Capacitive Humidity Sensor Tag Smart Refrigerator System using the Capacitive to Voltage Converter (CVC)

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Abstract

Recently, interesting about RFID sensor tag technology which can obtain information on the external environment to smart card is increasing worldwide. In case of sensor tag, most of sensor tag has been developed as resistive type sensor tags. Resistive type humidity sensor requires temperature revision as the influence of temperature and there are special environment to detect low humidity of 15% or less. To solve this problem, circuit was composed that capacitive sensor is interlocked to resistive type sensor tag. The composed circuit is a capacitive humidity sensor which is connected to resistive sensor tags. Using the CVC circuit, capacitive humidity sensor change is output voltage. The output voltage connects with resistive sensor tag. Implemented system's sensor value storage or real time monitoring experiment result was able to determine the usefulness. Also, developed humidity sensor tag is applied to the smart refrigerator.

Keywords: *Capacitive sensor, Capacitive to Voltage Converter, RFID, Reader, Sensor tag, Humidity sensor*

1. Introduction

Recently, interest in RFID technology is growing globally. Beginning with distribution logistics, research which apply to RFID has been developed in various fields like military, environmental, medical, aerospace, IT etc and will be future's the key of ubiquitous computing elements.

Like smart cards, RFID technology distinguishes automatically information which specific media is containing and can be used variously with the purpose of data collection. In particular, add sensor which can acquire information of the external environment to smart card, RFID sensor tag which not only senses the tag information but also has the capabilities to sense temperature, humidity, pressure, PH and information of surroundings has been developed. Montalbano Co.(社) began to commercialize a credit card-shaped MT smart RFID tag recently. MT smart RFID tag can be applied to all items in the box as well as spherical surface of the goods. Also, that stores information about impact of fragile items such as works of art in the weak shock, explosives and vintage wines and stores information of the humidity at the same time.

RFID sensor tag can be used to attach to the highly agricultural and marine products, pharmaceutical, beverage and art works etc. This is the thing that when we uncover the cap of these goods like drink, drug and so on or open the wrapping paper of the artworks and agro-

fishery products, use the change of attached sensor's resistance. This is can be applied in various security management fields like whether the authenticity and luxury goods, safety management, falsify test and so on. Also, this suggested a system which can process them. But, sensor tag which was being developed until today has largely used a resistive sensor. Resistive sensor consists of temperature, humidity, pressure, optical sensors etc. and capacitive sensor beside resistive sensor has the sensor of humidity, speed, acoustic displacement and so on. For example, resistive humidity sensor has a feature which can compose circuit simply. But, resistive humidity sensor needs temperature compensation because it is affected temperature and low humidity of less than 15% (rh) is difficult to be detected because it needs high resistance. Capacitive humidity sensor has the higher sensitivity of the sensor than resistive humidity sensor. And it has excellent reliability and low hysteresis when compared with resistive humidity sensor.

In this paper, when we carry humidity-sensitive goods such as stringed instruments, ginseng, chemicals, etc. We materialize a system so that checking the humidity information in real time. Also, we solve the problem of restrictive conditions by using a capacitive sensor which has more outstanding characteristics than resistive sensor to get precise information. And we propose materialization about capacitive humidity sensors and interface circuit (Capacitor to Voltage Converter) for interlocking of sensor tag. After store information of capacitive sensor in sensor tag through materialized CVC, we apply information of sensor to system which cans information monitoring in real time through Readers.

The remainder of this paper is organized as follows. Section 2 describes the capacitive sensor tag system and the characteristics of sensor, tag and reader. Section 3 describes proposed CVC interface circuit. Section 4 presents simulation and experiment on proposed CVC interface circuit. Section 5 presents sensor tag smart refrigerator system application. Section 6 presents some conclusions.

2. Proposed Capacitive Sensor Tag System

The Figure 1 shows system a developed's block diagram. After set the sensing time and number that you want on your PC, pass them through RFID reader. RFID reader passes a command with 13.56Mhz of the wireless. And operate a sensor through passed command.

In such a sensor, those vary the value of capacitor and convert the value into the value of voltage through the CVC. After RFID tag convert the value of voltage into data, store them in memory or send data to RFID reader. RFID reader can measure information as send data to PC again.

