Key Technologies Supporting RFID and Related Products

OIKAWA Yoshinori, KAMEI Koji

Abstract

Since the announcement of the "u-Japan Policy" by the Japanese Ministry of Internal Affairs and Communications, RFID has been attracting attention as one of the key technologies for pioneering the new trends toward the Ubiquitous age. The NEC TOKIN Corporation joined the RFID business as a device manufacturer from a very early stage and has since been offering products including non-contact IC cards, IC tags and RFID readers. The present issue for the industry is to develop a UHF/microwave IC tag that is suitable for application in the distribution and logistics industries. This paper describes the key technologies supporting RFID by taking as examples UHF/microwave antenna design methods and the electromagnetic wave-absorbing material Flex-Suppressor, which is used for preserving the communication range when an IC tag is attached to a metal. Some of NEC TOKIN's RFID-related products are also introduced.

Keywords

RFID, non-contact IC card, IC tag, RFID readers, antenna

1. Introduction

AIDC (Automatic Identification and Data Capture) techniques are used for various management purposes by associating information and goods. These techniques are regarded as some of the specific means of building the infrastructures of the Ubiquitous Society. With AIDC, identification information is recorded on data carriers such as bar codes, non-contact IC cards and IC tags in order to enable the real-time, integrated management of the history, flow, security, etc. of people, animals and goods. The ADIC techniques may be roughly divided into four categories: 1D/2D bar code symbols, optical character/symbol recognition, magnetic stripe card and RFID (Radio Frequency Identification). RFID is the category that is recently attracting most attention. It can be categorized further into the RF card (non-contact IC card) and RF tag (IC tag) techniques depending on whether the information is carried by persons or attached to objects[1)].

At NEC TOKIN, we started mass-production of non-contact IC cards in 1998 and have been producing more than 10 million products every year. For the IC tags, we started mass-production in 2000. At the beginning the products were 125kHz IC tags for use in the automatic charge registration for dishes in the company employee restaurants, etc., but the present products are mainly the 13.56MHz band IC tags and their applications have been expanding into the apparel and amusement industry domains.

It is expected that the year 2008 will be the turning point when the IC tag market will start to expand rapidly, so that they will be attached ubiquitously and used everywhere and for everything. When such a situation arrives, the antenna design technology will increase in importance because the antenna is together with the IC chip itself, one of the IC tag components that is indispensable for enabling the IC chip to achieve its optimum performance.

On the other hand, the IC tag involves problems in which their communication range shortens or they become incommunicable depending on the objects to which they are attached. Particularly, special techniques are required when they are attached directly to metallic objects.

In this paper, we will describe the key technologies supporting RFID by focusing on the UHF/microwave antenna design technology and the electromagnetic wave-absorbing material Flex-Suppressor, which is a sheet material developed originally for noise reduction purposes. Products specifically related to RFID such as non-contact IC cards, IC tags and the associated RFID readers will also be described.

2. RFID-Related Products

2.1 IC Tag Products

Fig. 1 shows the IC tag products we have released up to the present. The current products use mainly the 13.56MHz band and their applications are currently expanding in the apparel and amusement industries. The 125kHz IC tag has the shape of a coin with a size of 30mm dia. × 2.1mm thickness, which is used for the automatic charge registration of dishes in the company employee restaurants and sushi carrousel restaurants, etc. It has a communication range of 6cm maximum that is sufficiently robust to withstand the high temperatures associated with dishwashers and their repeated use.

The 13.56MHz IC tags are designed based on two international specifications; the ISO/IEC14443 standard featuring enhanced security for application in entrance/exit management and administrative cards, and the ISO/IEC15693 standard featuring a communication range of a few tens of centimeters for use with pricing and brand tags. In addition, the 2.45GHz radio wave propagation type IC tag featuring a compact size and an extended communication range is about to become a practical option.

