FRAM RFID LSI with Serial Interface

FRAM RFID has been used as data carrier tag because of the outstanding feature of large capacity memory and high-speed writing. Built-in Serial interface enables to connect sensors with RFID and creates new possibility to RFID applications.

Introduction

Thus far, FUJITSU SEMICONDUCTOR has developed RFID LSI products for the HF band (13.6MHz) and the UHF band (860MHz to 960MHz). The most significant feature of the products is that Ferroelectric Random Access Memory (FRAM) is embedded. They have been widely adopted all over the world as data-carrier-type of passive RFID LSIs because of the feature of high-speed writing and high read/write endurance.

The advantage of large capacity data-carrier is that RFID can record traceability data frequently such as fabrication, production, logistics, maintenance, and so forth. And also it can be used for various asset, products, and parts management. Because of these advantages, it has been expected to further utilize FRAM RFID with connecting sensor and so forth.

Due to these market needs, we have developed a technology with a built-in serial interface; SPI on our UHF band RFID LSI.

Added Value of FRAM as RFID LSI

FRAM is a nonvolatile memory, which utilizes the ferroelectric material as data capacitor. FRAM has the advantages of both RAM and ROM. As the nonvolatile memory used in RFID, E^2PROM has been widely adopted. But E^2PROM requires internal boosted voltage when data is written, because the principle of data storage is with or without electron charge. Thus its writing speed is quite slow (on the order of milliseconds) and its write endurance is limited to around 10^5 times. Therefore, the mainstream of E^2PROM based RFID LSI is small memory capacity products, which rather focus on read operation.

In contrast, the write performance of FRAM is the same as read performance because the both principle is the same. The writing speed of FRAM itself is on the 100ns order and its read/write endurance is 10^{10} times. This performance is the reason why FRAM RFID can offer the feature of large capacity memory as a data carrier.

The most significant advantage of the RFID with the feature of large capacity memory and fast writing is to record data in the memory itself, which enables to change the data handling from centralized data management to decentralized data management. In many cases, the conventional E^2PROM based RFID is mainly adopted for the centralized management in which the data is stored in server side and related with tag's own unique ID. On the other hand, FRAM RFID can realize the decentralized data management, in which the data is stored in the tag itself, and lightens the load of the servers. This is especially suitable for fabrication history management in the FA (Factory Automation) fields, where frequent writing is required during the several hundred of processes, and also for maintenance field where it is required for on-site data confirmation such as repairing history and parts information without asking data server.

Another key feature is that FRAM is overwhelming to E^2PROM in terms of radiation resistance. For example, in case of gamma-ray sterilization process conducted for medical instruments and packages, food, or linen, the data stored in the E^2PROM is strongly affected by radiation because of the data storage mechanism with electron charge. In contrast, the data stored in FRAM is confirmed to survive even under the irradiation level of 45kGy (gray).

Figure 1 shows the example applications that can be adopted by FRAM RFID

Built-in Serial Interface on RFID LSI

Built-in serial interface has now implemented to FRAM RFID LSI, and it provides additional function to RFID as a data carrier. The main feature is that the same FRAM memory area can be accessed from both serial interface and RF interface.

By connecting with a microcontroller (hereafter referred to as a MCU) through the serial interface, FRAM can be treated as an external memory for the MCU, while can be accessed through RF interface. As a consequence, it is possible for RFID reader to read the stored data written by the MCU, and on the other hand for the MCU to read the parameter data such as operating conditions written through RF interface.

For example, if we imagine that a sensor is connected to the MCU, it should be possible to treat the RFID as kinds of sensor tag. In this case, MCU regularly monitors sensor data and writes into the FRAM memory, then later the accumulated traceability data is read through RF interface. Also it should be possible to treat the RFID as parameter recorded memory for MCU. In this case, MCU refers to some parameter stored in the specific memory area where the data can be changed through RF interface, and then MCU changes for example the interval to get sensor data or the condition to flash LED for kinds of notification. Regarding the combination between RFID and the sensor, Active tag is also well known solution. But Active tag is one-way communication from the tag, and it dose not have data memory which can be read out later by RF reader. Therefore Active tag cannot be used for traceability purpose as data carrier.

