Application of FEKO in EM Protection Design from Electromagnetic Environmental Effects of Civil Aircraft

Project Description

The Commercial Aircraft Corporation of China, Ltd. (COMAC) was established in 2008 to implement strategy for large aircrafts. Established in the 1970s, the former First Aircraft Design Institute Shanghai Branch of China Aviation Industry Corporation I was restructured and incorporated into COMAC in the same year and was renamed as the Shanghai Aircraft Design and Research Institute of COMAC. Currently, the missions of Shanghai Aircraft Design include design, testing, pre-research and key technology research of ARJ21 aircraft and C919 passenger plane, complete independent intellectual property rights of ARJ21 aircraft and large aircraft C919 for which China has completely independent intellectual property rights.

The Shanghai Aircraft Design and Research Institute of COMAC has successfully designed the country's first homegrown large passenger aircraft, covering various areas such as overall pneumatic, strength, structure, integrated avionics, electrical, flight control, hydraulic, environmental control, power, fuel, standard material, airworthiness and information systems.

"FEKO has been a strong support for development of homegrown commercial aircrafts, especially for applications such as antenna placement/isolation, high-intensity radiated fields and electromagnetic compatibility. We hereby express our heartfelt thanks!"

Dai Jigang,
Senior Engineer, Shanghai Aircraft Design and Research Institute
COMAC

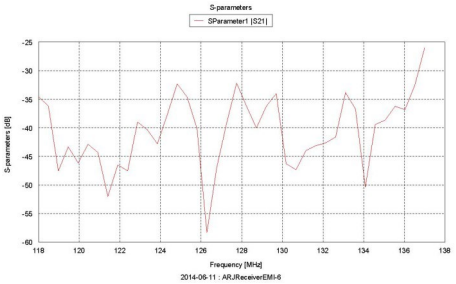
Challenge

With the rapid development of science and technology, more and more airborne radio equipment are being installed in aircrafts. Typically, an aircraft is equipped with dozens of radio systems, such as weather radars, communications and navigation systems and air traffic control systems, which involve a lot of antennas with very wide frequency range. However, due to the limited length of the aircraft itself, there is not much space for antenna placement. In practical applications, antenna pattern distortion caused by the aircraft body and inter-antenna electromagnetic compatibility are the highlighted concerns.

During take-off and landing or during its flight, an aircraft may be irradiated by high-power radio transceiver from ground, air or ships at sea, which is an electromagnetic environmental problem caused by human activities. These electromagnetic waves with high power, wide frequency spectrum and long duration of action are called high-intensity Radiated Fields (HIRF). After penetrating the skin, the electromagnetic energy can induce electromagnetic fields around airborne equipment or induce high-frequency current on interconnected cables, resulting in function disorder or loss of key/critical equipment, which may endanger the aircraft's ability to fly safely and land.

Another problem that cannot be ignored is electromagnetic compatibility (EMC), which is an interdisciplinary gradually built with the growing complexity of electronic equipments and systems. Its main research object is the emission, transmission and reception of electromagnetic energy. The study scope of EMC is relatively broad and includes interferences other than lightning, HIRF and electrostatic in the field of civil aircraft.

The development of homegrown commercial aircraft attaches great importance to EM protection design of electromagnetic effects. A comprehensive electromagnetic simulation and analysis tool is urgently needed in order to eliminate the personnel and equipment hazards caused by electromagnetic radiation fields and to improve the safety and reliability for aircrafts in complex electromagnetic environments.



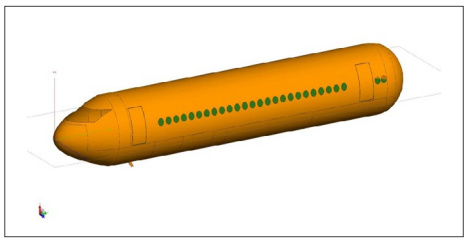
S Parameter of VHF-1 Transceiver at the Operating Frequency

Solution

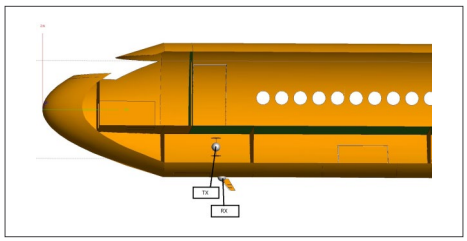
Shanghai Aircraft Design and Research Institute started to cooperate with FEKO® early in 2004. Using rich and powerful FEKO electromagnetic solvers, various types of high-frequency electromagnetic field problems can be quickly and accurately solved. During the development of multiple aircraft models, FEKO has helped to solve many problems related to antenna placement, inter-antenna isolation, high-intensity radiated fields and electromagnetic compatibility.

