

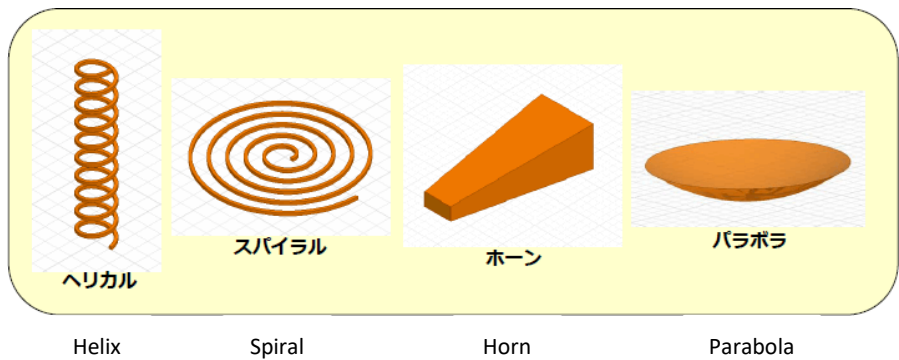
# Antenna analysis by Ansys HFSS

## Challenges in antenna design

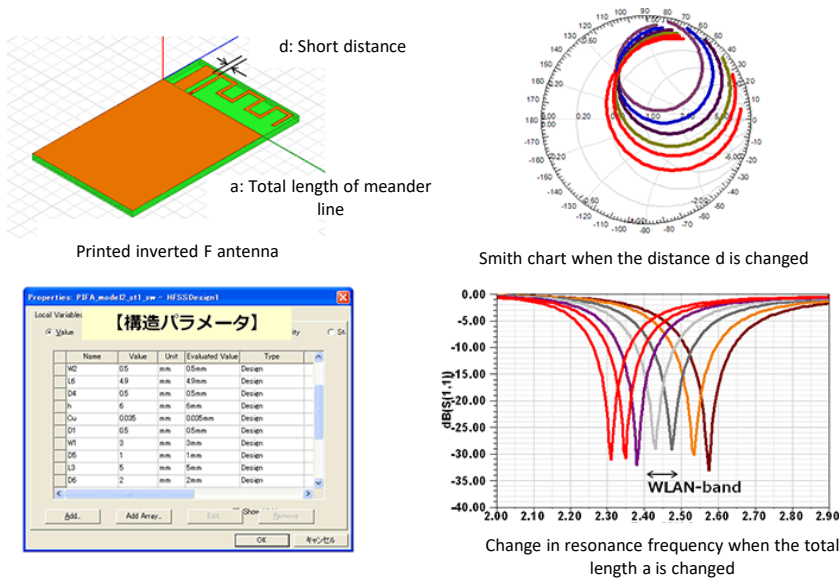
In recent years, the demand for antennas grows dramatically, and not only high performance, but also multi-functionalization and miniaturization are required. As a result, the antenna structure becomes complex. Because there are multiple structural parameters, optimizing the antenna characteristics is a very difficult task. When designing an antenna, it is necessary to not only optimize the characteristics of the antenna itself, but also include the behavior of the electromagnetic field around the antenna. Therefore, it is necessary to visually understand the electrical characteristics including the area around the antenna. However, it takes a lot of time and cost to perform simple simulations and repeated prototype experiments. By using the high frequency electromagnetic field analysis tool - Ansys HFSS, you can solve these problems in antenna design.

## Antenna analysis by Ansys HFSS

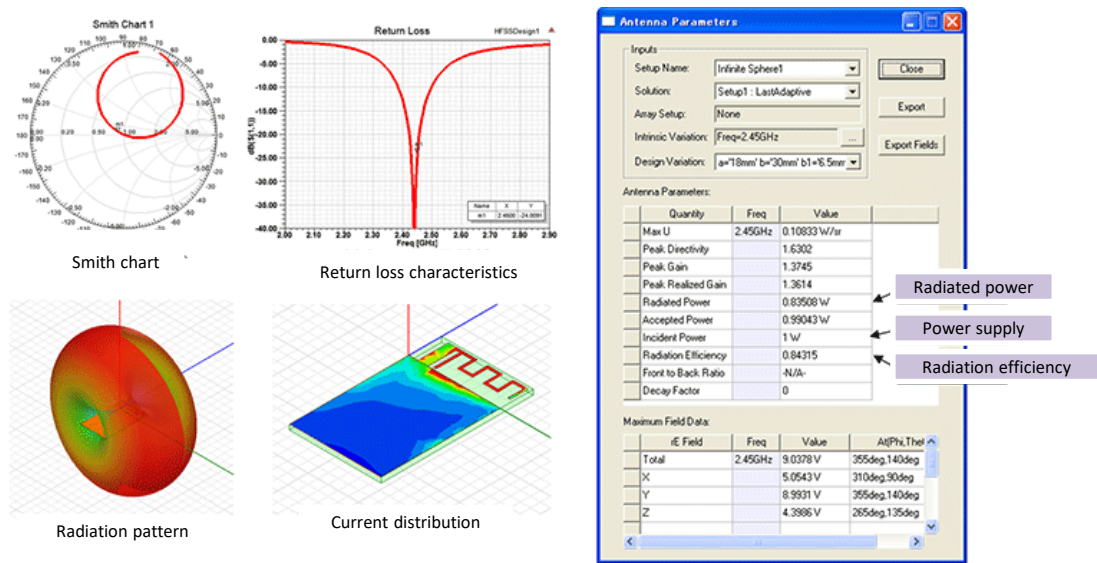
(1) With Ansys HFSS, you can easily create models such as helix and spiral. It also has a basic antenna model, which allows you to quickly model your antenna.



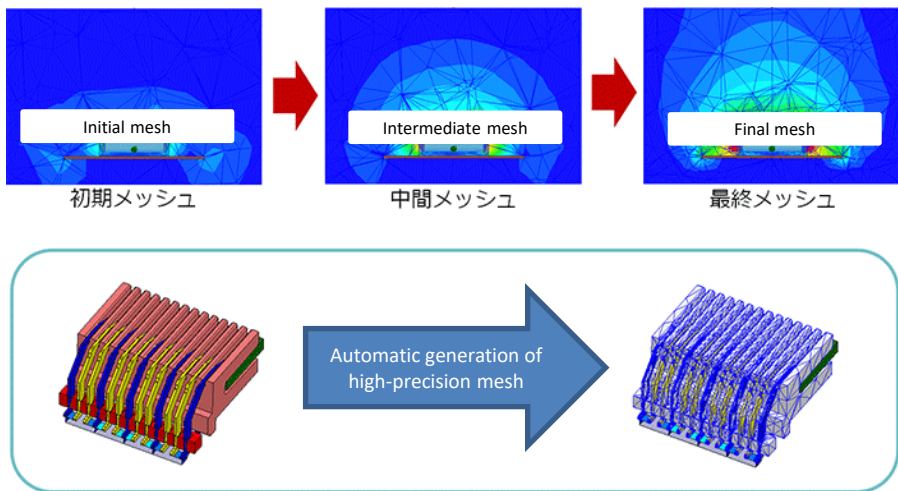
(2) By setting parameters to the structural value of the antenna, it is possible to easily grasp the characteristic changes due to the structural parameters, and it is possible to efficiently optimize the antenna characteristics.



