RFID Applications

RFID

Radio-frequency identification (RFID) is one of the many electromagnetic (EM) applications where WIPL-D software suite is successfully used. RFID assumes the wireless use of electromagnetic fields to transfer data, mostly for the purposes of automatic identification and tracking of various tags attached to target objects. The tags can operate as passive transponders, while other types have a local power source such as a battery. The operational range may be hundreds of meters from the reader. The line of sight is not a requirement. In that sense, WIPL-D Pro as a Method of Moments based code is very suitable for RFID applications. Most of the small and less complex tags are simulated in a few seconds.

WIPL-D is extremely efficient for open radiating problems and especially for simulation of coupling between very distant objects (no boundary box requirement). WIPL-D Pro does not require to mesh the space between reader and the tag.

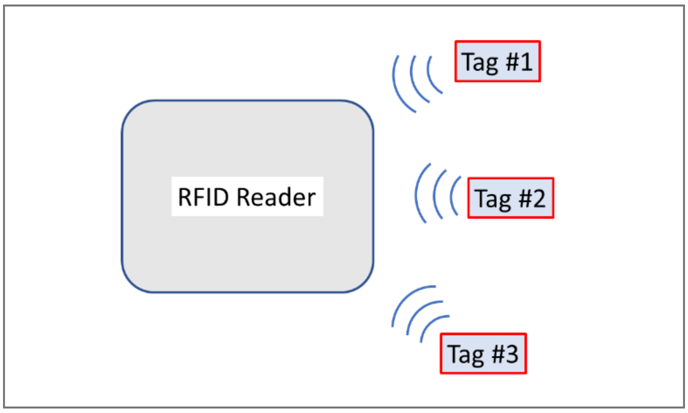

Fig 1 Typical RFID system

The range of industries is huge (automotive; RFID-tagged pharmaceuticals; RFID microchips in livestock and pets; storage of goods; tracking patients in hospitals). The world RFID market is one of the fastest raising industries.

In what follows, we will shortly describe part of the applications of WIPL-D software for devices marked as RFID (tags and readers).

Commercial RFID Tags

The most common form of industrial RFID tags is shown in Fig 2. The simulation of such device in WIPL-D Pro is extremely easy, no matter whether the tag is printed on dielectric, curved or placed in the vicinity of other objects.

The typical requirement for the impedance of the tag is to have 10+j200 ohms or similar, so that it can be matched to the chip with conjugated impedance. WIPL-D offers to calculate return loss of the device referenced to the complex impedance (of the chip in this case).

