

Design and Development of an Automatic Swine Feeding Machine Cooperated with Radio Frequency Identification Technique

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Abstract

In this paper, an automatic swine feeding machine controlled by the radio frequency identification technique has preliminary been designed and developed. The developed system is, generally, consisted of two main parts: input unit and controlling unit, respectively. The former part is operated as the tag detection system and also the weighting system, while the latter has, consequently, been employed for the machine controlling. The system operation is, firstly, used to check the electronics tag status that is entered to the input unit. Consequently, the tag information (registered tag) has then been identified and displayed on a LCD device under controlled by a microcontroller unit (MCU). Moreover, the swine's weight achieved from the weighting system has also been detected and then displayed the weight value on the LCD. This data is, generally, used for controlling the machine to load the swine feeding. By investigating the 100 registered tags and 50 of non-registered tags over 20 times of repeatability, the corrected results of 100% can be exploited. Otherwise, the accuracy and precision of the weight detection system has also been investigated. By exploiting the swine's weight from the range of ~500 - 10,000 grams over 20 times, a percentage of accuracy and precision can thus be resulted of 99.27% and 98.3% respectively.

Keywords: Electronics tag, radio frequency identification technique, microcontroller, automatic feeding machine

Introduction

Nowadays, the world population has been increased. We could say that every 5 minutes more than 1,000 babies are born. Absolutely, the basic requirement of food is important. It might, therefore, be proportioned to the population number. Moreover, the quality of food is, however, a significant factor that has always been considered and improved by the producer due to reliability and trustworthiness to the consumers or wholesaler etc. Pork is an example of a raw material that is often used for making the favorite food. Thailand is the one of several countries that exports the pork to the international markets such as Hongkong, China, India, and Japan etc.¹ However, there is several conditions have thus been considered and cared before exporting i.e. pork's color, foot and mouth disease, and also parasite etc. To eliminate such problem, the swine's herdsman or the producer has to think over in every procedures of swine's nurtur-

ing. The using of technology might thus be an answer to solve those problems and also very helpful to the producer. The computer technology, Electrical & Electronic technology and also Mechanical technology are examples of the technology for reducing those effects. The radio frequency identification (RFID) technique is a type of the electronic technology that could thus be applied to use for the animal nurturing. Several publication papers of the technique have, consequently, been published in the recently years ago. For example, *Trevarthen et al*² uses the RFID technique for investigating and controlling the cow's weight at the cattle farm in Australia. Moreover, *Garfinkel*³ was described some concepts of the RFID theories and its applications in science technology and engineering fields. Several advantages of the technology can, generally, be exploited in terms of the reduction in production cost, labor number, production errors, and also improve the product quality, etc.

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In this paper, an automatic system based on RFID technique has preliminary been applied to operate in the swine's nurturing. The developed system has been composed of two main parts of as followed by hardware system and software system respectively. The first part is, however, divided into four sub-sections; reader/identification system, weighting system, controlling system, and feeding machine, while the latter part is, consequently, operated for two purposes; identification the tag's information, and indication the weight's information on a LCD device. The tag information is, generally, detected and data transferred by using a RFID reader. This data is then processed and displayed its information such as tag's name, weight, and time duration to control the feeding machine on the LCD device by using a microcontroller (MCU). Moreover, the MCU is also used to control a stepping motor that has been composed to the feeding machine for feeding or non-feeding. However, it might imply that the feed quantity is, normally, proportioned to the weight value that is measured by the weighting system. Finally, the aim of this work is obtaining an automatic system for the swine's feeding machine. It leads to the reduction of labor number in the swine's farm, capability to monitor the swine's health, and also improving the pork quality.

Briefs of RFID Technology

The radio frequency identification or called as "RFID" is a smart technology, which has been employed for identifying the object appearance. It was developed since 1980s for instead of the barcode system⁴. Basically, it consists of two parts: reader system and electronics tag, respectively. The electronic tags is, generally, produced in the forms of a smart card that some electronics data such as ID code, user name, registered status, has, directly, been recorded on the tag⁵. These data are, normally, demodulated and transferred to the reader system. Several advantages of the system over the barcode system are exploited in terms of non-contact device, simplify to operate and, capability to identify in multiple tags, high speed processing, small size, etc.⁶⁻⁷. Many applications, currently, use the technology for security system, product identifying, and animal monitoring etc.⁸

As mentioned before, the RFID system has been composed with the electronic tag and the reader system. In general, the tag would often be attached to the desired objects such as goods, animal body, and/or security card. This system is, currently, resembled to the barcode system. However, the advantages and disadvantages between the RFID technology and barcode system can thus be summarized in table 1.⁹

Table 1 Comparison details between barcode versus RFID system

Descriptions	Barcode system	RFID system
Demodulation technique	Image encoding technique	Radio frequency technique
Distance to demodulate	< 10 cm.	> 10 cm.
Number of target to demodulate	1 barcode / time	60 tags / time
Type of identification	Text and Numbers	Frequency
Visibility	Need direct line of sight to read	No need direct line of sight to read

In this work, the RFID system has been operated for the swine's feeding. The structure of RFID system can, basically, be shown in figure 1.

