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# RFID Based System Usage in Process of Liquid Product Tracking

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***Abstract*—Primary aim of this paper is to present the concept to which it is possible to provide traceability of liquid products (fruit juices) which should result in increase of their quality and enhance the competitiveness of final products. Beside the requirements of the state customs regarding fulfillment of the regulations on food safety this concept emphasizes the ability to made information about the products to the customers available, as the most important in this chain. The question is how to achieve full traceability of agricultural products in the appropriate places starting with grow all the way to the sales point. This paper proposes the concept of application of RFID based system in an effort to achieve this goal. As an example of products to show this model, the paper will use fruit juices transported in aseptic bags.**

***Keywords*—Radio frequency identification (RFID), traceability, quality control, sensors, perishable food products**

## I. INTRODUCTION

The requirements of today's market are dramatically changed in the past decade and caused by the development of modern technology have become stricter and more complex to implement. We have witnessed in recent decades the trend of health care and attention is paid to the food quality and is becoming a major factor in the customer's choice by the product purchase. This is especially important when it comes to food products which are the subject to strict regulations and requirements. There are many challenges associated with providing food safely and with high quality to the market. This is especially true for perishable food products with short shelf lives that need temperature-controlled food supply chains (FSC), e.g. fresh fish and processed meat products [1]. Traceability should provide exactly that guarantee of the quality of products in order to protect customers as the end users of the product. Technology that provides us with this possibility is RFID technology. Within this work will be exhibited a new approaches of possible solutions of the problem by integrating RFID transmitter directly into a bottle or other types of the package of the fruit juice in order to measure and collect all the data required for the quality guarantee. Today customs requirements and regulations are strictly defining conditions under which goods may be imported or exported. However, for the fulfilment of these conditions it is not enough to have written confirmation of the exporter but the goods are often subject to laboratory tests which leads to delays in deliveries and hence problems in the processing. Example of this is fruit juice concentrate which is the imported by the factory for production and processing in aseptic bags which keeps the quality of the content. For a sampling of such materials by the customs authorities an aseptic bag of every kind of concentrate is opened and a sample is sent for the laboratory testing. In this way, further use of these packages is not possible and thus apply the financial loss for the processors. Bearing in mind that the raw material for the production of fruit juices i.e. packed in bags no less than 50kg is easy to come to a conclusion what are the losses of the company that imported fruit concentrate [2].

## II. RFID TECHNOLOGY

Technology based on radio frequency identification (RFID) is a very effective tool in the process of monitoring and digital processing in food production. RFID is a system for automated data acquisition based on tagging items.

The tags contain transponders that emit messages readable by specialized RFID readers. Most RFID tags store some sort of identification number (e.g. product / customer number), based on which reader can retrieve information about the ID number from a database, and acts upon it accordingly [3] (Fig. 1.). This allows collection and wireless (radio wave) transfer of production- and business-related data.

On the one hand, RFID systems can be based on active or passive tags. Active RFID tags are equipped with self-powered or battery on the tag, while passive tags are read with the help of the electric field generated by the reader (antenna).

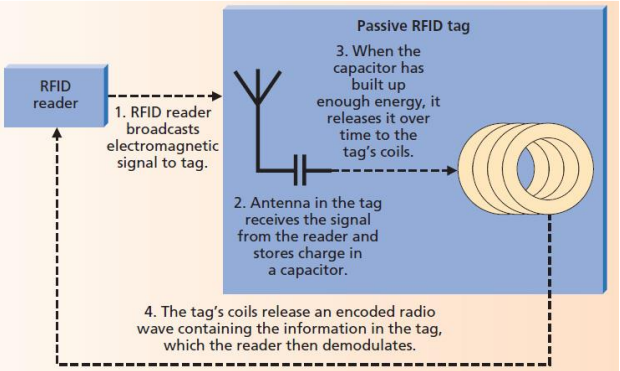


Figure. 1: Simplified view of data transfer in low-frequency passive RFID tags [3]

On the other, RFID systems are designed to operate on different frequencies depending on what we want to read and in what condition reading will be done. On this basis it was made the division of the RFID system [4]:

- Low frequency (Low Frequency) 125 KHz,
- High frequency (High frequency) 13,56 MHz,
- Ultra high frequency (Ultra High Frequency) 860-960 MHz, and
- Microwave (Microwave) 2.45 GHz

Each of these systems provides benefits to certain requirements of the distance at which it is possible to perform sensing sampling rate and the size of the tag. When it comes to tracking individual product best characteristics are shown in the ultra-high frequency (UHF) systems because the tag can be read from a distance of 3 to 10 meters, offering the possibility of cheap installation in processes such as monitoring product on pallets [5]. An important feature of this system is the ability to read multiple RFID tags simultaneously.