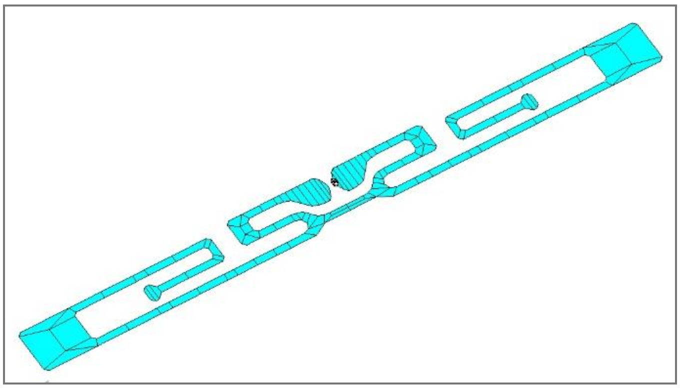

Fig 2 Typical industrial tag

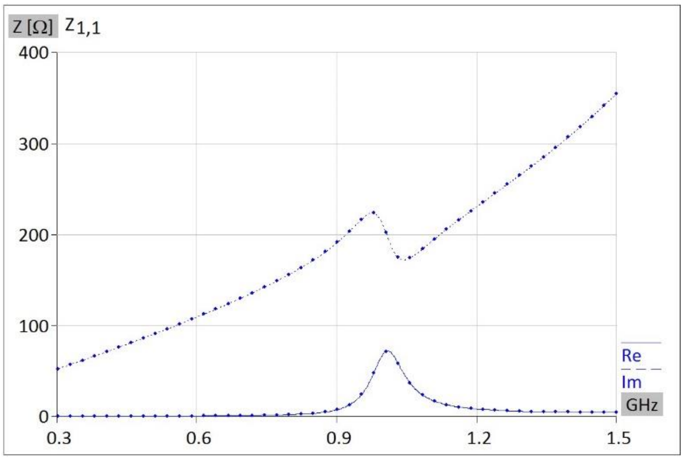

Fig 3 Tag impedance

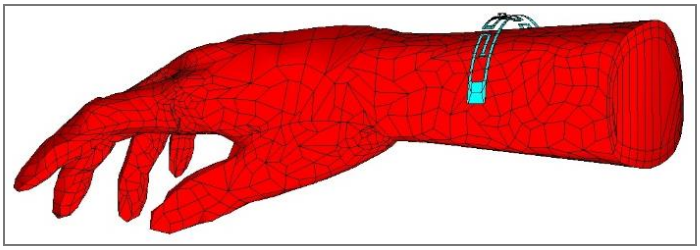

Fig 4 Tag placement at human hand

The metallic tag usually requires couple hundred of unknown coefficients, while the tag printed or immersed into dielectric requires up to a couple of thousand. Simulations are done in seconds on everyday desktop computers.

The power of WIPL-D simulation is especially useful when a tag should be placed inside a complex environment or near large objects. Fig 4 illustrates the scenario when the tag is winded around human wrist and its performance tested for degradation. The simulations have increased EM complexity but remain fast and efficient.

Complex RFID Reader

RFID devices can operate in several frequency bands starting from LF (~130 KHz) over HF (13.56 MHz) and many devices work at ~900 MHz band. For the bands with lower frequencies, RFID devices are mostly made as electrically small devices. In that sense, WIPL-D pro ability to simulate very precisely projects with electrically small details by using double precision only is invaluable.

RFID reader at 13.56 MHz may have many turns in order to achieve electrical length needed to register low level tag signals. They are also usually covered or immersed into plastic for protection and compact form. Figs 5-7 show 13.56 MHz RFID reader implemented in 7 layers.