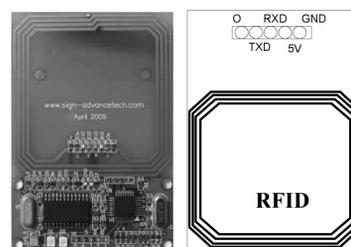


Figure 1 Structure of RFID reader system

There are four important signals has been required for the reader system that is followed by +Vcc, Gnd, TXD, and RXD respectively. The power requirement of the system is, generally, +5 volts, while the transmitted and received signals from the RFID tag are denoted as TXD, and RXD respectively. These signals are, normally, used for data interchanging between the RFID tag and

the reader system. If the tag is, however, registered into the database system, the tag information would be demodulated by the reader system.

dsPIC30F4011 Micro-controlling Unit

In this work, a dsPIC30F4011 microcontroller (MCU) fabricated by the *Microchip Inc.* has been employed for data transferring from the RFID tag to the reader system¹⁰. Moreover, it's also used for controlling a stepping motor to switch on/off a feeding machine. A brief of the MCU specification can thus be detailed as a 16 bits microprocessor, which has a digital signal processing inside. Consequently, it also consists of the 10 bits of analog to digital convertor (ADC) with a sampling frequency of 500 KS/s has been generated. Furthermore, there are six input/output ports (I/O) within the MCU part. In this work, a microcontroller embedded board “*model ET-BASE dsPIC30F4011*” has, preliminary, been used as a processing system. A structure of the board can, therefore, be illustrated in figure 2.

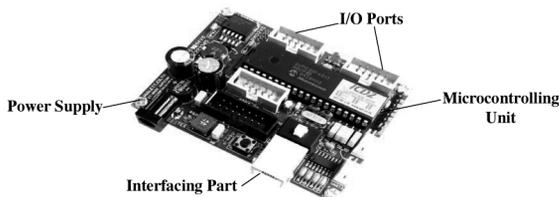


Figure2 ET-BASE dsPIC30F4011 microcontroller board used as processing unit

The advantages of the *dsPIC30F4011* microcontroller over the other MCU families such as MCS-51, ARM7, or FPGA are exploited in terms of low cost, easily to implement, build-in DSP module, and high speed clock etc.¹¹ However, the specification details and also the interfacing diagram would then be explained in the next section.

Experimental Setup

As mentioned above, the developed system can be classified into three main parts; input, processor and output sections respectively. The signal from the RFID tag is first scanned and demodulated by the reader system at the input section. This signal is then transferred to the

microcontroller section for checking and monitoring the tag status or information from the database system that is stored in the internal memory at the embedded system. Moreover, the sensing signals from a strain gauge (included in the weighting system), which its maximum amplitude has been amplified to 5 volts by a signal conditioning circuit, are also transferred to the MCU as input signal for demodulating the swine's weight. These signals; tag and sensing signals, have thus been data processed at the processing part and then send to the output part for controlling a stepping motor and also displaying the processed information on a LCD device. A diagram of the hardware system can be summarized in figure 3.

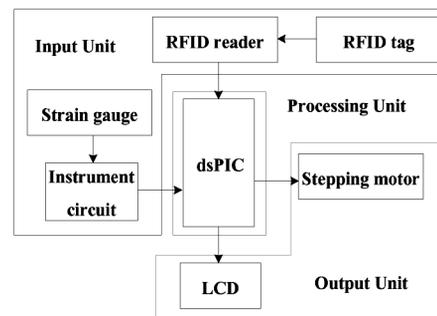


Figure3 A structural diagram of developed system in hardware section

An overview of the hardware section as mentioned above can, precisely, be illustrated the interfacing details between the micro-controlling unit and peripheral devices in figure 4.

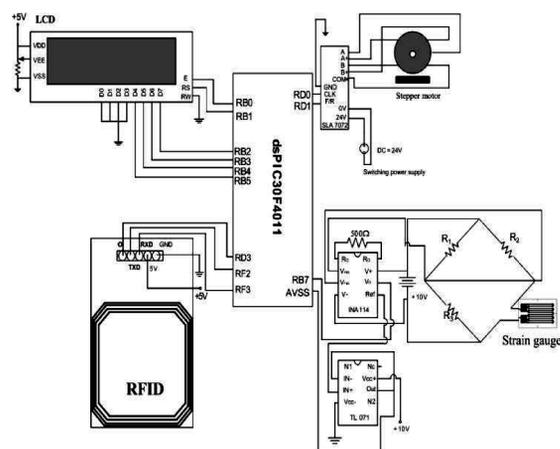


Figure 4 An interfacing diagram between MCU and peripheral devices of developed system

There are three interfacing pins; tag status, TXD and RXD, of the RFID reader have been used to connect to the microcontroller via the RD3, RF2, and RF1 ports. These ports have thus been operated for transmitting-receiving the serial data, and also transferring the tag information to the MCU section. Furthermore, the sensing signal from the input strain gauge after amplified by the instrumentation amplifier circuit has next been sent to the MCU via the RB7 port. This signal is then processed and used to control the stepping motor at the RD0 and RD1 ports respectively. In addition, the output signal would also be displayed at the LCD module via the RB0 – RB5 ports.