RFID technology is an innovative but still under-utilized technology that offers a wide range of possibilities. It allows real-time identification, during delivery, storage, or any other process taking place within an enterprise. Using RFID technology, it is possible to track products and equipment, with minimum human intervention. This can potentially cut back operating costs and increase real-time visibility during complete product life cycle [6].

Monitoring the production process with the help of this technology enables all the collected data being automatically imported into the database without the mediation of communication, avoiding the human factor in these processes. Besides the obvious benefits of using RFID technology, which are reflected in the competitive advantage of companies which have undergone such a process of monitoring production, increasingly, the producers put conditions on the detailed monitoring of origin and production process, with a goal of providing safe food and placing products on the market .

Recent developments in technology offer new features now achievable. These include: advanced data handling systems based on RFID and WSN (wireless sensor networks), precise and informed crop management, operational and recording systems arising from the concept of 'Precision agriculture', the availability of transport information management and decision support systems [7].

## III. POLICY REQUIREMENTS

Global food safety policies have been created and adopted all over the World, with particular incidence in the EU and the USA, as a consequence of several food incidents and scandals. According to the actual regulation in the EU, traceability is required in all stages of the supply chain, covering all food and feed as well as business operators [7].

A food business operator must register and keep information such as: (1) name, address of supplier, nature of products which were supplied from him, also, (2) name, address of customer, nature of products that were delivered to that customer and (3) date of transaction/delivery. Also, there is additional information which is highly recommended to be kept: volume or quantity, batch number and a more detailed description of the product. Unless specific provisions for further traceability exist, the requirement for traceability is limited to ensuring that businesses are at least able to identify the immediate supplier of a product as well as immediate subsequent recipient, with the exemption of retailers to final consumers [8].

As in the same way as the aforementioned EU regulation, in the USA, the Bioterrorism Act 2002 calls for one-up/one-down traceability for each link in the supply chain. This regulation requires that each company in the supply chain keeps information about the company that they received the products from, the company who delivered the product to them, the company who took it away, and the company they gave the products to [9].

ISO (International Standards Organization) ISO/DIS 22005, focus on the same approach to traceability (''one-step-up/one-step-down", giving the principles and specifies the basic requirements for the design and implementation of a feed and food traceability system (ISO 22005, 2007).

## IV. PROBLEM

Food safety is obviously a major issue in the food system, especially for fresh foods, which are characterized by their perishable and temperature-sensitive nature. The quality and safety of such foods decrease over time and are affected by temperature, causing difficulty in preservation in supply chains [10].

After an extensive review of many studies, [11] concluded that food traceability should be considered as an important and integral part of logistics management, so the information is stored on the go and it can be retrieved at any moment. The term intelligent food logistics is becoming and important topic about food chain, meantime,

intelligent food logistics are called to reduce the perishable waste along the food supply chain by means of reduction of the deviation from the optimal cold chain, to do that it is necessary to quantify these deviations, making shelf life variation know and remote monitoring [12].

Perishable food products have to be maintained in optimum temperature and relative humidity in order to keep optimum freshness. Nonetheless, it is very common that these controlled measures cannot be maintained for the journey duration especially in places such as seaports or transitions in airports, where the containers can be exposed to adverse conditions during long periods of time. The distance and mode of transport also presents product stability challenges. The most common long distance transport modality are covered by sea and air across the globe however when produce arrives at ports and airports they are transported via a network of 4 million food transport vehicles [13].

The 2008 Manufacturers Association (GMA) and the Food Marketing Institute (FMI) Unsaleable Report on perishable food items estimates that the total 'unsaleable products' increases to about $3–5 Billion in 2010. While the reason for unsaleable could be anything from package design to the handling of products in supply chains, in perishable food supply chains, unsaleable are primarily due to damage or deterioration below acceptable levels, expiration, or discontinuation. Such unsaleable items are immediately taken out of distribution channels. Every reasonable attempt is made to keep the amount of unsaleable to a minimum. However, when unsaleable are present, there is uncertainty on the exact party (e.g., retailer, distributor) that is responsible for those unsaleable and who should be reimbursed (e.g., based on examination of unsaleable collected at retail reclamation centers) or who should be compensated by whom with an up-front payment to cover unanticipated unsaleable [14].

