

UHF Portable Reader/Writer and Antennas

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Abstract

NEC TOKIN started its RFID business from a very early stage and has been expanding its reader/writer range as well as that of antennas that feature compatibility with various frequency bands, including the 125kHz, 13.56MHz, 2.45GHz and the UHF bands. This paper is intended to introduce a UHF band portable reader/writer and a group of antenna products developed newly by NEC TOKIN.

Keywords

UHF band, IC tag, reader/writer, antenna, miller subcarrier system, ILT, antenna switch

1. Introduction

At NEC TOKIN, we started the RFID business by beginning the mass-production of IC tags in 2000. Subsequently, we have been providing the market with IC tags and reader/writers for various frequency bands, including the 125kHz band for the auto register at worksite cafeterias, the 13.56MHz band mainly for individual authentication purposes, the 2.45GHz band suitable for the distribution and logistics industries, and the UHF band.

In particular, as the RFID system using the UHF band is recently attracting attention thanks to its operational advantages compared to other frequency bands such as the longer communication distance and the possibility of communication range expansion making use of diffraction of transmitted waves, we are currently enhancing the UHF band products as a priority.

As our products are compliant to the EPC global Class 1, Generation 2 standard, which is the current global standard, they are enabled to be used in technological renovations in the US, thus leading the world in this field. Additionally, the projected cost reduction from increased production also allows us to expect a future growth in the demand for the products.

This paper introduces the latest information on our UHF band products, including both for the reader/writer and for our various antenna products.

2. NEC TOKIN's Line of UHF Band Products

Our UHF band reader/writers include the in-plant radio station type products with frequencies of 952 to 954MHz and an output power of no more than 1W and the specified low pow-

er station type with frequencies of 952 to 955kHz and an output power of no more than 10mW.

We are already marketing a stationary reader/writer of the in-plant radio station type. The features of this product include an output power at the higher limit of the STANDARD of 1W, compatibility of two communication methods, which are the Japan-first FM0 baseband and the Miller subcarrier systems, and the highest available transmission rate among Japanese products of 640kbps (tag → reader/writer).

For purposes such as merchandise management in the distribution industry, for which the information on individual articles carrying IC tags is read with POS terminals for accounting or for the personnel movements inside the shop and for inventory management, the reader/writers are required to be more compact in size, easy to install, low in power consumption and extendible by the use of various antennas.

Therefore, we have been promoting expansion of compact

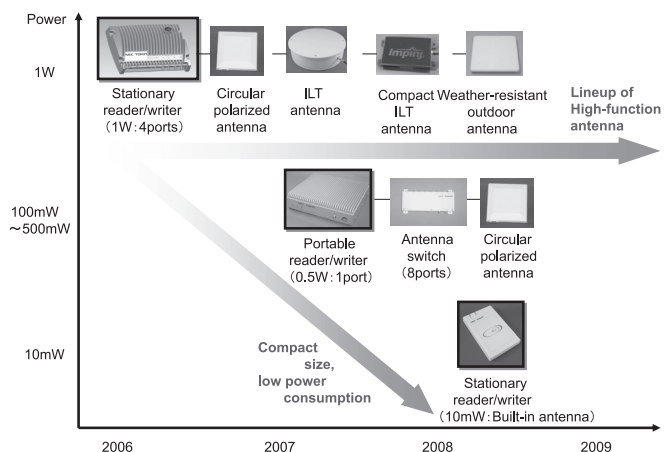


Fig. 1 Developed product lineup plan.

reader/writers and various antenna products in addition to the existing high-power reader/writers as shown in **Fig. 1** .

3. UHF Band Portable Reader/Writer

Photo 1 shows the external view of our newly commercialized portable reader/writer device and **Table 1** shows the main specifications of both stationary and portable reader/writers.

This product retains the high-performance core engine of our stationary reader/writer, uses one antenna terminal port and offers an output power of 500mW while reducing the volume to about a third and the weight to less than a half and the power consumption to below 60% compared to that of the previous stationary product. For interfacing, it is newly equipped with an RS232C port in addition to the LAN port in order to widen the device selection feature for controlling the reader/



Photo 1 External view of portable reader/writer.