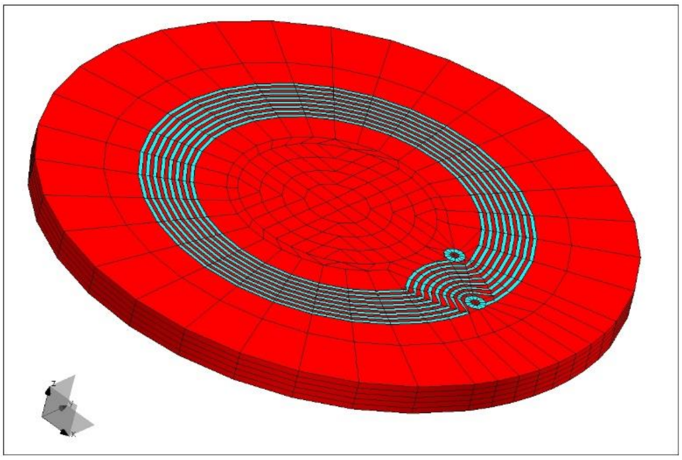

Fig 5 RFID reader

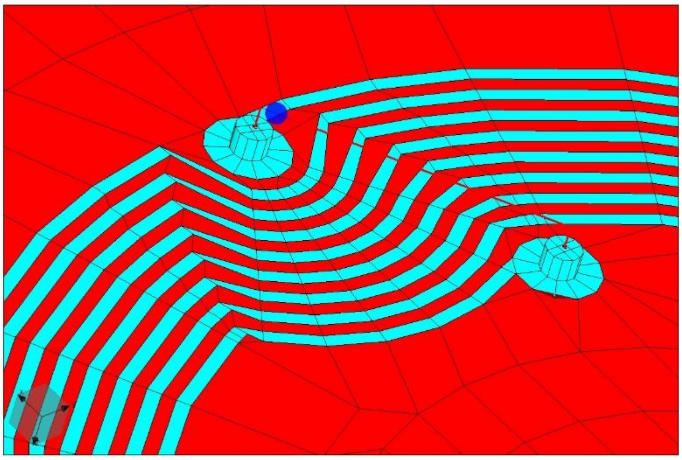

Fig 6 RFID reader feeding area

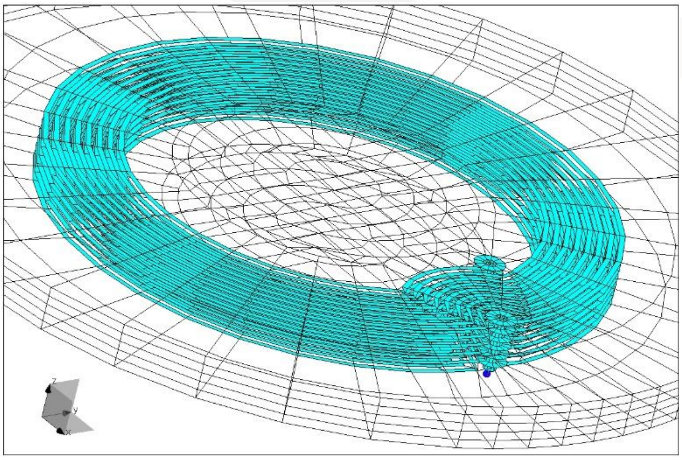

Fig 7 RFID reader interior (7 metallic layers)

Despite the significant complexity of the RFID reader, simulation remains fast. The problem requires less than 10,000 unknown coefficients and simulations last under a minute. WIPL-D Pro predicts the measured impedance of 1+j66 Ohms with great reliability by simply using double precision for the low frequency simulation problem. Simulations show great accuracy even when user should deal with lower performances such as calculation of near field or the device radiation pattern.

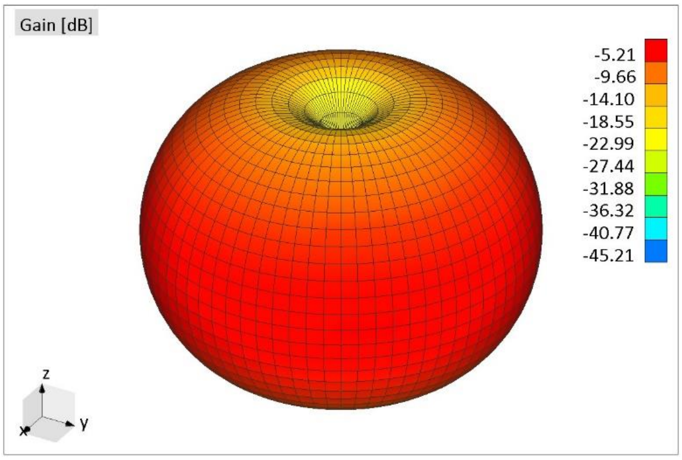

Fig 8 RFID reader with low gain performance

Multiband RFID Device

Very often the devices made for RFID are universal and made for several applications. An example can be cross spiral antenna shown in Fig 9. The antenna exhibits good performances at 3 frequency bands so it is supposed to be used as combined RFID, mobile-phone (UMTS) and GPS band device - 1.0 GHz, 1.8 GHz and 1.67 GHz, respectively.