An aircraft is also equipped with a large number of radio equipment, such as airborne navigation, communication and cabin information systems. These systems may be affected by electromagnetic fields radiated by other airborne electrical and electronic equipment during operation (which is defined as front-door coupling interference in the newly released standard). In the design process of commercial aircrafts, the front-door coupling interference of airborne receiver has attracted more and more attention in airworthiness reviews. In engineering applications, interference source equipment is distributed throughout various compartments inside the aircraft, including cockpit, cabin, electrical and electronic equipment bay (E/E bay) and cargo bay. Many airborne antennas are located in the back and the belly of the aircraft. The cabin door gap and window structure also need to be taken into account during modeling and simulation. Both modeling and meshing works can be completed within the FEKO pre-processor module.

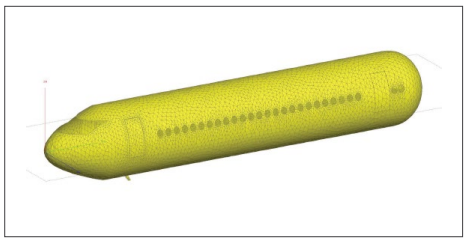
The S parameter at VHF operating frequency band was calculated with FEKO. Both the simulation results and the inspection on the radiated power of electrical and electronic equipments in E/E bay indicated that the flight control computer (FCC) with radiated power of -60 dBm at 125 MHz might be the source of the radiation interference. Therefore, a front-door coupling test of the VHF receiver was conducted on the aircraft. It was found that the signal was lost when measured with FCC was powered off. It can be seen that the calculation results is a valuable guide for not only engineering design at the development phase, but also troubleshooting at the flight test phase.



A Simplified Model of Passenger Plane



Front-door Coupling Antenna Placement



Mesh

For high-intensity radiation fields, HIRF simulation generally involves aircraft being illuminated by plane waves from all directions, focusing on the EM fields' distribution inside the compartment and the induced currents on cables. The HIRF band is very wide (ranging from 100 kHz to18 GHz). Currently the medium and low frequency bands have been well addressed. The solvers provided by FEKO, such as the Method of Moments, Multilevel Fast Multipole Method, Physical Optics and Geometrical Optics, can get the electromagnetic field distribution inside the compartments and the induced voltages and currents with many valuable conclusions.

FEKO is also widely used by Shanghai Aircraft Design and Research Institute in electromagnetic compatibility troubleshooting. Since the airborne systems are rather complex, it takes a lot of time to perform on-board troubleshooting during flight-test for the electromagnetic compatibility issues arising during the development process. Therefore, relevant simulation analysis and calculation become particularly important. For example, during the flight test of an aircraft to check the DME (distance measuring equipment) small-angle long-distance receiving capability, the DME output was found to be discontinuous. It could be seen from the partial view around the horizontal plane of the aircraft coordinate system on the calculated DME antenna radiation pattern that, although the two antennas provided good coverage for the lower half of the space, the tail and head patterns of the upper half of the space showed significant depressions. The zero point in the tail pattern was particularly deep. According to the aircraft's flying attitude at the lost point, it could be determined that the radiated power of the DME antennas were slightly low. In this way, the problem was quickly solved by appropriate measures.

Conclusion

FEKO offers multiple solvers and extensive engineering experience in terms of electromagnetic problems in the field of civil aviation, which can help the customers analyze all types of electromagnetic problems. During many years of co-operation with the Shanghai Aircraft Design and Research Institute, FEKO has provided efficient solutions in the fields of antenna, high-intensity radiated fields and electromagnetic compatibility and so on.

Altair Engineering, Inc., World Headquarters: 1820 E. Big Beaver Rd., Troy, MI 48083-2031 USA
Phone: +1.248.614.2400 • Fax: +1.248.614.2411 • www.altair.com • info@altair.com