Table 1 Main specifications of reader/writers.

Item	Stationary reader/writer	Portable reader/writer	Advantage of portable type (compared to stationary type)
Compatible protocol	EPC global UHF Class 1,Gen.2		—
Frequency	952-954MHz		—
Output	30dBm (1W)	27dBm (500mW)	—
Communication methods	FM0,MS		—
Antenna terminals	× 4 (TX/RX common antennas)	× 1 (TX/RX common antenna)	—
Interfaces	LAN/GPIO	LAN / RS232C / GPIO / Antenna switchbox dedicated terminal (option)	Extendibility
Power consumption	50VA	30VA	Low power consumption
Weight	2.7kg	1.2kg	> 1/2 weight
Dimensions	324 × 229 × 57mm	203 × 177 × 44mm	Approx. 1/3 volume

writer. It can also be equipped optionally with a dedicated terminal for antenna switching control. When used in combination with the newly developed “antenna switchbox” to be described below, it can be used to increase the number of connected antennas as well as to switch them antennas automatically.

As in the case of the stationary reader/writer this reader/writer is compatible with both the FM0 and MS (Miller Sub-carrier) methods. The concept of the MS method is shown in **Fig. 2** .

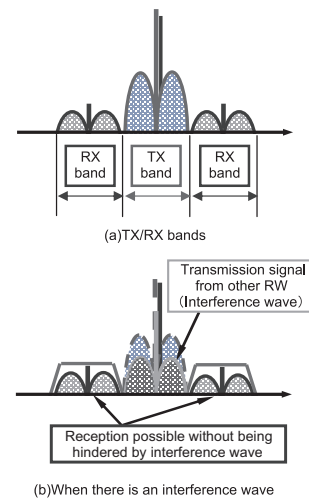


Fig. 2 Concept of MS method.

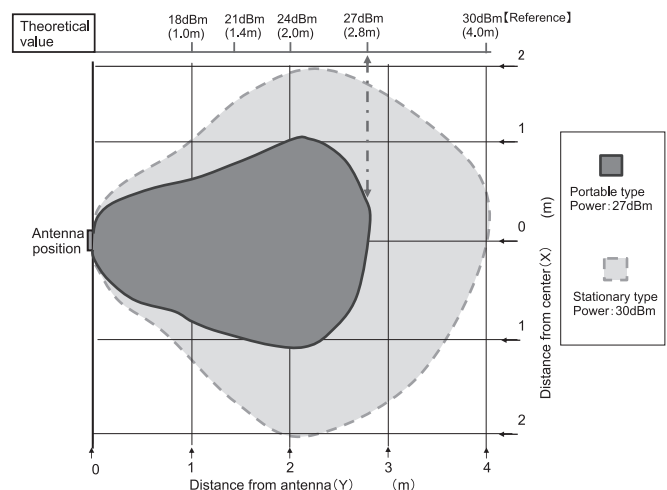


Fig. 3 Results of IC tag read distance measurements.

In order to reduce interference with other reader/writers the MS method assigns different frequencies for the reader/writer's transmission band and the IC tag's response band, or the transmission and reception bands of the reader/writer. This method enables reception without being affected by interference, even when there are interference waves from other reader/writers that use the same transmission band as shown in Fig. 2(b).

Fig. 3 shows the results of measurements of the IC tag read distance, which serves as an index of the communication performance evaluation. The dashed line indicates the measurement of the stationary type with an output power of 30dBm (1W) and the solid line indicates that with the newly developed portable type with an output power of 27dBm (500mW). The same antenna and IC tag were used in both measurements. The communication distance (theoretical value) calculated from the output power of the portable type with reference to that of the stationary type was 2.8 meters. This value coincides with the result of the measured value and indicates that the portable type has an adequate communication performance.

4. Antenna Products

4.1 UHF Band Antennas

The reason for the use of the UHF band reader/writer is to select the optimum antenna according to the installation environment and application. In order to enhance the compatibility with various installation environments and a wide range of applications we have newly developed a linear polarized antenna, a weather-resistant outdoor antenna and an ILT (Item Level Tagging) antenna in addition to the existing circular polarized antenna (Fig. 1). The following subsections will describe each of the newly developed antenna products. These antenna products can be used either with the stationary reader/writer or with the portable reader/writer.

