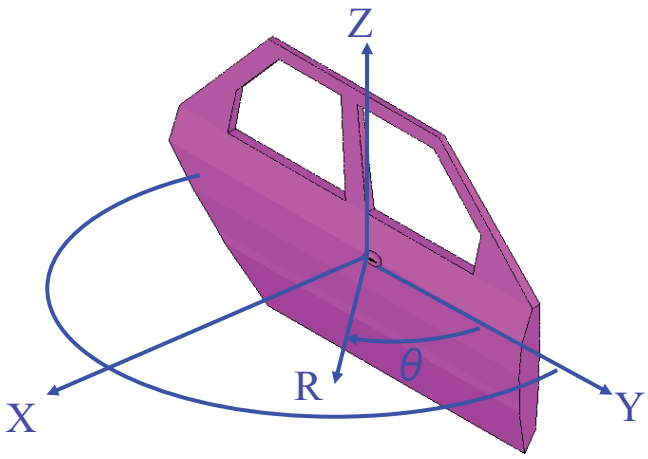
Flux: Horizontal to the face of the magnetic material

Electrical Force: Perpendicular to the face of the magnetic material

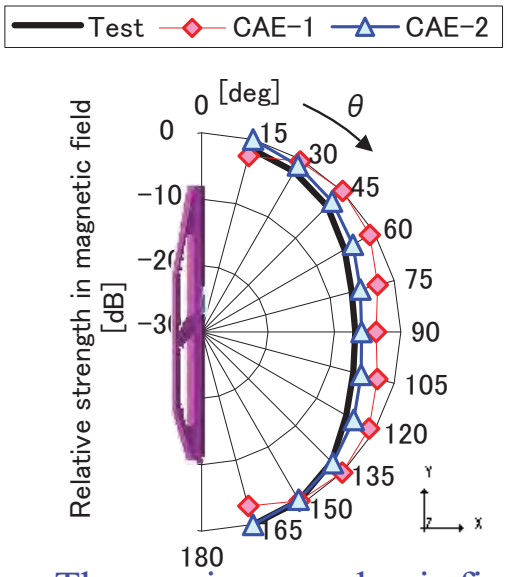
5. Validity of Directional Calculations for Magnetic Fields Including the Door