(3) Sufficient output is available to evaluate antenna characteristics, including antenna gain, radiation pattern, and radiation efficiency.



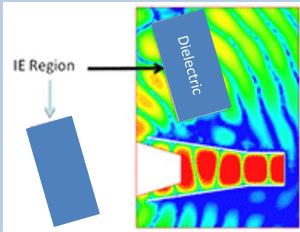
(4) The adaptive auto-mesh function automatically generates an accurate mesh and realizes stable and highly accurate analysis even for complicated shapes.



(5) There are multiple analysis engines that are useful for antenna analysis. By selecting them appropriately, the memory used and analysis time can be greatly reduced.

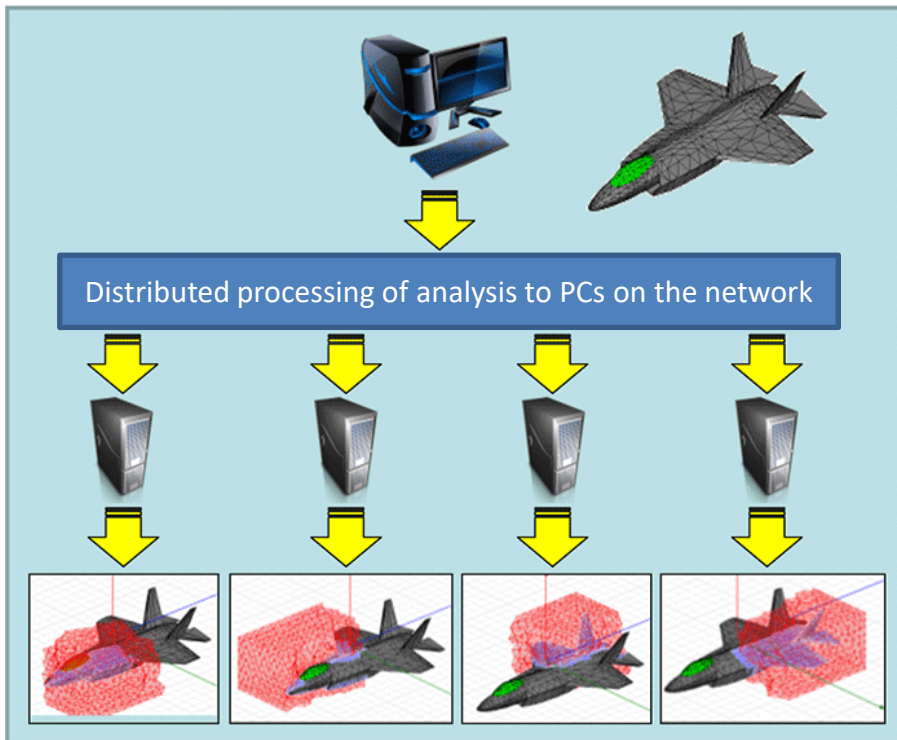
- **FEM Solver (finite element method)**
  - A universal solver that can efficiently analyze all shapes
  - Faithfully reproduce the electromagnetic field phenomenon that actually occurs
- **Integral Equation Solver (moment method)**
  - Efficiently analyze models that are mainly composed of conductors
  - Good at analyzing scattering characteristics of antennas and electromagnetic fields
- **Physical Optics Solver (PO)**
  - Approximate analysis of high frequency phenomena
  - Efficiently analyze structures that have electrically large and smooth curved surfaces

- **Hybrid Solver**
  - A solver that combines the finite element method and the moment method. Large-scale analysis is possible with less memory



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(6) By utilizing the distributed analysis environment, it is possible to perform very large-scale analysis, which was considered unrealistic until now.



## Analysis examples

### <Index>

- 24GHz car radar analysis example (Finite Array function)
- Miniaturized design of printed inverted F type antenna
- Antenna design including supply circuit
- Antenna design considering the housing
- Analysis of smartphone built-in antenna near human body
- Effect of car chassis and windshield on antenna
- International Space Station S-band antenna analysis example

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## 24GHz car radar analysis example (Finite Array function)

### Recommended for such people

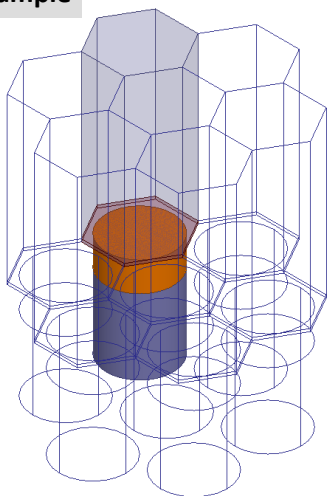
- High-speed analysis of large-scale array antenna that takes time to analyze
- Understanding the effect of the characteristics of the power supply circuit on the antenna

### Overview

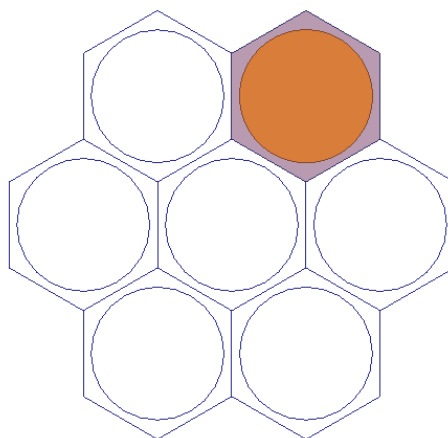
Ansys HFSS enables the calculation of finite size phased array antennas including coupling between antenna elements and array edge effects.

Previously, in order to simulate a large phased array antenna, an infinite array was assumed and the operation of the antenna was approximated. The Finite Array function of Ansys HFSS can analyze a full-size array model based on one analysis result at high speed and analyze a full model considering the influence of edges.