In order to test the accuracy, feeding area of the structure was done in two completely different ways. One was via a very simple wire bridge, while the second feed area included coaxial feeders, and connector with all the details (Figs 10-11)

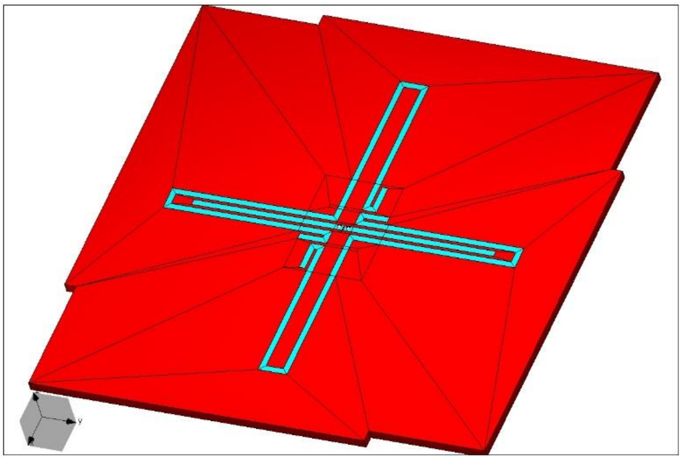

Fig 9 3-band CSA

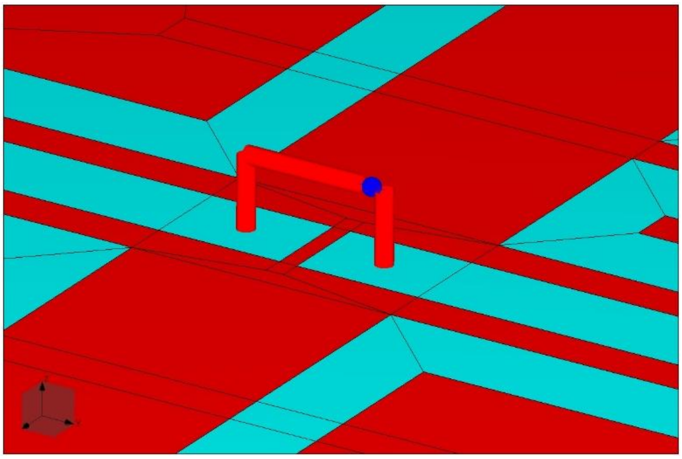

Fig 10 CSA simple feed

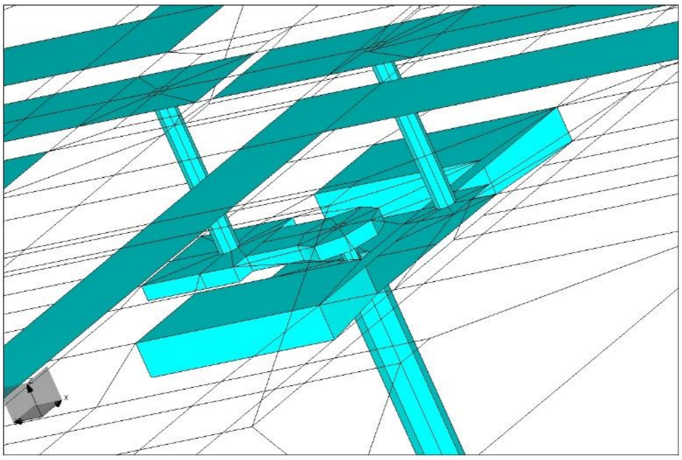

Fig 11 CSA complex feed

Although the model in WIPL-D was fed in two very different ways, results are very stable and similar.

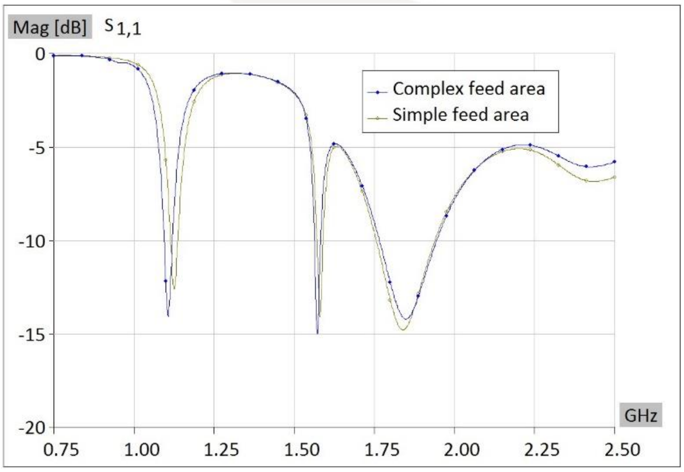

Fig 12 Two feeding methods

The model with simple feed runs in a few seconds with ~2,000 unknowns required, while the complex feed model runs in a few more seconds with ~4,000 unknowns required. The excellent agreement with measured results is shown in Fig 13.