Calculation results for the directivity of the antenna with a door

test: Actual values
CAE-2: Calculation accounting for eddy currents



Measured radius: 3000 mm

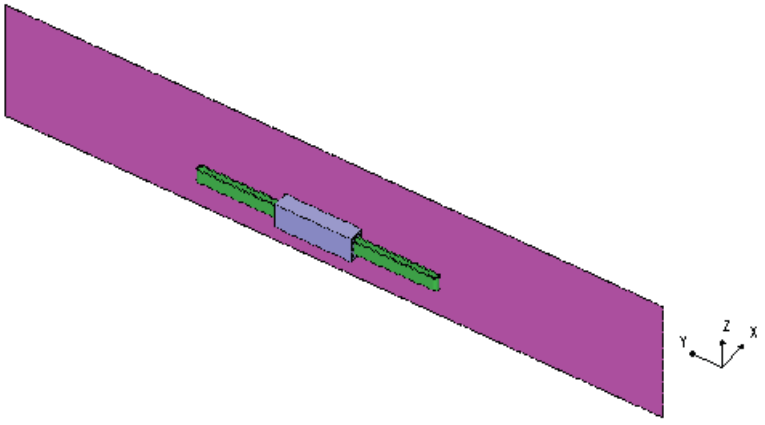


The maximum value is fixed to compare the directivity

6. Evaluating the Effects on the Directional Magnetic Fields of Conductive Plating

Effects of a simple plating model on the magnetic field

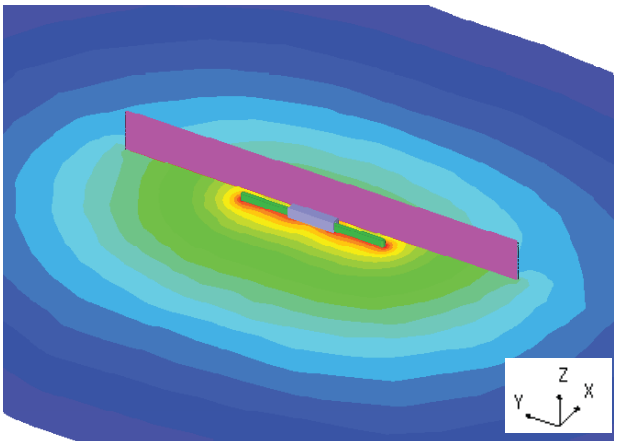
Calculation model for plating

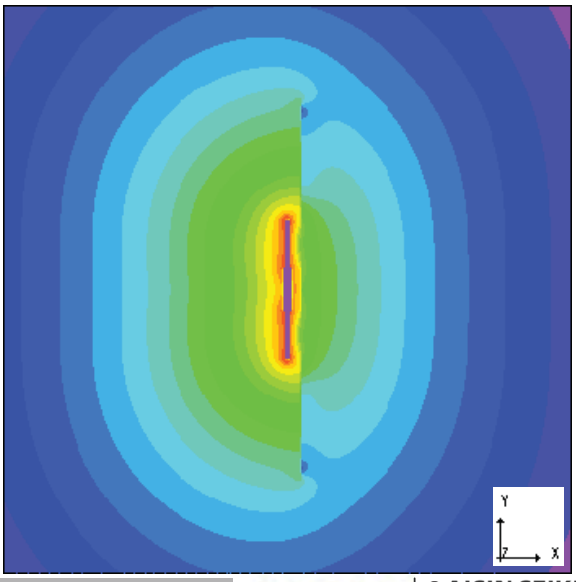


6. Evaluating the Effects on the Directional Magnetic Fields of Conductive Plating

The directivity calculation results of the magnetic field for simple plating geometry

The magnetic field concentrates and distorts around the plating

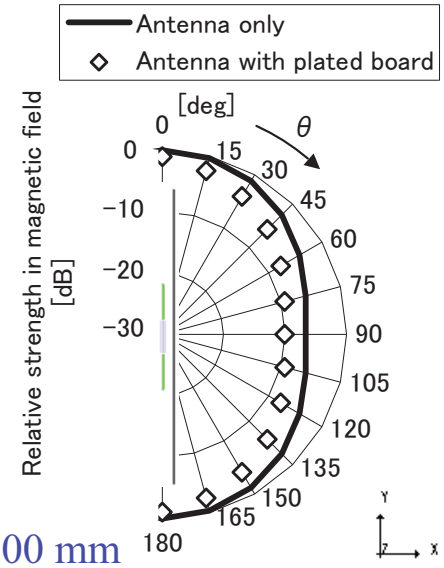




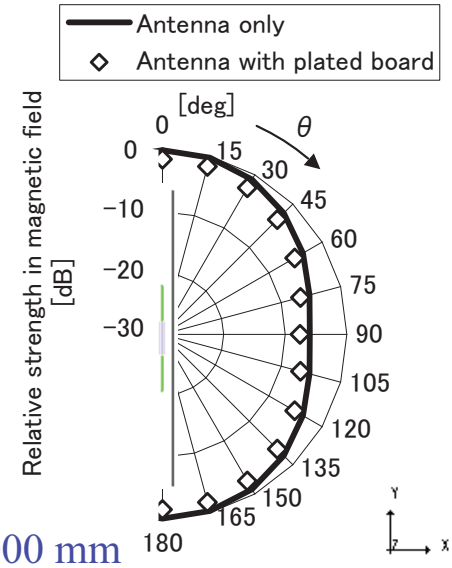
6. Evaluating the Effects on the Directional Magnetic Fields of Conductive Plating