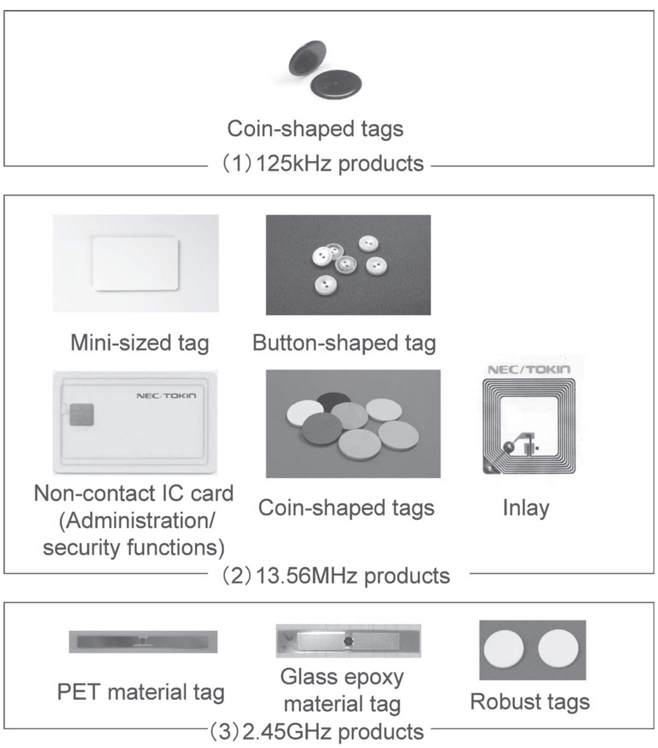


Fig. 1 IC tag/non-contact IC card products.

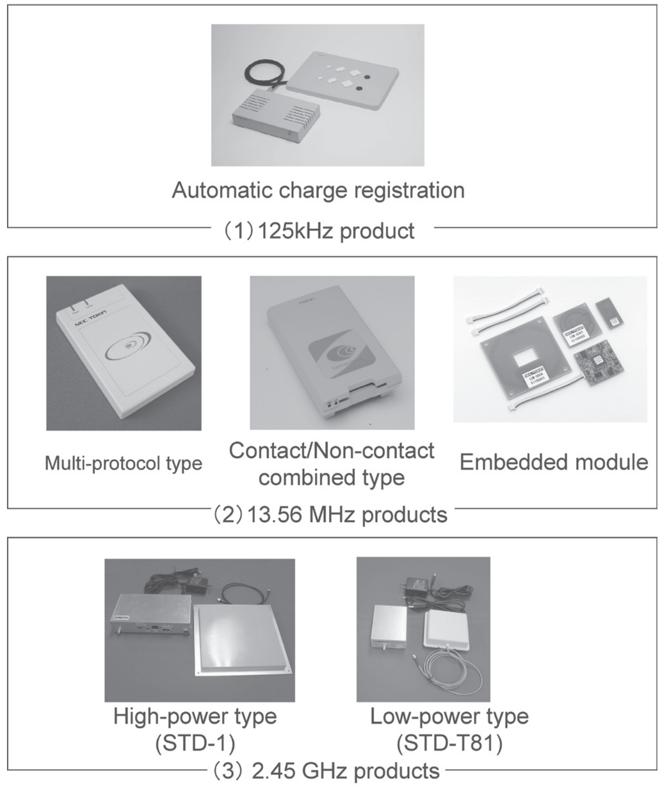


Fig. 2 RFID reader products.

2.2 RFID Reader Products

In parallel with the IC tags, the RFID readers that play the role of inquirer in the RFID system have also been developed and released as shown in **Fig. 2**. The 13.56MHz RFID readers have the multi-protocol compatibility covering ISO/IEC1443 Type A/Type B and ISO/IEC15693. They can be applied to many applications by selecting the required standard using software.

3. Antenna Design Technology

The technologies that are critical for the fabrication of IC tags are the antenna design and the mass-production technologies. This section deals with the results of research into the antenna design for UHF/microwave IC tags that are expected to be introduced on a significant scale in the future.

3.1 Antennae for Tags Corresponding to Metallic Material

Actual communication devices are often made of metal and it is expected that IC tags will typically be attached to metal surfaces in the future. If an ordinary IC tag is attached to metal, its impedance matching is deviated and communication is not possible. This situation implies that new research and development is required for IC tags to become compatible with metal fixings. Specifically, the antennae should be designed to be separate and at a certain distance from the metal so that the impedance can be matched according to the proximity of the metal. In this context, although the directivity increases due to the presence of a metal conductor, the effect of the metal in the direction of the front of the tag can be eliminated as the separation distance is increased. **Fig. 3** shows the results of simulations in the frontal direction, in which the maximum communication range can be reserved. The figure shows that the effects of metal can be avoided when the separation distance d, is about 3mm or more.