### Model example

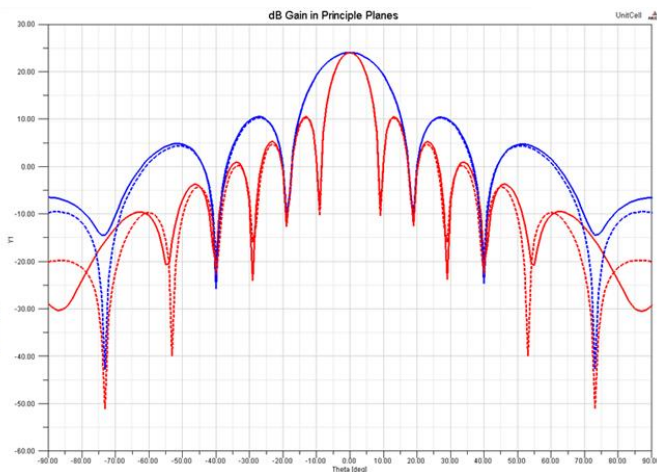
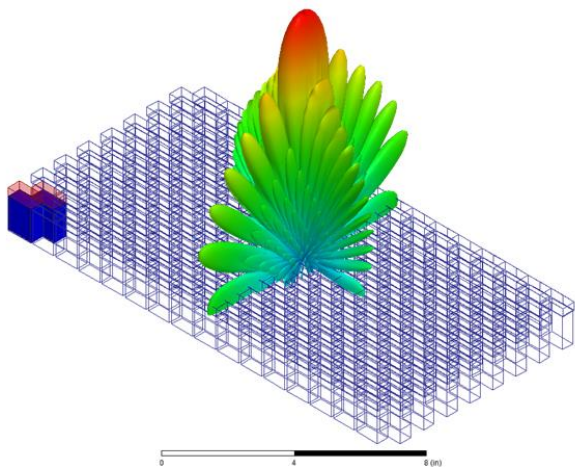


The entire display



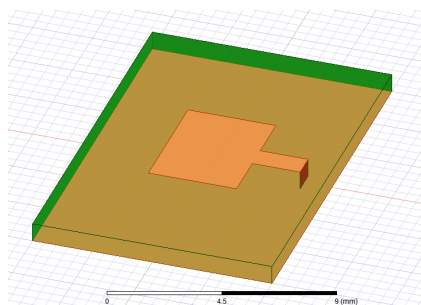
Top view

### Analysis Example

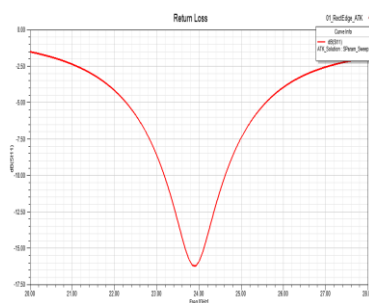


Far-field antenna pattern calculated with the Finite Array function. The solid line in the graph indicates a finite array and the dotted line indicates an infinite array.

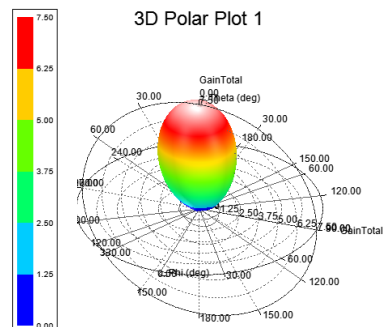




Example of single antenna

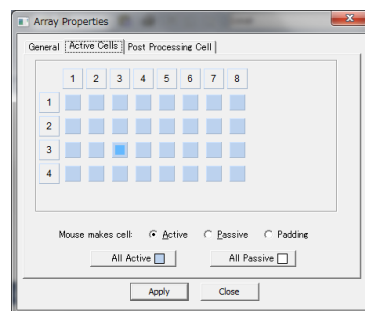
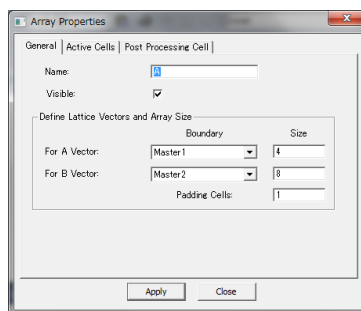
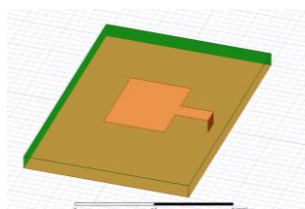


Return loss

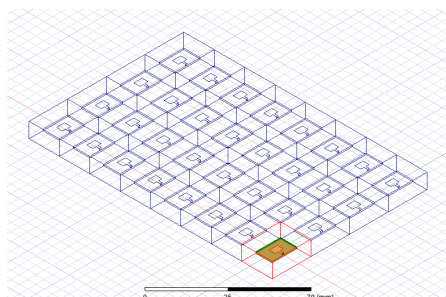


Radiation pattern

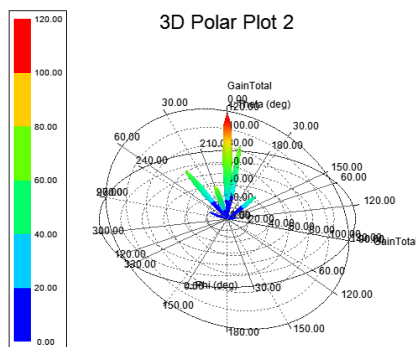
### Example of array antenna analysis using the Finite Array function



Number of vertical and horizontal elements can be set from a single antenna



Array antenna consisting of 4 x 8 32 elements



Radiation pattern

### Effectivity

The radiation characteristics of the antenna change depending on the supply conditions of the antenna. You can design an antenna with Ansys HFSS alone, but by linking with the circuit simulator attached to Ansys HFSS, you can design an antenna supply circuit and an antenna design that takes the supply conditions of the supply circuit into account.

### Analysis Type

- Electromagnetic field analysis
- Circuit analysis

### Required products

- Ansys HFSS

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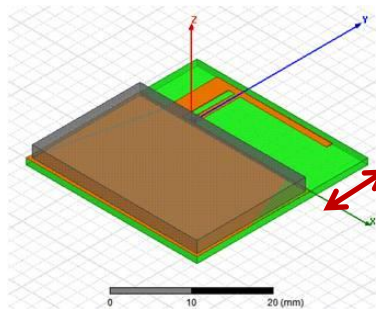
# Miniaturized design of printed inverted F type antenna

## Recommended for such people

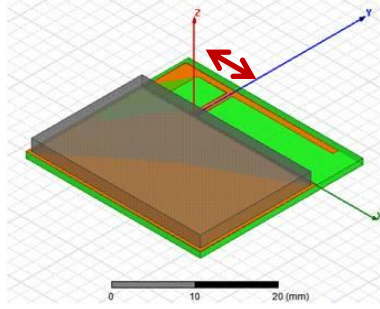
- When designing a built-in antenna, the space given to the antenna is small and it is unknown how to downsize it.
- Grasping changes in properties when changing structural parameters
- Design a small antenna with good performance

If the antenna is downsized, the input impedance will decrease and the antenna characteristics will deteriorate. In addition, the characteristics of the antenna change significantly due to the influence of surrounding structures. Therefore, it is very important to understand which parameter of the antenna should be adjusted to match the characteristics. In the example, the structural value of the antenna is defined as a parameter, and the change in the characteristics when each structural value is changed is clarified. Design becomes easier because you can see how the characteristics change when miniaturized, and where to adjust to improve the changed characteristics.