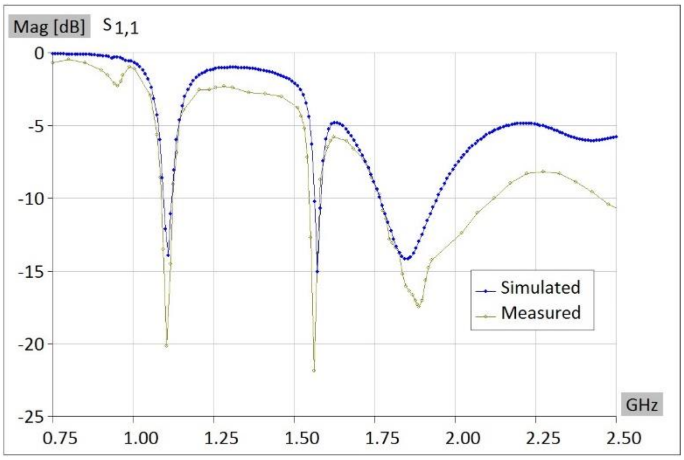

Fig 13 Comparison with measured results

Reference: “A multi-polarization multi-band cross spiral antenna for mobile communication devices”, ISAP 2012 International Symposium.

Mobile RFID Reader

Very often the requirements for RFID system are such that all the devices must be mobile, compact and with extremely high performances. An example of such device can be square quadrifilar spiral antenna with circular polarization for UHF mobile RFID reader.

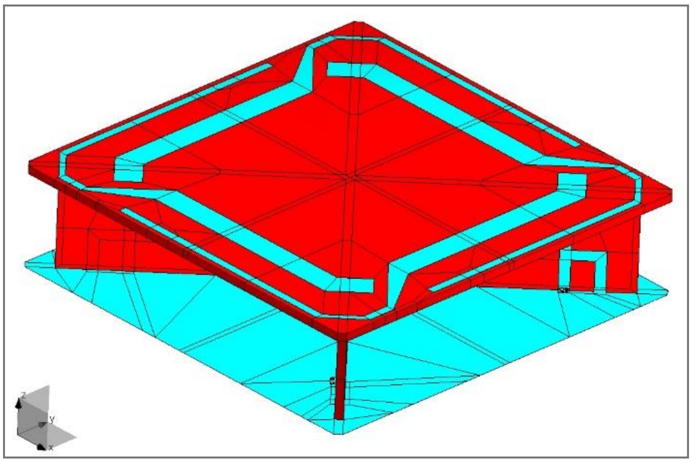

Fig 14 QSA antenna

In order to make a device with excellent performances but firm positioning, the separate dielectric substrates are used for power divider and feeding.

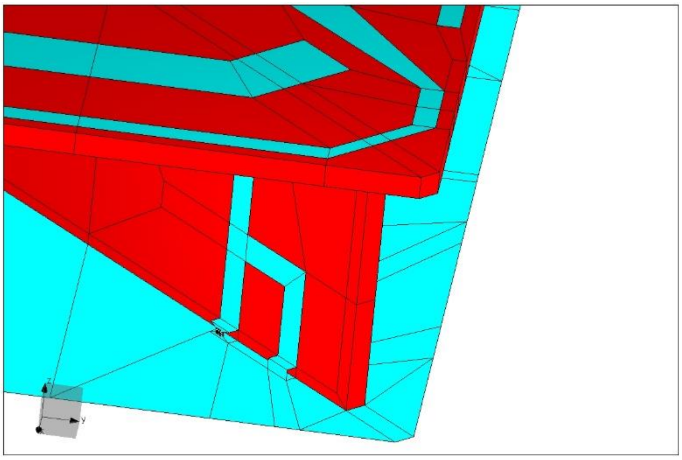

Fig 15 QSA feeding zone

Antenna exhibits extremely low axial ratio.