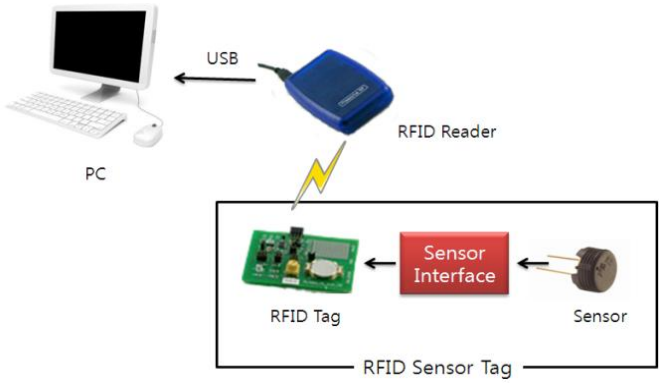

Figure 1. Capacitive Sensor Tag System

2.1. Humidity Sensor (HS1101LF)

Capacitive devices are often preferred since they offer very low power consumption and a linear output response. HS1101LF lower than resistive humidity sensor be measured humidity. The variation of humidity appear linearity shown in Figure 3.

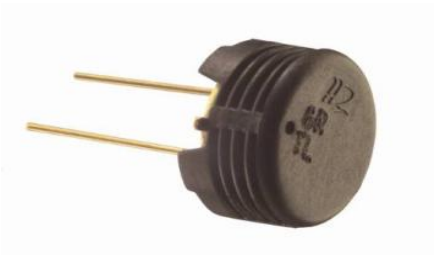

Figure 2. Humidity Sensor

Characteristics of humidity sensor are shown in Table 1.

Table 1. Characteristics of humidity sensor

Characteristics	Value	Unit
Humidity Measuring Range	0 to 100	% (RH)
supply Voltage	10(Max)	V
Nominal capacitance @55%RH	177 to 183	pF
Operation Temperature	-60 to 140	°C
Average Sensitivity from 33% to 75%RH	0.31	pF/%RH

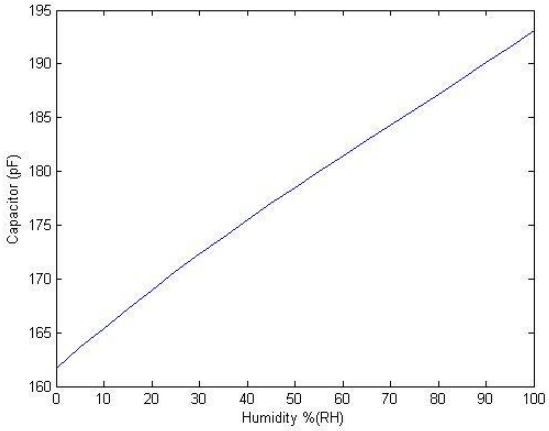

Figure 3. Humidity Sensor Response

2.2. RFID Reader

Proxima RF to develop a compatible RFID reader. An off the shelf Proxima RF USB Desktop Reader. Communications between the reader and the tag use amplitude shift keying

(ASK) modulation in accordance with ISO15693. Data rate per ISO15693 is 36 Kbps. Reader has an internal antenna, and receives power from the USB connection to a PC. The RFID reader is the source of RF energy for the RFID sensor tag. The read/write tag harvests energy from the HF RFID reader and supplies a regulated voltage to the other components in the embedded sensing node.

The receiving antenna influences the read range. Most desktop RFID readers have an internal antenna with limited power and thus a short read range. the desktop reader achieves a transmission range of 2.5 cm to 5 cm, depending on the antenna design. RFID reader is shown in Figure 4.

Figure 1. RFID Reader

2.3. RFID Tag

The EVB90129 is an assembled printed circuit board that simplifies evaluation of the MLX90129 sensor tag IC and to facilitate the development of wireless sensor applications based on the MLX90129. The board can be powered either by an external voltage supply, the on-board battery or the electromagnetic field from a RFID reader. The EVB90129 is capable of storing 128 Kbit of data's in the SPI EEPROM memory connected to the MLX90129. The user prototyping area allows users to integrate their own sensor or circuit into this evaluation board.