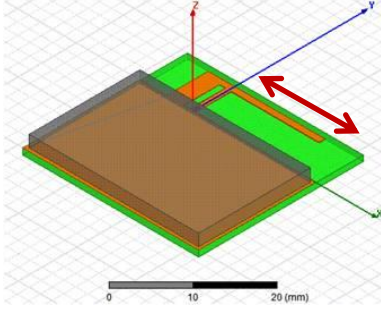
## Analysis Model



(a) Change the height of the antenna



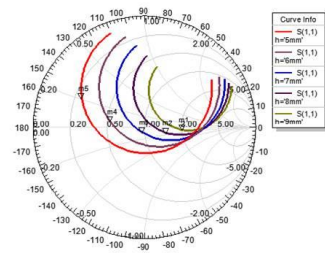
(b) Change the distance between the power supply point and the short



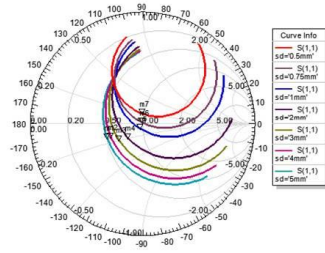
(c) Change the total length of the antenna

## Analysis Result

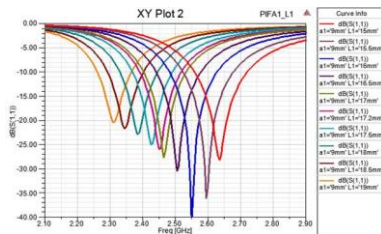
### Changes in properties for each structural parameter



(a) Change in Smith chart when the height of the antenna is changed



(b) Change in Smith chart when changing the distance between the supply point and the short



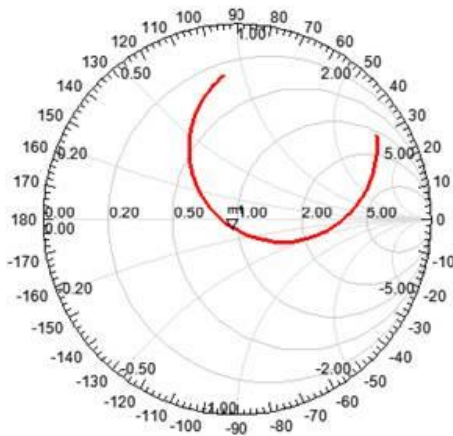
(c) Change the total length of the antenna

It can be seen that as the height of the antenna decreases, the circle on the Smith chart increases and the input impedance decreases.

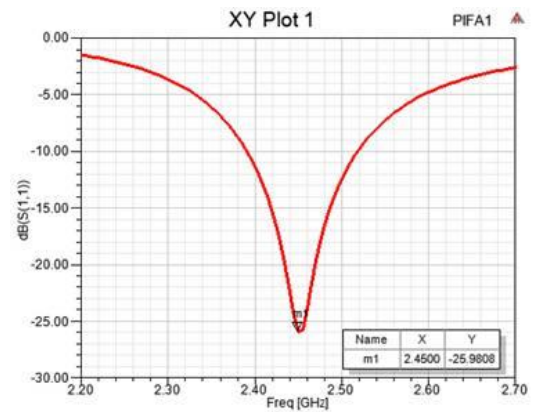
By adjusting the position of the reverse F short, the circle on the Smith chart can be made smaller and the input impedance can be stepped up.

Adjust the total length of the antenna to match the desired frequency.

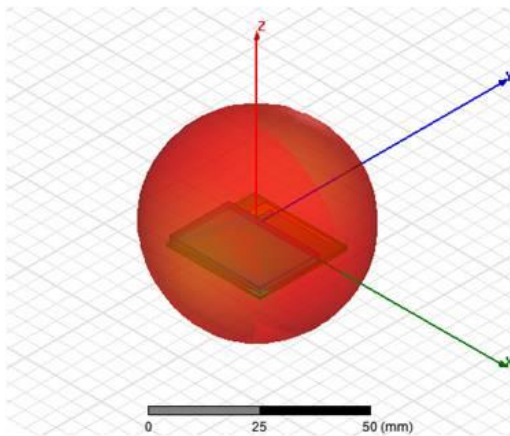
## Final characteristics of printed inverted-F antenna



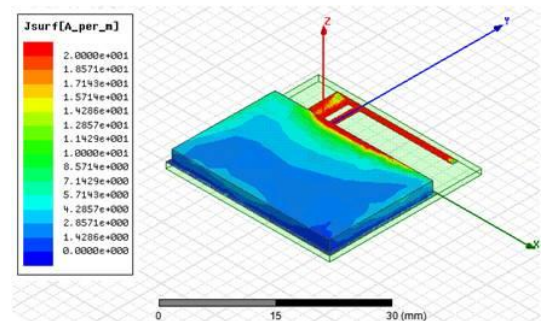
(a) Smith chart



(b) Return loss characteristics



(c) Radiation characteristics



(d) Current distribution

### Effectivity

In an environment where a small built-in antenna is placed, there are many parts around it, which greatly affects antenna characteristics.

If changes in characteristics due to structural parameters are understood, it is possible to facilitate miniaturization design and quickly improve characteristics that have been deteriorated due to the effects of the surroundings.

### Analysis Type

- Electromagnetic field analysis

### Required Product

- Ansys HFSS

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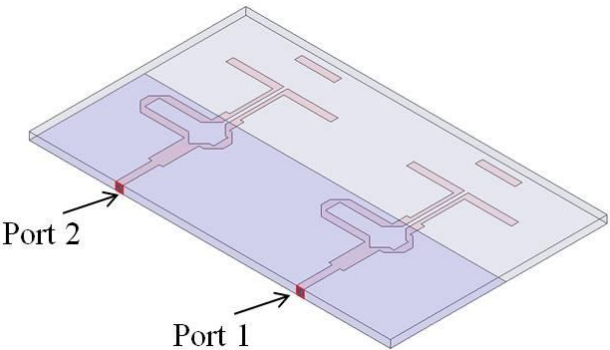
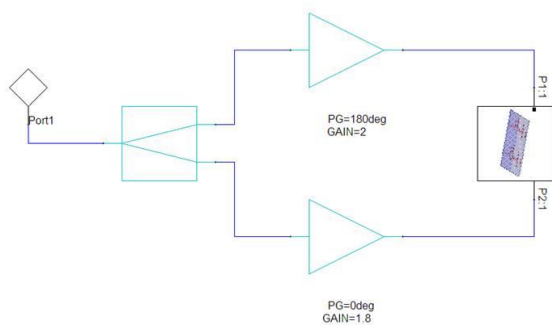
# Antenna design including supply circuit

## Recommended for such people

- Power supply circuit design that can bring out the performance of the antenna
- Understanding the effect of the characteristics of the power supply circuit on the antenna

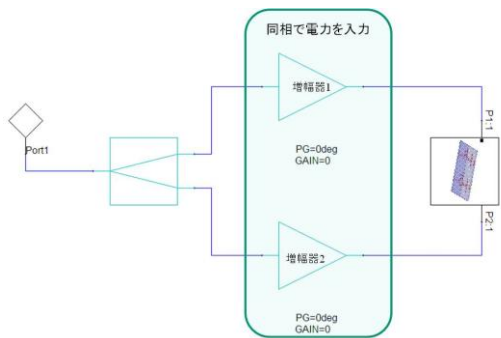
It is possible to analyze the radiation characteristics and gain of the antenna in consideration of the circuit characteristics by incorporating the supply circuit including the distributor and amplifier in the printed Yagi array antenna.