(1) Linear Polarized Antenna

The linear polarized antenna has a single polarization plane, which is advantageous for long-distance communications.

As the linear polarized antenna radiates radio waves in the form of a single polarized wave, it can supply a 3dB higher power to the IC tags than the circular polarization wave that is created by the synthesis of two polarized waves. When this difference in power is converted into the communications it is found that the communication distance of the linear po-

larized antenna is about 140% that of the circular polarized antenna and that the linear polarized antenna can communicate with IC tags located at greater distances.

However, efficient communications using the linear polarized antenna require matching of the polarization planes between the IC tag and the reader/writer antenna. The communication distance is maximized when the polarization plane of the IC tag and that of the reader/writer antenna match but is decreased as the matching is deviated. Due to the characteristics of the linear polarized antenna as described above, it is suitable for use in the management of the production processes in which IC tags are arranged in a specific orientation or in applications with a need for long-distance communications.

(2) Weather-Resistant Outdoor Antenna

The weather-resistant outdoor antenna is suitable for applications that require the installation of an outdoor antenna, such as for those that are relevant to vehicle entrance/exit management.

In an outdoor environment where the antenna is exposed to sunlight, wind and rain, a high environmental resistance is required. Our weather-resistant antenna meets the IEC 529 IP67 (dust-tight and immersion-proof) environmental resistance standards. It also features excellent light resistance properties and offers a wide operating temperature range from -45°C to $+65^{\circ}\text{C}$ and it may be used outdoors regardless of the season.

(3) ILT Antenna

The ILT antenna employs an electromagnetic induction system that is different from the radio wave system of the conventional UHF band antennas.

One of the characteristics of the UHF band radio wave is that it is easily affected by moisture, which has hitherto made it difficult for radio wave system antennas to be used in the individual item management of merchandise that contains moisture. Therefore, we have developed an antenna based on the electromagnetic induction system that is resistant to the effects of moisture. This product is suitable for communications involving compact IC tags for individual article management based on the electromagnetic induction system. Although the communication distance is only a few centimeters, it is able to facilitate the management of individual articles containing moisture when used in combination with the IC tags. Either a large antenna ($\phi 230 \times 66\text{mm}$) that can function over a wide communication area or a compact antenna ($133 \times 70 \times 19\text{mm}$) providing easy installation can be used.

4.2 Antenna Switchbox

We have also developed an antenna switchbox that can expand the operating area of the portable reader/writer. **Photo 2** shows its external view and **Table 2** shows the summarized specifications.

This product is a switch device that enables an extension of up to 8 antennas for a 1-port reader/writer. It can be used to control antenna connections using the “GPIO signal (3-bit) from an application running on a higher-level device.

When this product or a portable reader/writer is connected via a dedicated cable, automatic antenna switching is possible according to the availability of the IC tags.

The antenna switchbox functions in two operating modes. One of them starts to select the next antenna immediately when the antenna being selected cannot find IC tags available for communication. The other mode recognizes all of the IC tags available for communication and then selects the next antenna if the antenna being selected can find IC tags available for

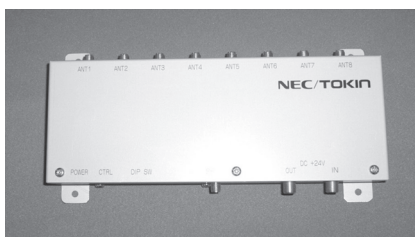


Photo 2 External view of antenna switchbox.

Table 2 Summarized specifications of antenna switchbox.

	Item	Specifications
Electrical characteristics	Operating frequencies	950-956MHz
	Insertion loss	1.5dB
	Isolation	25dB
	Max. input power	36dBm
	Supply voltage	3.3V
	Current consumption	20mA
Physical characteristics	Weight	Approx. 455g
	Dimensions	198 × 97 × 30mm
	RF input terminal	SMA-J (1 port)
	RF output terminals	SMA-J (8 ports)
	Control signals	① GPIO signal, 3-bit, 0/3.3V ② Antenna switching signal, 4-bit + GPIO signal, 1-bit, 0/3.3V.

communication. Either of these modes may be selected from an application running on a higher-level device.