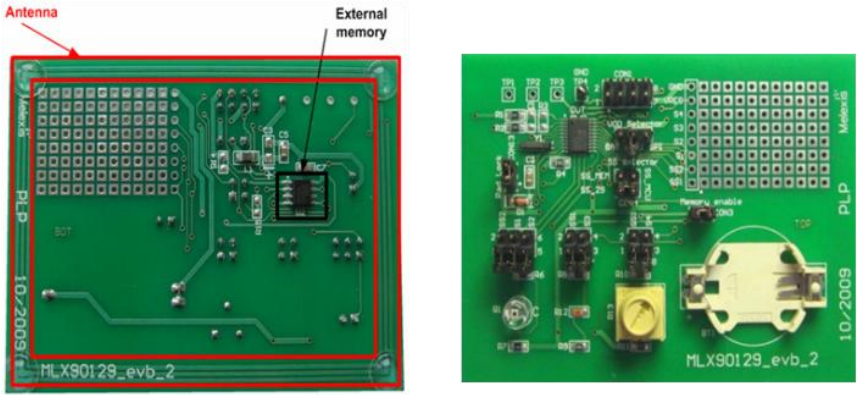

Figure 2. RFID Tag (EVB90129)

3. Proposed CVC Interface Circuit

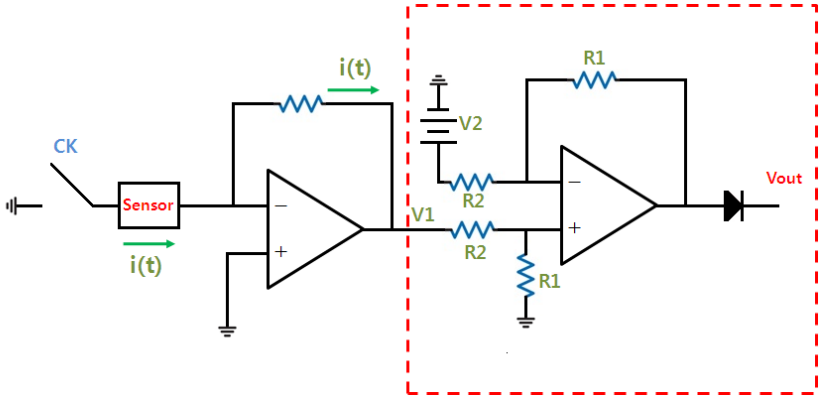

Figure 3. Proposed CVC Interface Circuit

With the variation of humidity, sensor change capacity value as shown Figure 6. The proposed interface circuit uses a differentiator. Currents in Figure 6 same Eq. 1

$$i(t) = C\frac{dv_i(t)}{dt} \quad (1)$$

DC does not flow. Because capacitive sensors same capacitor characteristic. Using the CK switch make pulse in Figure 6. Pulse is cause of the charging and discharging of the sensor. Changes in humidity alter the size of the capacitors. Virtual ground is 0V, the output value in Eq. 2.

$$V_{out}(t) = -R_i(t) = -RC\frac{dv_i(t)}{dt} \quad (2)$$

According Capacitive sensor(C) alteration knows Vout change. Differentiator pass voltage value which is lower than sensor tag input voltage, and capacitive alteration affect to ensure the linearity problem. In order to solve these problems, the differential amplifier as shown in Figure 6 was used. Differential amplifier's output value observed in Eq. 3.

$$V_{out}(t) = \frac{R1}{R2}(V1 - V2) \quad (3)$$

Using a differential amplifier is depended by the size of R1/R2. The variation of sensor linearity is ensured by amplifying variation of voltage. Also, Sensor tag require voltage that shift through differential amplifier (V1-V2). We use diode to remove positive wave in Vout location.