## Analysis Model

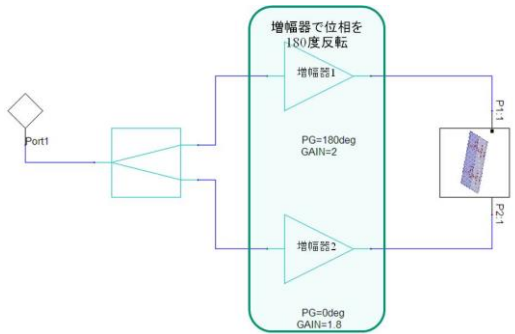


## Result

### Printed Yagi array antenna and supply circuit



Input power in phase



180 degree phase inversion with amplifier

The power and phase obtained from the result of the circuit simulation are automatically set to supply the antenna.

Edit post process sources						
Spectral Fields		Source Contexts				
	Source	Type	Magnitude	Unit	Phase	Unit
1	P1.1	Port	0.00124921978161063	W	-90.0133404782547	deg
2	P2.1	Port	0.00124942467787779	W	-90.0062590345731	deg

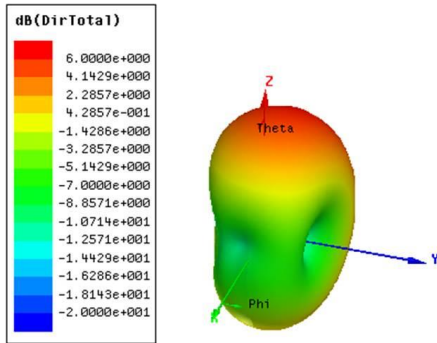
Since the two amplifiers have the same gain and phase delay, the power supply conditions are also the same.

Edit post process sources						
Spectral Fields		Source Contexts				
	Source	Type	Magnitude	Unit	Phase	Unit
1	P1.1	Port	0.00191599477615811	W	90.206673629176	deg
2	P2.1	Port	0.00185163631270153	W	-89.4169319213069	deg

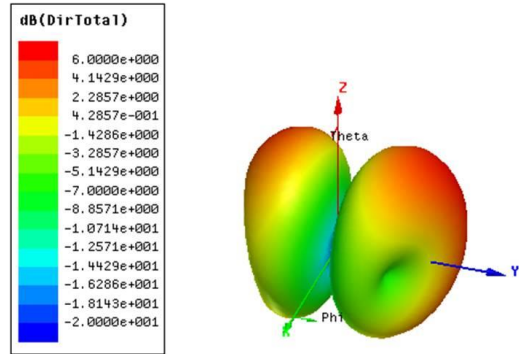
Since the two amplifiers have different gains and 180 degrees different phases, the power and phase are 180 degrees different.



## Antenna Radiation Pattern Considering Excitation of Circuit Simulator

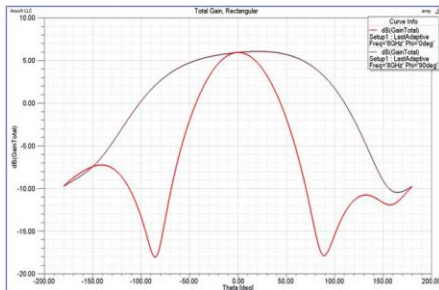


Input power in phase

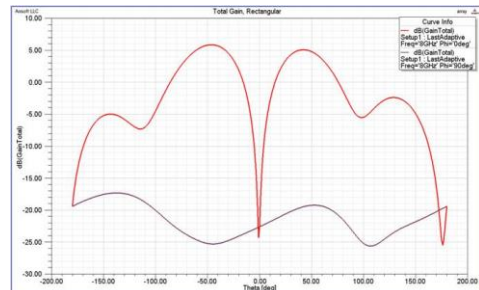


180 degree phase inversion with amplifier

## Antenna gain



Set the same gain and phase for antenna elements  
 Amplifier 1: Gain = 0, Phase delay = 0  
 Amplifier 2: Gain = 0, Phase delay = 0



Set different gain and phase for antenna element  
 Amplifier 1: Gain = 2, Phase delay = 180  
 Amplifier 2: Gain = 1.8, Phase delay = 0

## Effectivity

The radiation characteristics of the antenna change depending on the supply conditions of the antenna. It is possible to design the antenna with Ansys HFSS alone, but by linking with the circuit simulator attached to Ansys HFSS, it is possible to design the antenna supply circuit and the antenna design considering the supply conditions by the supply circuit.

## Analysis Type

- Electromagnetic field analysis
- Circuit analysis

## Required Product

- Ansys HFSS

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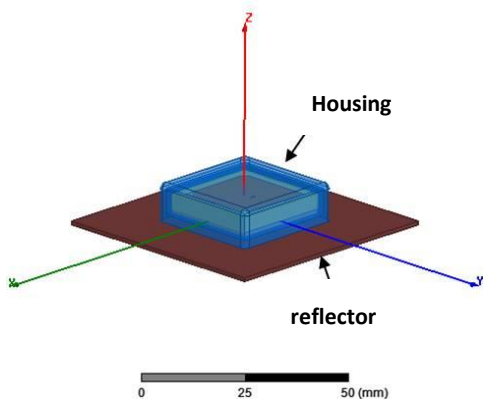
## Antenna design considering the housing

### Recommended for such people

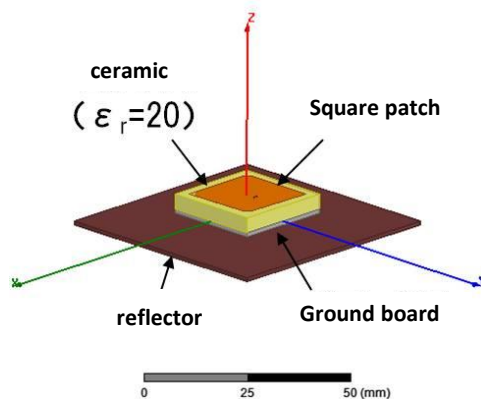
- When the antenna is incorporated in the housing, the characteristics change greatly
- Implemented antenna design considering changes in characteristics when incorporated in a housing

When the antenna is installed in the housing, the characteristics will change significantly. Therefore, it is important to design the antenna in consideration of the change in the characteristics when it is installed in the housing. In the following example, the GPS ceramic patch antenna is analyzed including the housing to clarify the changes in the characteristics when the housing is installed.