Quality problems should be detected as quickly as possible, and alarms should be triggered when temperature gradients cross a threshold [15].

## V. RESULTS

The main elements of the solution proposed are illustrated in Figure 2. below. The key ideas are:

- To equip each container with an integrated circuit (IC) comprising the usual elements of an RFID tag and transmitter, along with a set of sensors for monitoring general and specific parameters. For example, a fairly simple temperature sensor can indicate whether the temperature of the IC (thus of the container) was maintained within a set range; a pressure sensor can flag the apparition of gas-generating biological process such as fermentation; more complex sensor can monitor the apparition/concentration of chemical and biological agents [16]. These data will be recorded by the RF tag and be available for inspection through the integrated radio transceiver
- The IC should be placed within the lid/cap/plug of the container, with a mechanical implement that disables the chip once the container is opened.
- Other security measures should be considered for preventing the improper use of the tag: for example, the electronic signature of the sender can be stored within the RF tag, to prevent misrepresentations. The IC can also produce an encrypted report, which only the sender is able to read.

The producer of perishable goods such as fruit concentrates will buy a blank RFID tag equipped with the suitable set of sensors, will record the origin-related data for traceability and its own (public) electronic signature; the producer will also set a password, which will be used by the system to generate the encrypted report, readable only by the producer. The IC will be then incorporated in the cap/lid that seals the container (Figure 3.). The transport company will read the RFID data when taking responsibility of the container, and verify that the sensors indicate no issues with the content. The status of the content can be assessed on arrival to its destination without un-sealing the container; if problems are detected the receiver will inform the sender by forwarding it the encrypted report read from the RFID tag. Routine customs inspections can also be done by simply reading the RFID tag – possibly provided with specific security features.

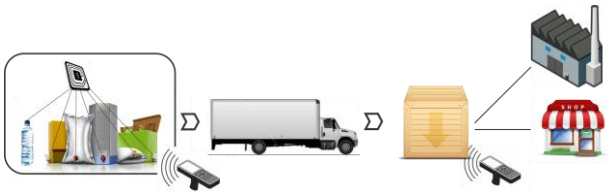

Figure. 2: Possible solution of integration of RFID and sensors

IC that can be used in this case is based on ROHM Semiconductor BM1383AGLV Pressure Sensor IC which is piezo-resistive pressure sensor that offer temperature compensation for MEMS inside chip, allowing pressure information to be easily obtained. The BM1383AGLV Sensor features a piezo-resistive pressure sensor and has a 300hPa to 1100hPa pressure range with ±0.12hPA (typ) relative pressure accuracy and ±1hPA (typ) absolute pressure accuracy. Typical applications include smartphones, healthcare, and mobile devices [17].

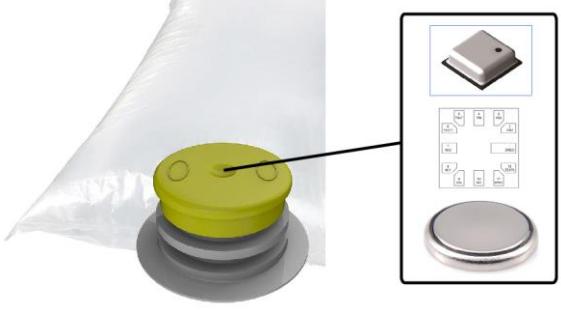

Figure. 3: Suggested container lid IC integration

## VI. CONCLUSIONS

Globalization of food production influences the structure of food supply chains. This impact is mainly reflected in the increasing complexity of food supply chains and in raising distance to which food is transported on its way to consumers, which has a negative impact on the environment, food quality and sustainability of food production.

Discussed problem especially impacts shipping of perishable goods, contents than can be spoiled and/or otherwise diminished by opening the container outside a protected environment. We identified key elements and proposed overall design of a solution. The research mainly focused on liquids used in the food industry, such as fruit concentrates, but the concepts presented here can be applied to a wide range of perishable goods that are to be shipped in strictly-controlled conditions. A model is presented in which the RFID-based system and pressure and temperature sensors are integrated into the lid of a packaging (mostly aseptic bags in which concentrates for the production of juices are transported). When fully developed, the solution can be useful for numerous situations, from routine customs inspections to robust transfer procedures between a producer and its end customer, and thus bring significant savings, improvements in food safety, and supply chain management. Further research will be oriented towards realization of system and testing in different real-life settings.

## ACKNOWLEDGMENT

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