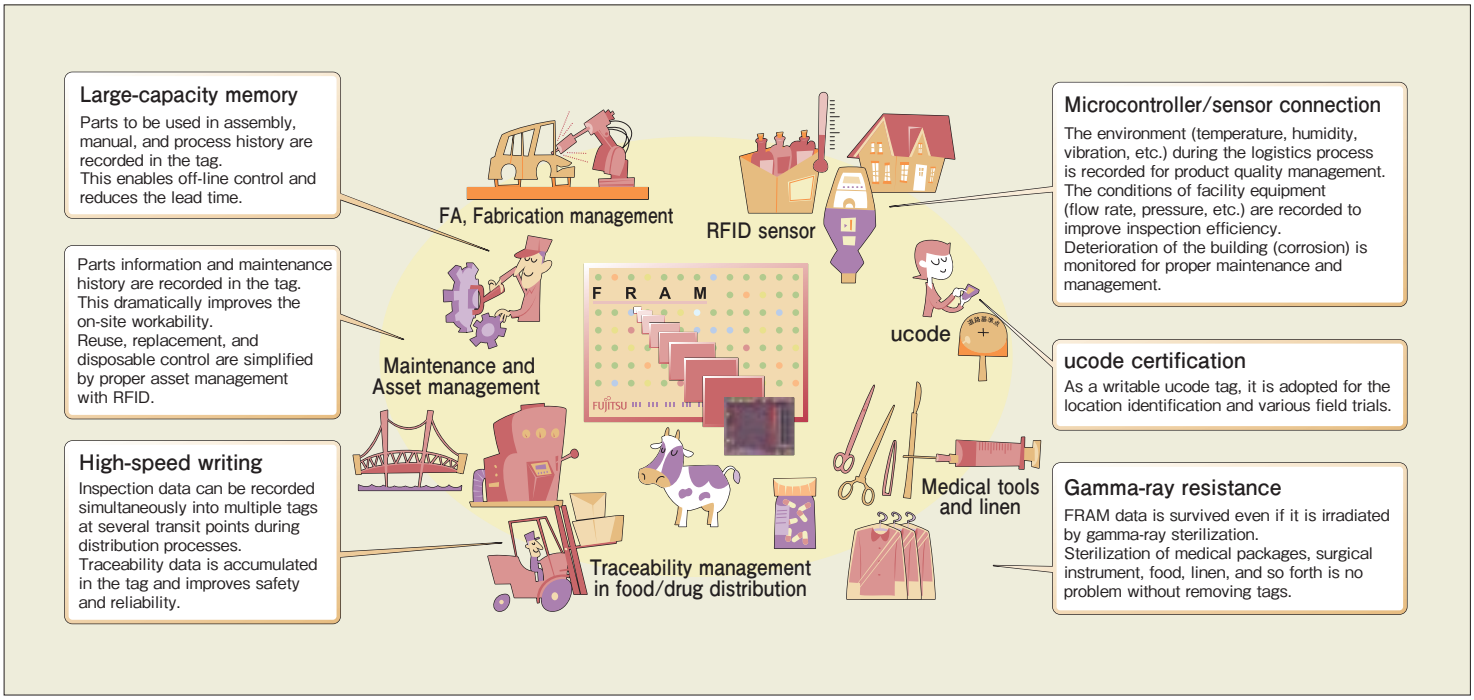
On the other hand, FRAM RFID has capability to record traceability data to be read out later because of large capacity memory, which enables to record data through serial interface when the tag is not in the RF fields.

In addition to sensor applications, built-in serial interface feature theoretically makes it possible for RFID to connect with various kinds of applications, if they're controlled by MCU.

Practical applications might be the status monitoring of facility and equipment in the plant (e.g. pressure, flow meter, etc.), or the history data record for game machine, healthcare instrument, and so forth. As already known, some of those applications have already been realized with existing technology like contactless smartcard, and some of them may not meet their requirement with our specification in terms of memory capacity, transmission speed, and so forth.

However, we're expecting that this technology will help to find new RFID usage and applications, and will be used for further examination to realize various ideas.

Figure 1 Example Applications of FRAM RFID



Discussion about Serial Interface Usage

Through the feedback from customers so far, we recognize something to be considered regarding the usage of serial interface connection. One issue is relating with battery, and the other issue is communication distance.

RF data transmission is established by passive communication, which means that the power is provided from reader/writer. Hence the serial data transmission requires external battery. Battery issue is a common issue with Active tag and in fact our technology is sometimes misunderstood as Active tag. But anyway, the lifetime of battery is issue to be considered.

From this point, the serial interface feature is the most suitable for the embedded applications in the machines or instruments, where stable power is always provided. However if the tag is firmly assembled and attached to some assets or objects to be moved, battery management would become an issue, because the battery cannot be replaced when it is the end of life.

It is thus important to estimate the battery lifetime based on the usage condition, and consider some rechargeable mechanism such as rechargeable battery or battery generation with some energy. Ideally it must be good if the power is generated during RF communication. However, it is not realistic because the communication distance would be seriously deteriorated.

In regard to the communication distance, it is well known that impedance matching is extremely important for UHF and it determines the communication performance. Therefore it must be considered that the impedance matching is heavily affected by connecting various LSIs and devices through the serial interface, and also by being assembled on the board. From the points above, antenna design may become more complex compared to the conventional RFID tags when the serial interface is used.

Future Developments

As RFID stands for Radio Frequency IDentification, RFID was originally used as ID storage read by RFID reader. FUJITSU SEMICONDUCTOR adapted FRAM for RFID, and realized the data carrier tag with large capacity memory because of its fast writing and high write endurance. And now built-in serial interface on RFID added a new feature, which enables to record traceability data from sensor and so forth via MCU even if it is not in the RF fields, and read them out by RF later.

Although several issues have to be solved for the practical use, we'd like customers to evaluate this feature with samples in order to find some new possibilities. Throughout the evaluation and the discussion with customers, we would improve the issues on the coming LSI specification. In addition, we have lineup of MCU products to be connected with RFID and we'd like customers to consider adopting them as well. *