4. Simulation and Experiment

4.1. Simulation

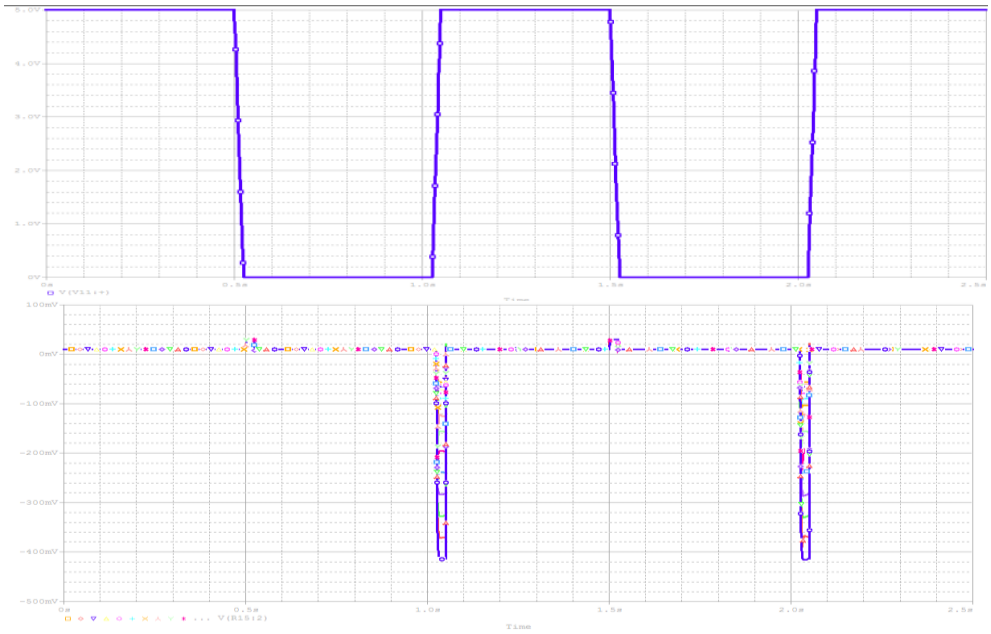

Figure 4. Simulation Input and Output

Using the clock switch input voltage create pulse as shown in Figure 7. Pulse pass differentiator and difference amplifier as shown in Figure 7. Humidity sensor discharge when CK change from low to high. And the variation of humidity sensor capacities confirm increasingly output wave.

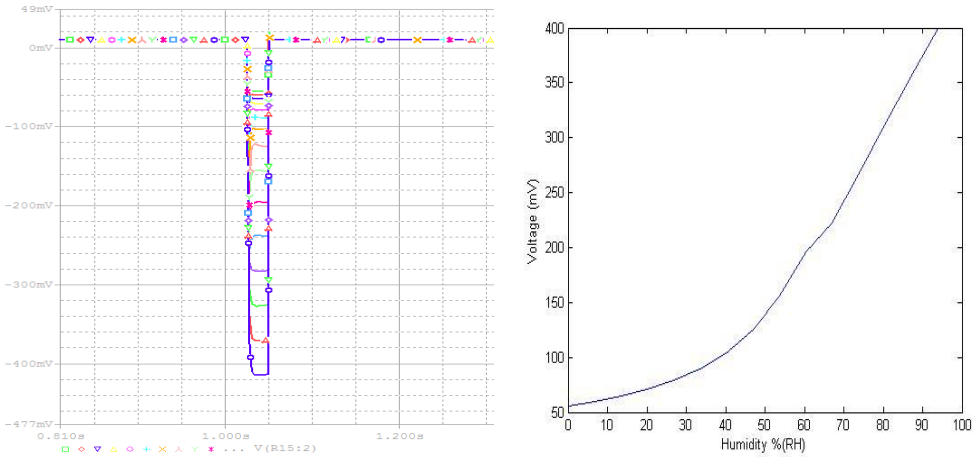

Figure 5. Output Wave and Output Graph

Results of the simulation are shown in Figure 8. The variation humidity (0~100%) alter variation of capacitors (160pF ~ 193pF). These changes are based on the output voltage is changing gradually as 50mV ~ 400mV.