Directivity of the antenna for simple plating geometry

Comparing directivity by measured radius



300 mm

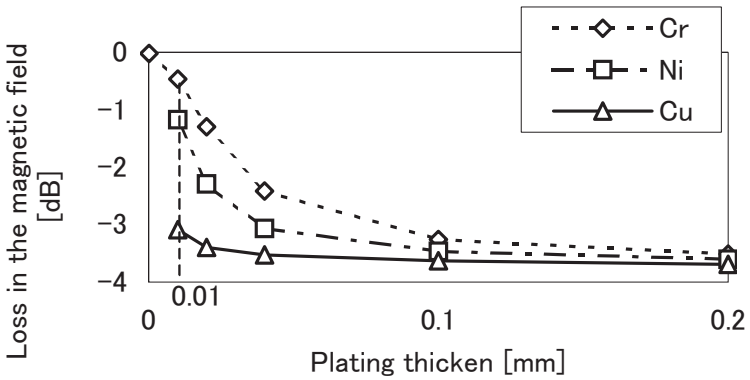


3000 mm

6. Evaluating the Effects on the Directional Magnetic Fields of Conductive Plating

Magnetic field intensity by thickness

Compared by thickness of plating



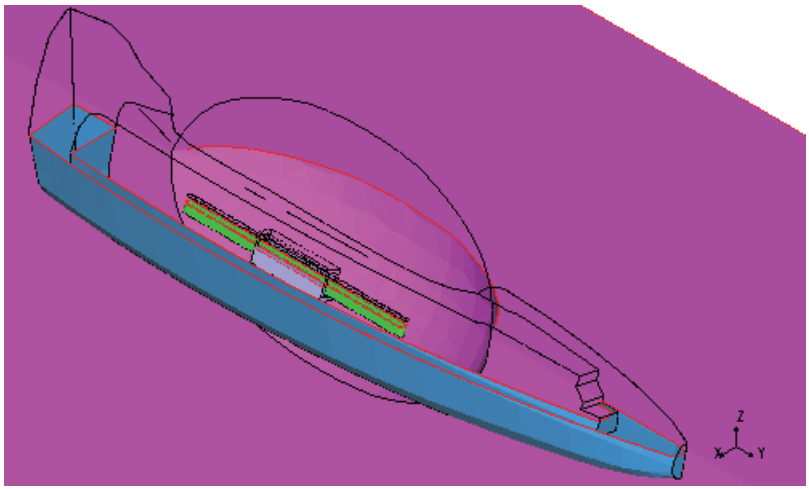
Measured radius: 300 mm

Measured angle: 90 degrees

7. Confirming Dead Areas When Building Vehicles

Calculating door handle type plating

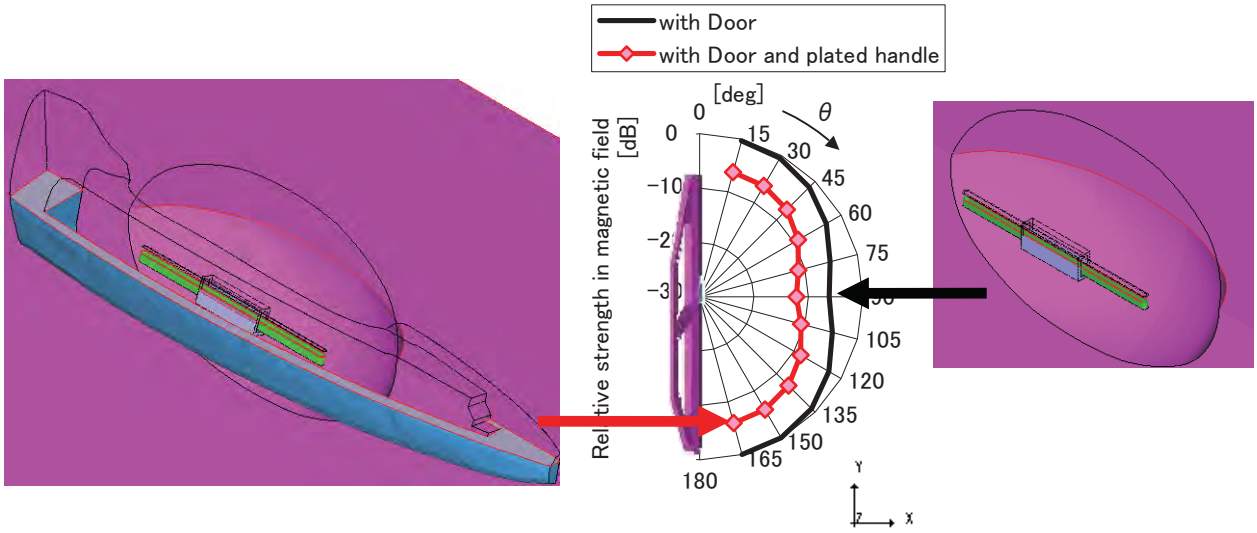
Calculation model for door handle type plating



7. Confirming Dead Areas When Building Vehicles

Directivity calculation results of the antenna with door handle type plating

Compared with and without plating

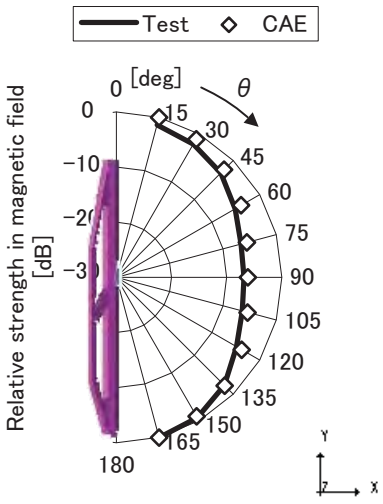


Measured radius: 3000 mm

7. Confirming Dead Areas When Building Vehicles

Compared to the tested results of an antenna with door handle type plating

Comparing the tested results and calculation results



8. Conclusion

1. The accuracy of the directivity calculation of magnetic fields using a magnetic field analysis software was confirmed.

2. The accuracy of the calculation improves when calculating magnetic materials by accounting for eddy currents. The calculation results match the tested results.

3. The conductive plating for the handle design attenuates the magnetic field, but doesn't affect the directivity of the operation range.

4. There are no dead areas for the magnetic field of the antenna built into the vehicle because the magnetic material increases the directivity.

Thank you for coming.

AISIN
Geared up for the future