### Analysis Model



(a) Housing + antenna

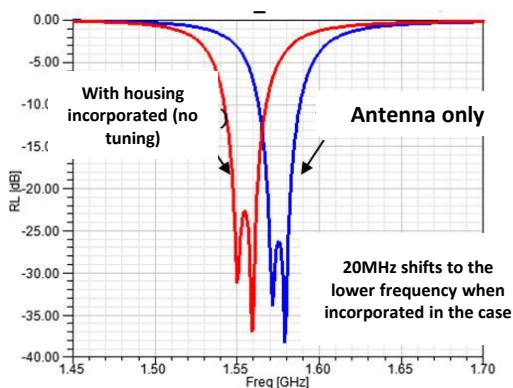


(b) Antenna only (without housing)

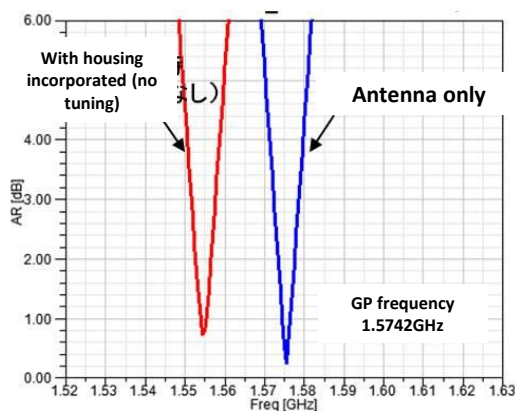
GPS ceramic patch antenna

### Result

#### Characteristics of antenna alone and characteristics when assembled in case

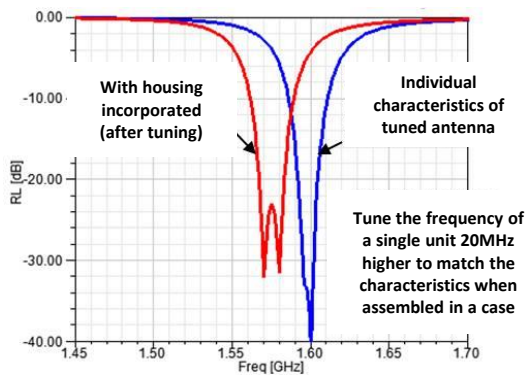


(a) Return loss characteristics

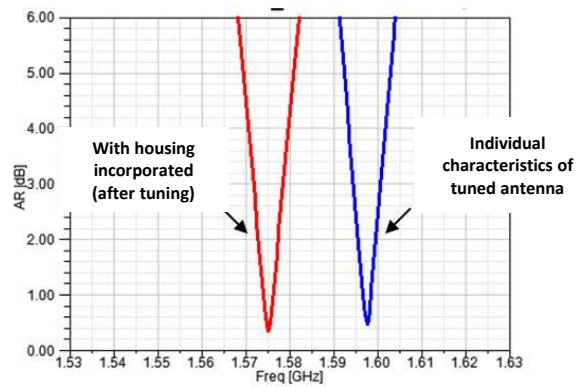


(b) Axial ratio characteristic

## Antenna characteristics when assembled in case after tuning

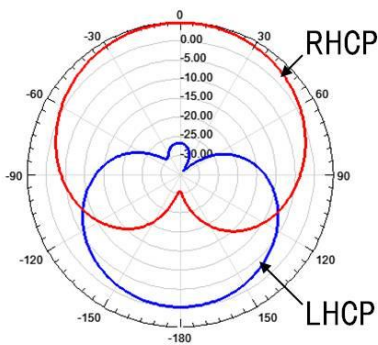


(a) Return loss characteristics

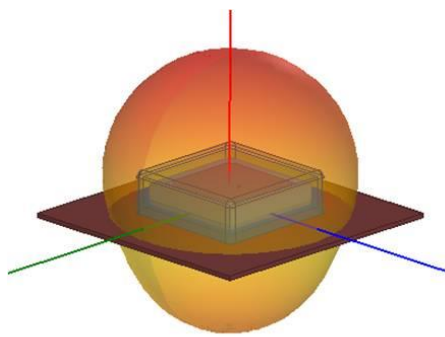


(b) Axial ratio characteristic

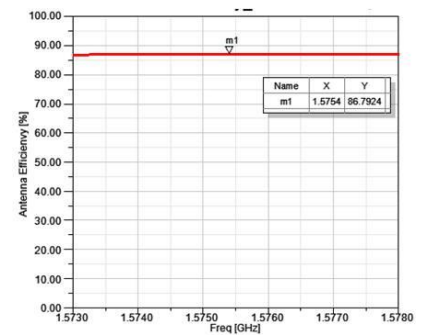
## Radiation characteristics of GPS ceramic patch antenna



(a) Two-dimensional radiation pattern



(b) Three-dimensional radiation pattern



(c) Radiation efficiency

## Effectivity

It is possible to confirm changes in the antenna characteristics when incorporated in the housing, and it is possible to feed back to the design of the antenna itself.

### Analysis Type

- Electromagnetic field analysis

### Required Product

- Ansys HFSS

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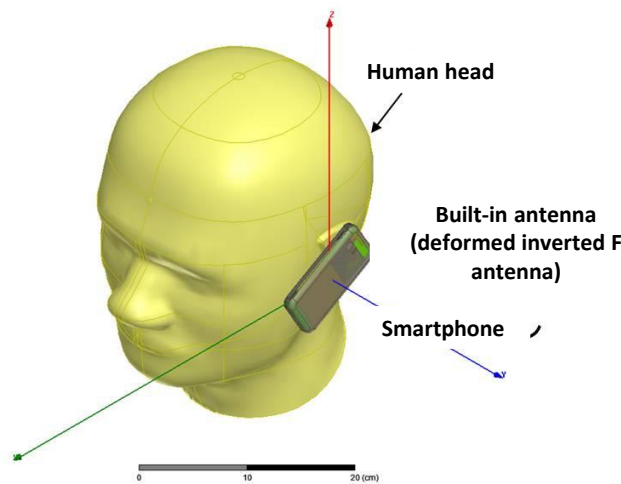
# Analysis of smartphone built-in antenna near human body

## Recommended for such people

- Analyze the characteristics that the human body gives to the antenna characteristics
- Implemented antenna design considering changes in characteristics when approaching the human body
- SAR (Specific Absorption Rate) analysis

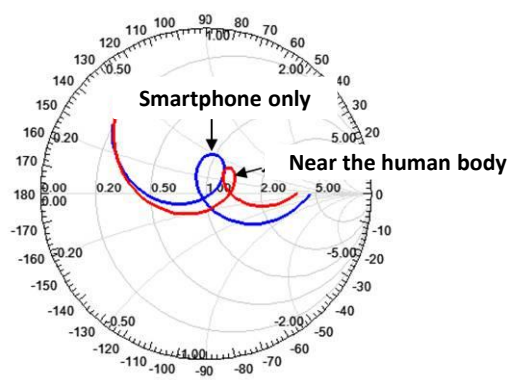
In the usage environment of a smartphone, the influence of the human body on the antenna characteristics greatly affects the actual communication characteristics. Therefore, it is important to understand what the antenna characteristics will be like when approaching the human body. In the following example, the deformed inverted F antenna mounted on the smartphone near the human head is analyzed, and the input impedance characteristics, the radiation pattern, the radiation efficiency, the electric field distribution, and the SAR distribution in the human head near the human body are calculated.