4.2. Experiment

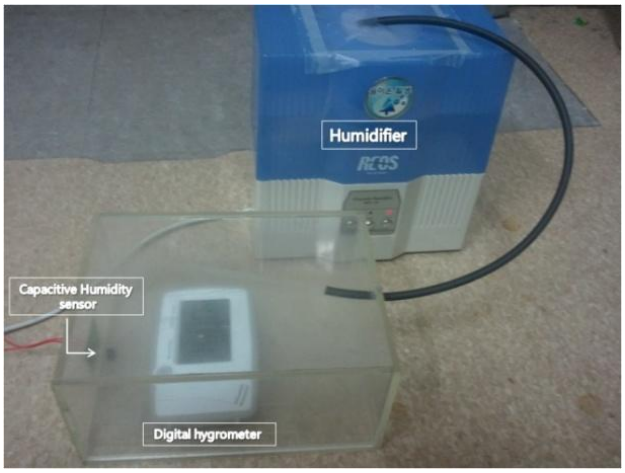

Figure 6. Experimental Environment

To measure various output voltage by variation humidity, we make a experimental environment which is shown in Figure 9. Humidifier regulates humidity in the enclosed space, and digital hygrometer measure humidity in the enclosed space. Oscilloscope measure output voltage through the measured humidity.

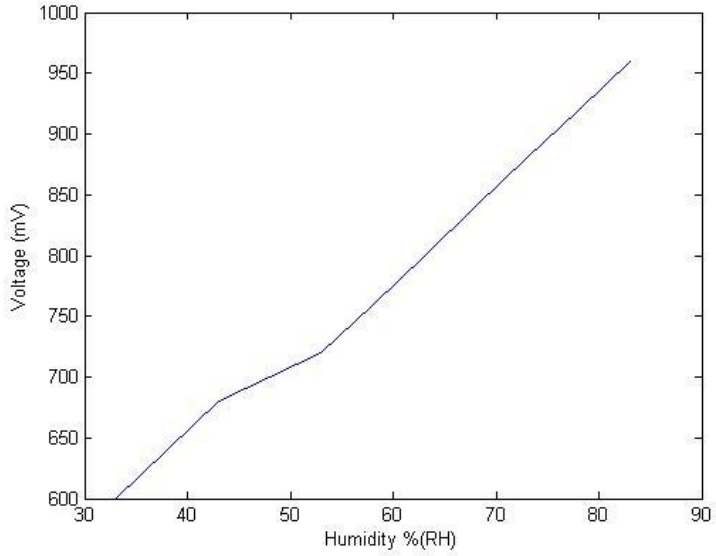

Figure 7. Experimental Output Graph

Temperature of 25 degrees, humidity 33% environment began experimenting. Also, composed experimental more than 83 percent weren't able to maintain humidity. Therefore, between 33-83% humidity was measured according to the variation of voltage. When humidity is 5%(RH) increase, voltage appears variation of 40mV. As a result, variation of humidity changes linearly voltage as shown in Figure 10.

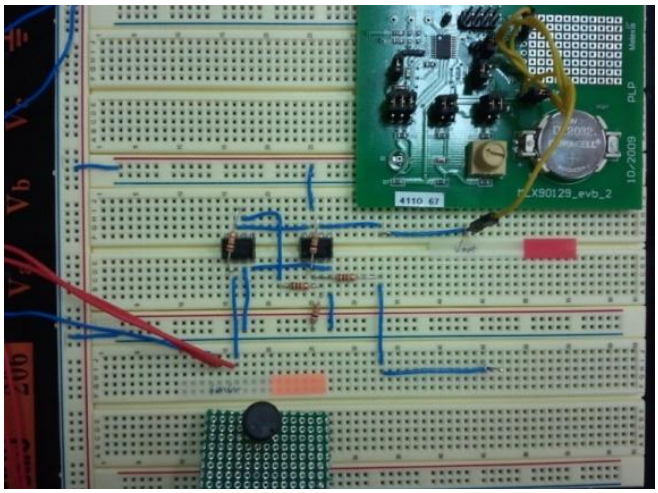

Figure 8. Sensor Tag Interface Circuit

As shown in Figure 11, proposal circuit was connected to a sensor tag. Variation input voltage of sensor tag as the humidity changes. Input voltage is stored in sensor tag memory through MLX 90129 chip in ADC and amplifier. And after RFID reader read humidity information, this is transferred to a PC. The information sent can be monitored in real time or save files through programs as shown in Figure 12.