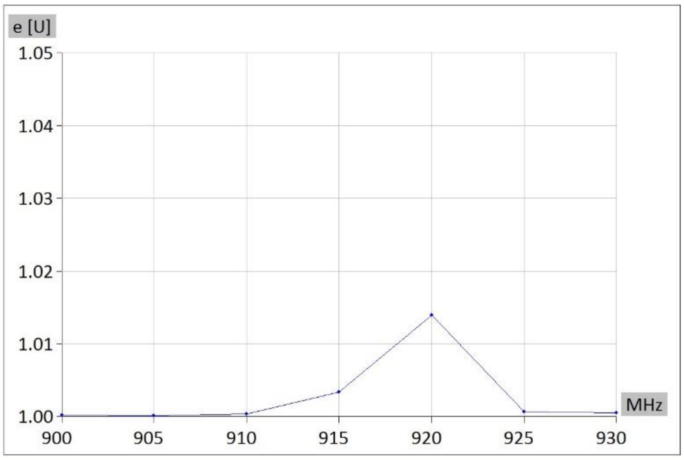

Fig 16 QSA axial ratio

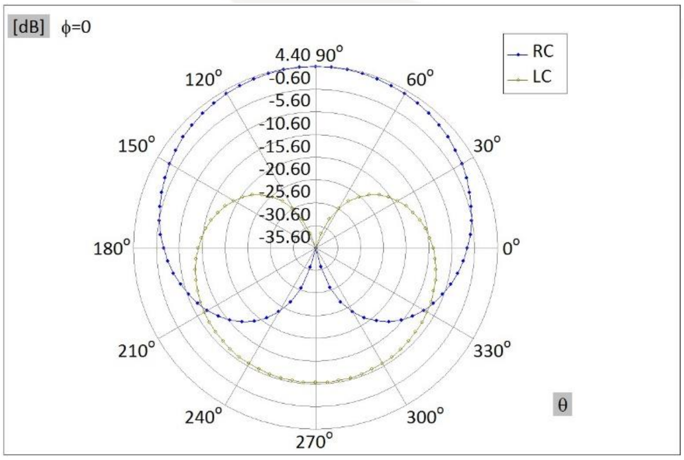

Fig 17 RC and LC polarization gain

The advantege of WIPL-D Pro is its ability to precisely calculate the coupling between the feeding ports.

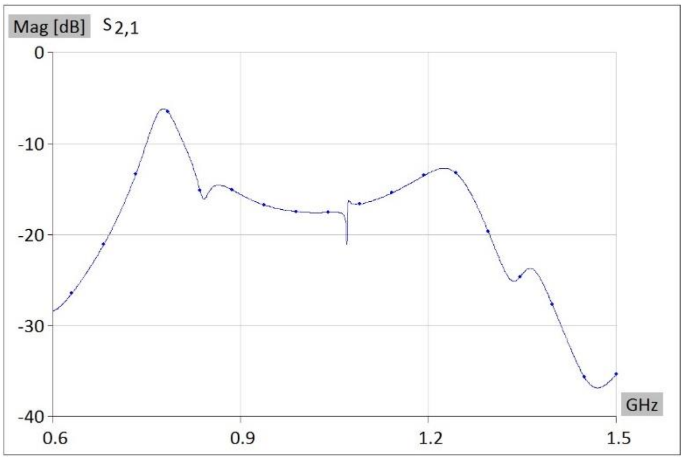

Fig 18 Coupling between ports

The project requires around 5,000 unknown coefficients with the antenna, feeding network and finite ground. The simulation runs in just couple of minutes.

Reference: “Compact Square Quadrifilar Spiral Antenna with circular polarization for UHF mobile RFID Reader”, Microwave Conference Proceedings (APMC), 2010