However, tags corresponding to metallic material are required to achieve more severe impedance matching than ordinary tags. **Fig. 4** shows the effects of the frequency on prototype tags corresponding to metallic material. When frequency hopping is taken into consideration, the communication range may be halved in the hopping range (2.4 to 2.4835GHz) thus indicating that frequency stability should be considered when the communication range is important.

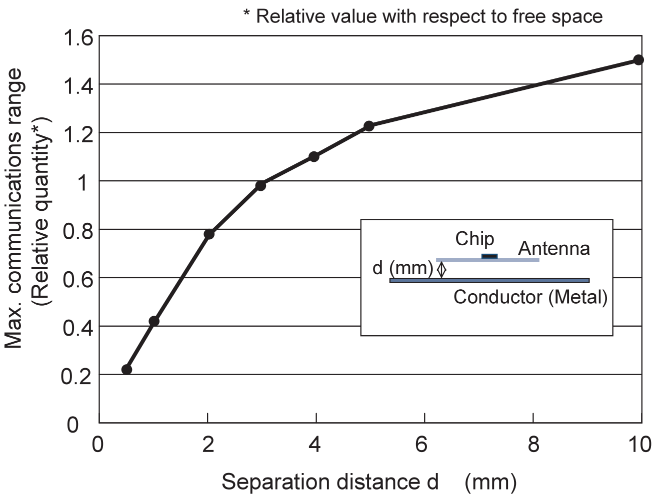


Fig. 3 Max. communications range vs. separation distance from a conductor.

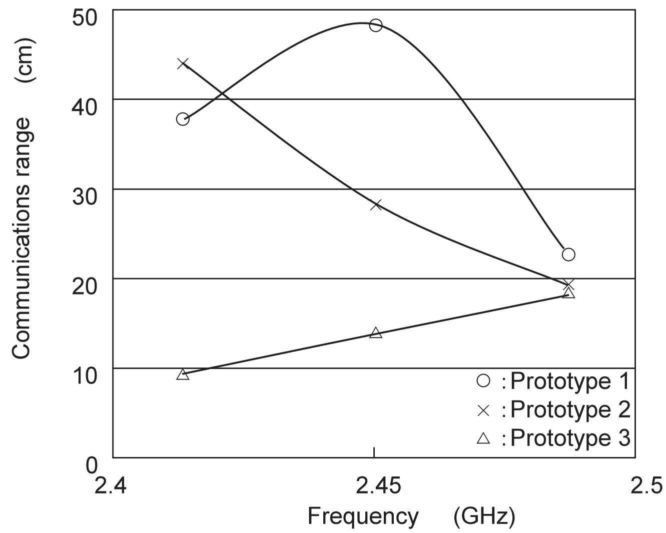


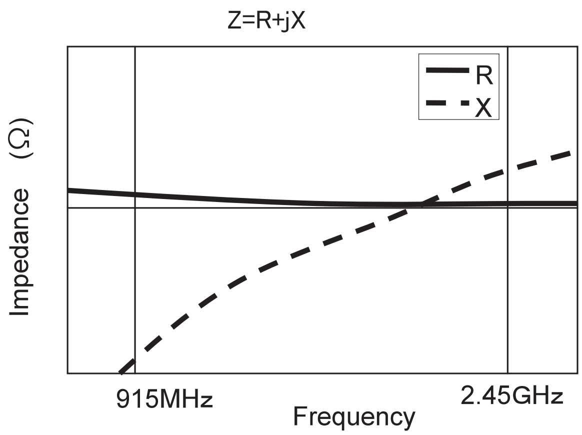
Fig. 4 Frequency dependence when the tag is attached to metal.