5. Examples of Applications of the Portable Reader/Writer

The applications of the UHF band reader/writer have recently been expanding from the comprehensive management at the dock doors of warehouses to the areas of physical distribution and general logistics, including goods shelves and POS registers. The following subsections will deal with some examples of applications of the reader/writer for a variety of such purposes.

5.1 Application to Belt Conveyor Systems

Photo 3 shows an example of an application of the portable reader/writer and ILT antennas to a belt conveyer system.

This belt conveyer system is for use in a production line of bottles for medicines and liquids. Compact ILT antennas are

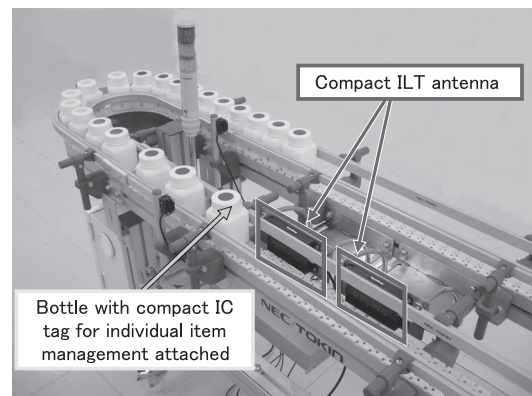


Photo 3 Example of application to a belt conveyor system.

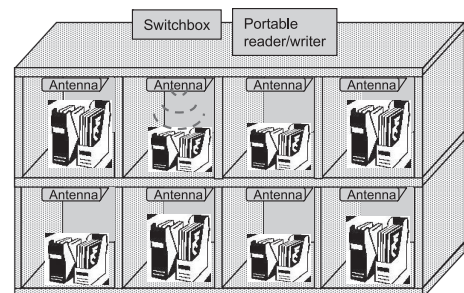


Fig. 4 Example of application to a smart shelf system.

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installed on the side of the belt conveyer in order to read the compact IC tags that are attached to the bottles and to enable individual article management.

5.2 Application to a Smart Shelf System

Fig. 4 shows an example of an application of the portable reader/writer and antenna switchbox to a smart shelf system. In this example, eight antennas are connected to the portable reader/writer via the antenna switchbox and are installed on the ceiling of each shelf. These antennas are switched sequentially to read the merchandise information from the IC tags attached to the merchandise on each shelf and use the information thus obtained in the management of articles such as books and clothes.

5.3 Application to a Gate

Fig. 5 shows an example of an application of the portable reader/writer and antenna switchbox to a gate.

The gate antennas for use in the simultaneous management of a large amount of articles for use in warehouse input/output management should be selected by performing site engineering and simulation of the optimum antenna layout in advance. However, when a large variety of articles are managed at the gate, the optimum antenna layout varies depending on the types of articles.

By using our antenna switchbox and increasing the number of antenna placement points without adding a reader/antenna, such as in this example, it is possible to construct a gate that can easily manage articles of various shapes.

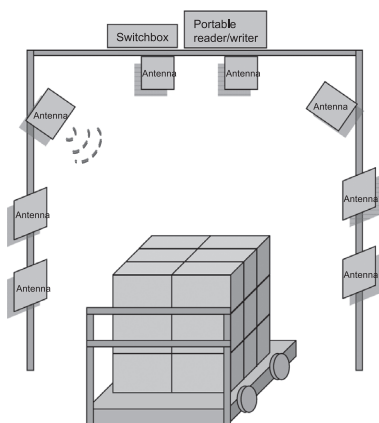


Fig. 5 Example of application to a gate using the switchbox.

6. Conclusion

At NEC TOKIN we have developed a linear polarized antenna, a weather-resistant antenna and an ILT antenna and antenna switchbox that feature compact sizes, light weights, low power consumption and high extendibility that are suitable for use with a portable reader/writer. These products are intended to meet the diversifying needs of our customers.

We aim thus to serve our customers as their best choice partner by offering a group of products that are able to combine these reader/writer and antenna-related products with our IC tag products.

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