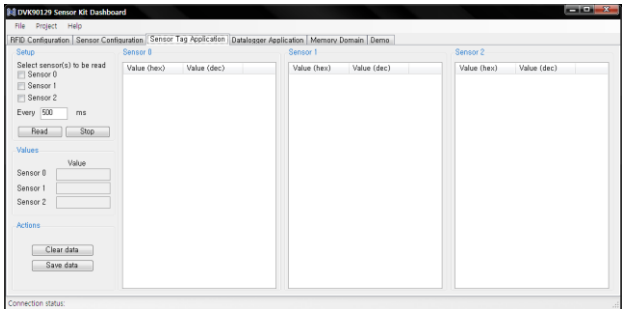

Figure 9. Test Program

5. Humidity Sensor Tag Application

In this paper, humidity sensor tag used to smart refrigerator. And, also combination of smart refrigerator and humidity sensor tag attached on container can be integrated into one system. If you use electric resistance sensor, sensor temperature compensation is required. Also, low moisture foods is impossible to measure the electric resistance sensor. To solve these problems, proposed sensor tags are applied to the smart refrigerator system. Proposed smart refrigerator is shown in Figure 14. Humidity sensors tag are attached inside the container. We can put vegetables, fruit, fish, meat in container. Container should be kept in the refrigerator. RFID reader is attached to the refrigerator interior. RFID reader inside the container will acquire humidity information. A external screen of refrigerator is shown in Figure 13. Using the external screen enter types food and amount of food. Food status measured in using the first moisture and the food information. Using changes in moisture, freshness to check real-time. Also, after checking the location of food, you can adjust the temperature to food location. Temperature control can affect energy savings.

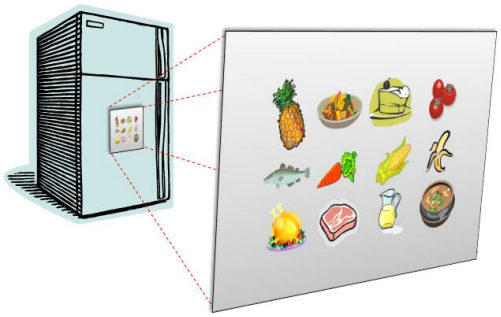

Figure 13. Refrigerator Screen

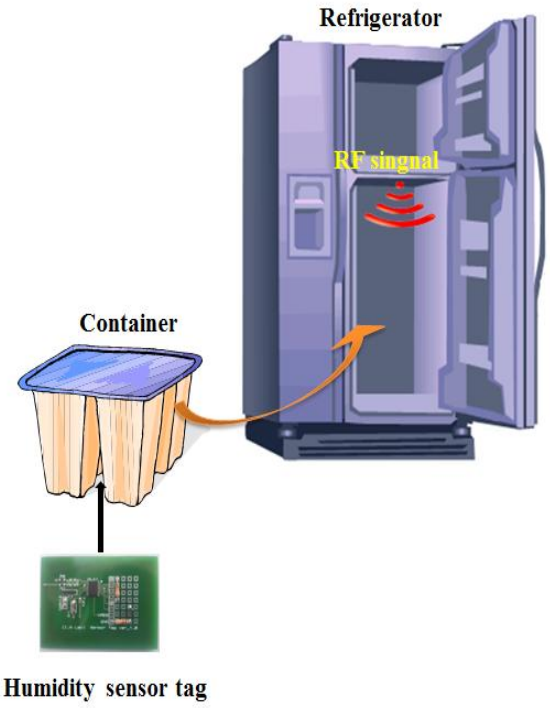

Figure 14. Smart Refrigerator System

6. Conclusion

In this paper, resistive humidity sensors are affected by the temperature and low humidity which is difficult to be detected. To overcome this restrictive environment, using capacitive humidity sensor to built monitoring system. Propose circuit that is capacitive humidity sensors connects resistive sensor tags. Using the CVC circuit, capacitive humidity sensor change output voltage. The implemented system is connected the output voltage with resistive sensor tag. Implemented system's sensor value storage or real time monitoring experiment

result was able to determine the usefulness. Also, developed humidity sensor tag is applied to the smart refrigerator.

To future research challenges, humidity sensor will increase sensitivity, small size, low power and tag security etc research. Also, system is connected pressure, speed, sound and other types of sensors not only humidity. And system will be used in various fields.

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