3.2 Antennae for Tags Corresponding to Multi-Band

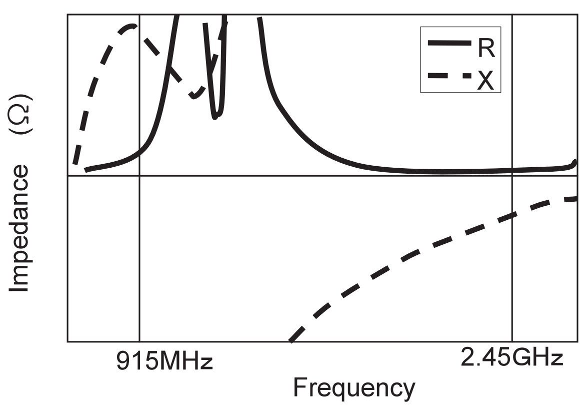
In the case of the current microwave band usage in Japan, the 2.45GHz band is used to support ISM (Industry, Science and Medical) applications, and the use of 950MHz band (UHF band) is also permitted so that two frequency bands are coexisting. On the other hand, in North America, the 915MHz band is becoming the *de facto* band (a position occupied by the 869MHz band in Europe). As a result, when global distribution is taken into consideration, it becomes necessary to attach two or three tags in order to allow RFID operations for both the sending and receiving parties. This scenario is not only too complicated but it is also disadvantageous from the viewpoint of cost.

As one of the solutions to the above problem, we studied the possibility of an IC tag that can be applicable to multiple frequencies and concluded that it would be possible to achieve impedance matching by means of the antenna. This can be done either by adopting the dual-band system for impedance matching with two frequencies or by expanding the frequency band to include more than one of the currently used frequency bands.

We first studied the dual-band system covering the 2.45GHz and 915MHz bands by assuming international distribution between North America and Japan. **Fig. 5** shows the results of our dual-band IC tag design; (a) shows the results of the impedance measurement of the IC tag chip and (b) shows the results of the antenna design. Here, impedance matching is achieved by canceling the reactance components at the 915MHz and 2.45GHz bands and matching the impedance



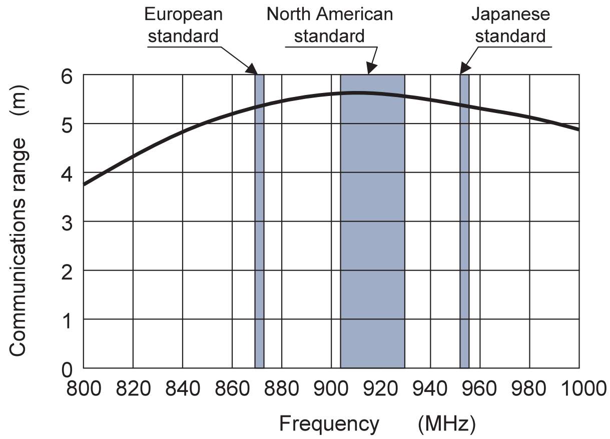
(a) IC tag chip impedance



(b) Antenna impedance

Fig. 5 The example design of a dual-band IC tag.

(a) Prototype IC tag



(b) Frequency vs. Max. Communications Range (Design simulation)

Fig. 6 Design and prototyping of 900MHz band IC tag.

components. This reduces the communication range slightly compared to an IC tag tuned to a single frequency band. However, we confirmed that the tag is able to communicate in both frequency bands and is sufficiently practical for the purpose.

In order to broaden the frequency band, we focused on a research target in the 900MHz band because it is unrealistic to expand the band into a range covering from hundreds of MHz to a few GHz. **Fig. 6**(b) shows the results of our antenna design for the 900MHz band. As a result of a simulation assuming a communications range of more than 5 meters, the IC tag was capable of communications over 850MHz to 990MHz, indicating that a single IC tag can be used in Europe, North America and Japan. Fig. 6(a) shows the prototype IC tag. We also measured the samples in a radio anechoic chamber and thereby confirmed its feasibility.