## Analysis Model

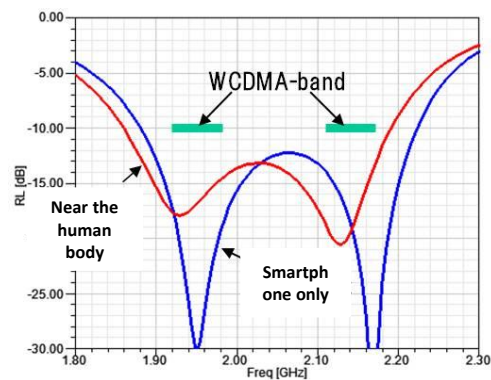


Human head and smartphone analysis model

## Result



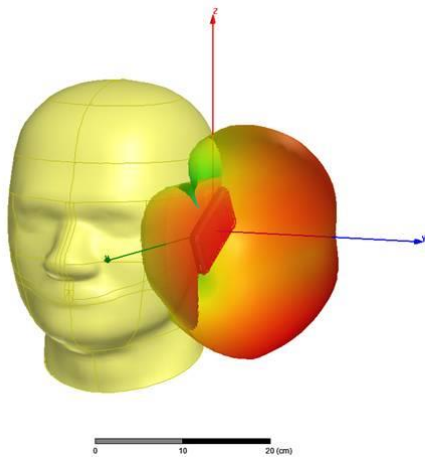
(a) Smith chart



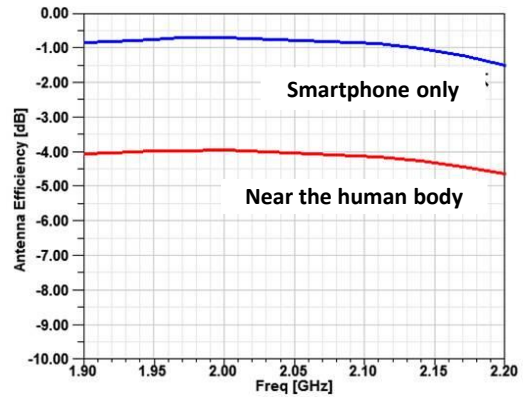
(b) Return loss characteristics

Change in input impedance

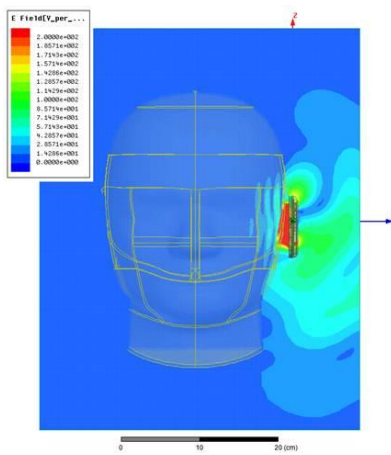




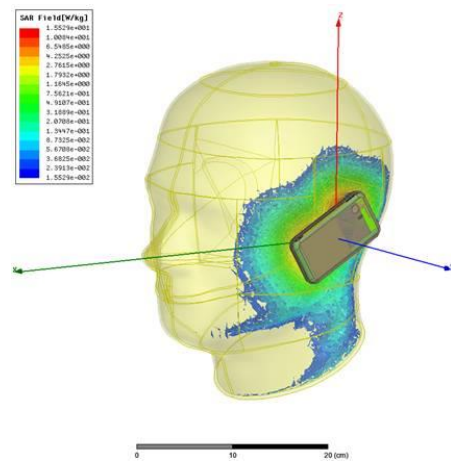
Three-dimensional radiation pattern



Antenna efficiency



Electric field distribution



SAR distribution

## Effectivity

It is possible to confirm changes in the antenna characteristics when approaching the human body, and it is possible to provide feedback to the design.

### Analysis Type

- Electromagnetic field analysis

### Required Product

- Ansys HFSS

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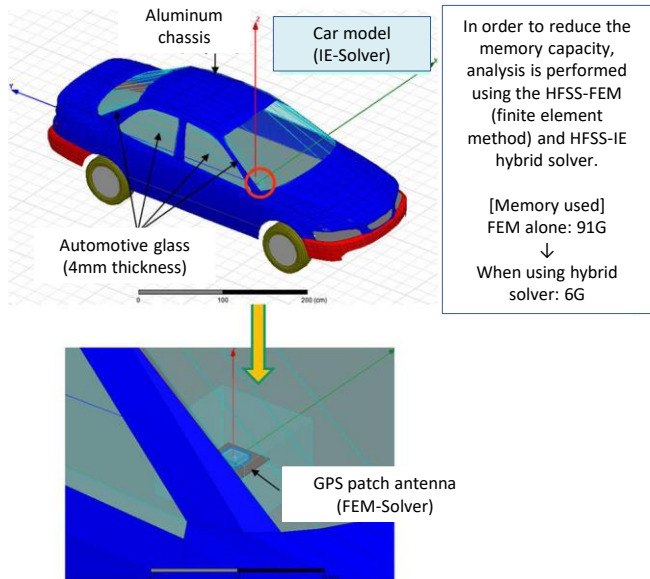
# Effect of car chassis and windshield on antenna

## Recommended for such people

- Communication characteristics deteriorate when an antenna is installed in a car
- Analyze the effect of car chassis and glass on antenna characteristics
- Antenna design considering changes in characteristics when incorporated in an automobile

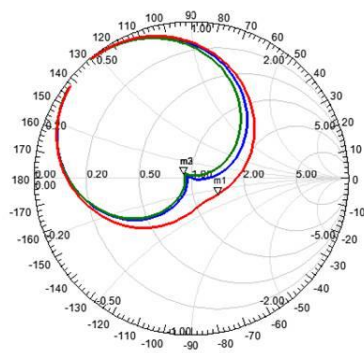
The characteristics of the antenna change significantly due to the influence of surrounding structures. It is important to know in advance the changes in characteristics in the actual usage environment. In the example below, we analyze the GPS patch antenna installed in a car and clarify the effects of the chassis and glass.

## Analytical model of car and GPS patch antenna

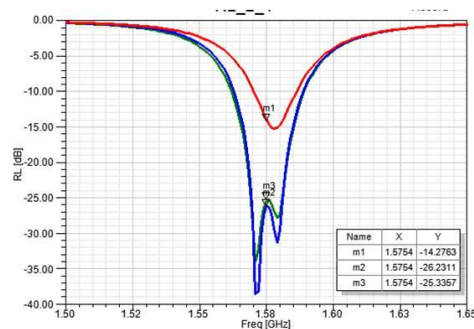


## Result

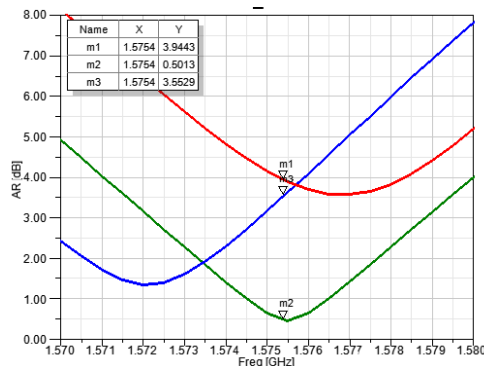
### Comparison of antenna characteristics when assembled in a car (1)