4. Application of Flex-Suppressor in RFID

Following the rapid dissemination of cellular phones; the reduction in the product development period, digitization of internal components and reduction of product sizes have all contributed to making it very important for manufacturers to develop effective noise countermeasures over a short time period. The relevant noise countermeasure component that has been developed by us is “Flex-Suppressor,” which is an innovative noise reduction sheet that needs only to be attached to a part to effectively reduce noise. Flex-Suppressor, which is based on electromagnetic induction with a carrier frequency of no more than 13.56MHz also presents excellent characteristics as a part corresponding to metallic material for RFID products. The RFID-oriented Flex-Suppressor products (which include the “AD” and “RS6” brands) enhance the magnetic flux convergence effect at 13.56MHz by increasing the relative permeability μ' while keeping the magnetic loss μ'' low. When a loop antenna is in the proximity of a metal, its magnetic energy is consumed as current inside the metal and the communications range is thereby reduced. However, when a Flex-Suppressor sheet is placed between the loop antenna and the metal, it functions as a magnetic yoke and increases the communications range (**Fig. 7**). This fact may also be applicable to a loop antenna for a cellular phone that incorporates a non-contact IC

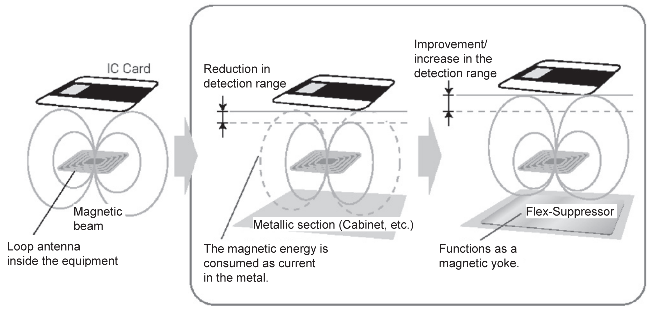


Fig. 7 Effects of Flex-Suppressor when the tag is attached to metal.

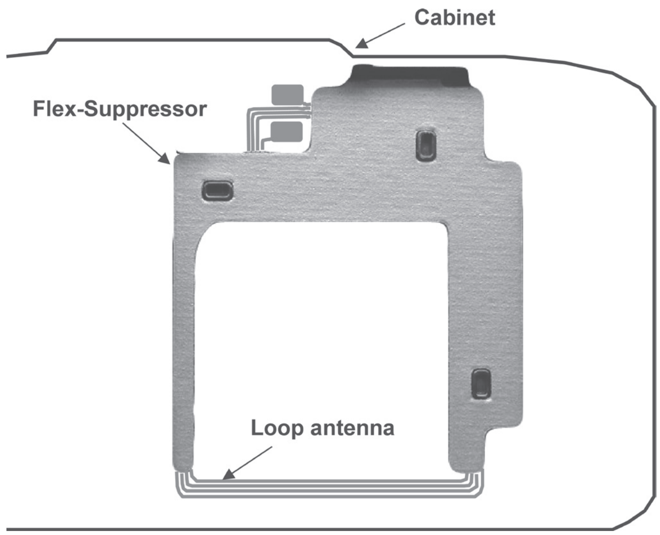


Fig. 8 Example of application in a cellular phone terminal with a non-contact IC card function.

card function. An image of this application is shown in **Fig. 8**.

5. Conclusion

In the above, we have described the UHF/microwave antenna design technology and the application of Flex-Suppressor to implement noise countermeasures for IC tags corresponding to metallic material. We present these innovations as some of the key technologies of the RFID devices and the RFID-related products that form part of the infrastructures of the Ubiquitous age. As IC tags are introduced more massively in the future, it is expected that they will be attached to an increasing variety of objects. In this context we are determined to advance our program of technological development in order to respond promptly to the related market needs.

References

1) "RFID JISSEN SEMINA (RFID Practice Seminar)," JEITA, March 11, 2004.
2) "2006 RFID GIJUTSU GAIDOBUKKU (2006 RFID Technical Guidebook)," DENSHI JAANARU, Nov. 10, 2005.

Authors' Profiles

OIKAWA Yoshinori
General Manager,
Development Dept., Access Devices Division,
Network Devices Operations Unit,
NEC TOKIN Corporation

KAMEI Koji
Expert,
Solution Engineering Division,
Functional Devices Operations Unit,
NEC TOKIN Corporation

●**The details about this paper can be seen at the following.**
Related URLs:http://www.nec-tokin.com/product/dl_net.html
http://www.nec-tokin.com/product/pdf_dl/BUSTERAID.pdf