(a) Smith chart

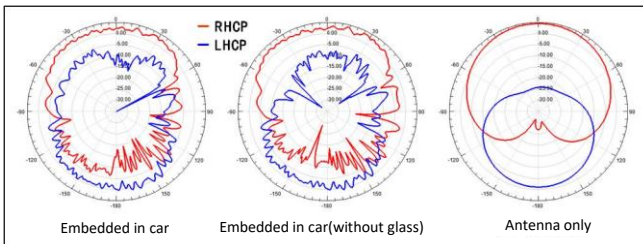


(b) Return loss characteristics

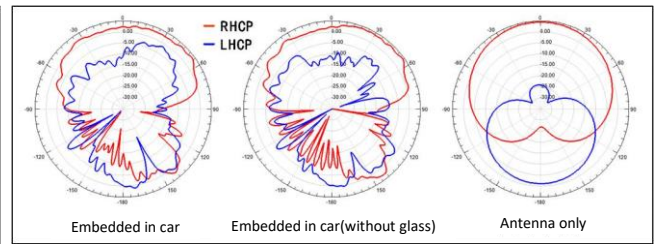


(c) Axial ratio characteristic

## Comparison of antenna characteristics when assembled in a car (2)

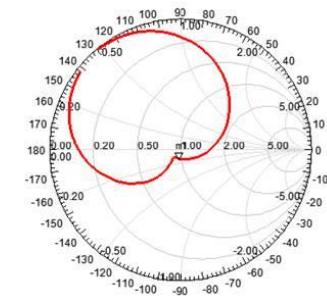


(a) Radiation pattern in the longitudinal direction of the vehicle

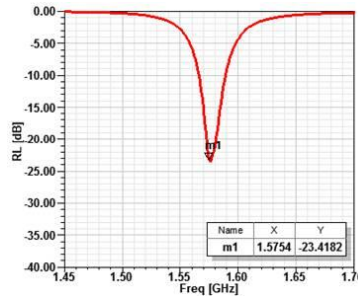


(b) Radiation pattern in the lateral direction of the vehicle

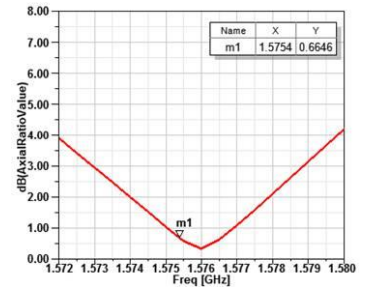
## Characteristics of GPS patch antenna tuned to be optimal when installed in a car



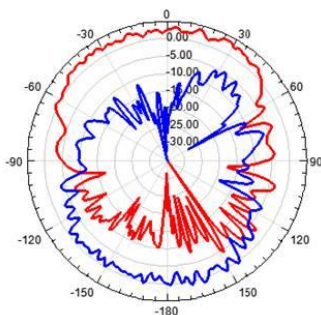
(a) Smith chart



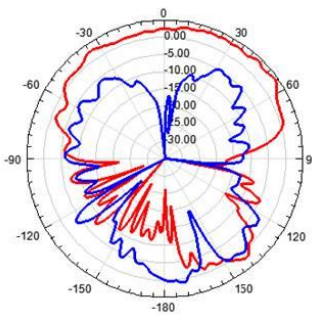
(b) Return loss



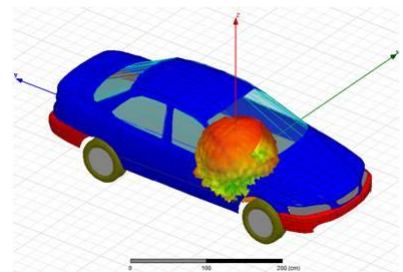
(c) Axial ratio characteristic



(d) 2D radiation pattern (vehicle longitudinal direction)



(e) 2D radiation pattern (vehicle lateral direction)



(f) 3D radiation pattern

## Effectivity

It is possible to confirm changes in the antenna characteristics when incorporated in an automobile and feed it back to the design of the antenna itself. In this example, we confirmed the characteristics when it was installed in one place in the car, but the characteristics differ depending on the installation location. It is also possible to select the optimum position to install by electromagnetic field analysis.

## Analysis Type

- Electromagnetic field analysis

## Required Product

- Ansys HFSS

The company names and product names described are generally trademarks or registered trademarks of each company.

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## International Space Station S-band antenna analysis example

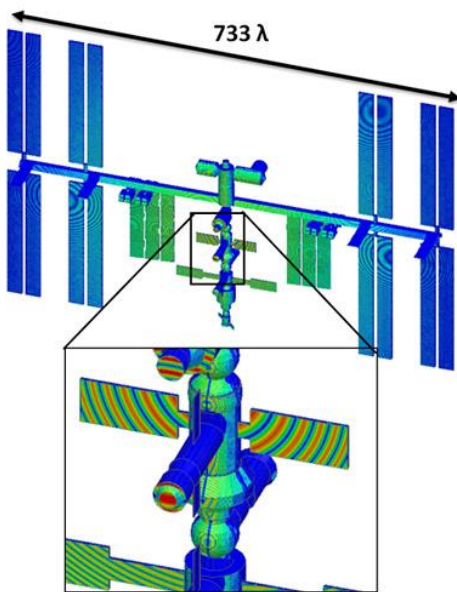
### Recommended for such people

- Antenna designers who are designing and experimenting with antenna characteristics, including the target for antenna installation
- A designer who wants to carry out a large-scale antenna analysis design including an object of  $100\lambda$  or more, which was difficult until now.

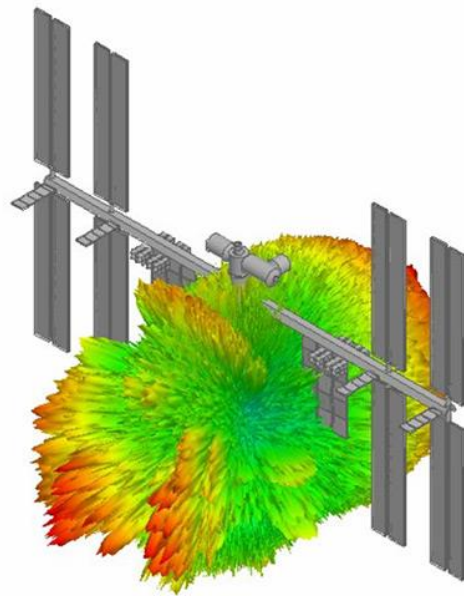
This is an analysis example of the S-band antenna installed on the International Space Station. Even if the analysis target is very large,  $733\lambda$ , and it is usually difficult to analyze electromagnetic fields, it is possible to analyze with realistic PC specifications by using the Ansys HFSS Physical Optics solver. In this example, we were able to analyze with 47GB of physical memory.

### Result

Current density distribution



3D radiation pattern from antenna



### Analysis Type

- Electromagnetic field analysis

### Required Products

- Ansys HFSS
- Ansys HFSS-IE Solver