Moreover, an application program from C programming has, therefore, been developed as the controlling system. A flowchart of the developed program can thus be illustrated in figure 5. In preliminary process of the developed system, any tags which are supposed as the swine in the farm have, firstly, been registered their information, such as ID number, name, sex etc., into the database system. Consequently, the program is then checking the entered tag status that is scanned through the reader system. If the input tag is, however, found some information on the database system after scanning, the processing unit will demodulates the input data and then display the tag information on the LCD device. On the other hand, if the input tag is not registered, the developed program will send a message of "No tag registered" on the LCD device.

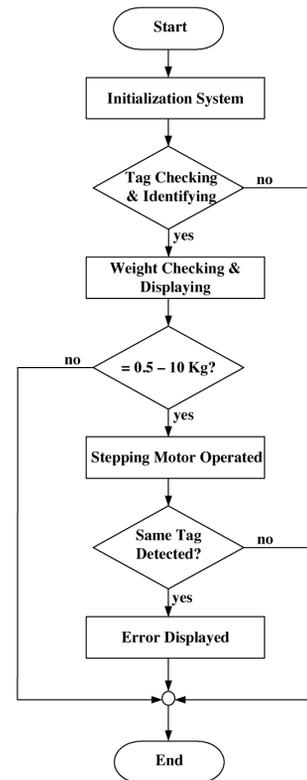


Figure 5 A flowchart of developed program

The weighting system is next operated for measuring the swine’s weight and then displayed the weight’s value on the LCD. Moreover, this value is next transferred to the microcontroller for generating a controlling signal to control the stepping motor. Consequently, the time duration to switch on/off the motor is also depending on the measured value.

Experimental Results and Discussions

The structure of developed system can be shown in figure 6.

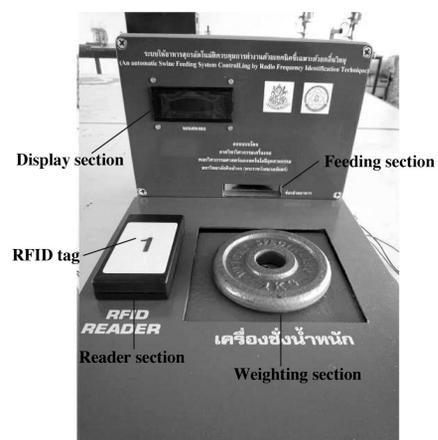


Figure 6 Structure of swine’s feeding machine

To verify the performance of the developed system, few experiments have been studied. The first experiment is testing the demodulation signals from the RFID reader. By using a hundred registered tags and fifty of the non-registered tags, which has thus been entered to the reader system over 20 times per each, we found that the automatic feeding machine can correctly identify all tags. This implies that the developed system has an accuracy of 100%. The output signal from the MCU can, consequently, be shown some results in figures 7.

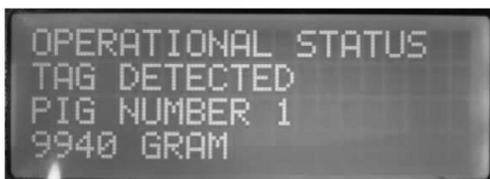
These results display the examples of three different tag statuses; no tag detected, no registered tag detected, and registered tag detected, respectively. In figure 7(a), the output message from the LCD module is displayed when there is no tag detected into the system, while figure 7(b) shows that there is a tag has been scanned into the developed system, but it is no data registered. Moreover, the output information (ID number and weight's value) as shown in figure 7(c) are indicated on the LCD, when there is a registered tag has been scanned into the system.



(a)



(b)



(c)

Figure 7 Experimental results for tag detection on LCD device (a) no tag detected, (b) with tag detected but without registered tag, and (c) with tag detected and with registered tag

The second experimental process is investigating the performance of weighting system. By using the weight's value from ~500 to 10,000 grams, the results over 20 times of repeatability can thus be summarized in table 2. We found that a maximum percentage error has been obtained of 3.64%, while a minimum error is 0.27% respectively. These caused to three important factors; un-stability of the strain gauge to obtain an exact value, conversional error, and gross error respectively. The un-stability error has been generated when the temperature, and also the environmental vibration changed, while the conversion error has, therefore, been exploited due to missed conversion of the ADC part for converting a small input analog signal to digital signal. For example, if the small significant value of input signal changed, it might not be changed to the digital output signal, leads to measurement error occurred. The last error effect is, normally, happened when the user has to be undisciplined to the measured system, and missing understand or unknown to the measurement system. Otherwise, an accuracy and precision of the experiment has also been investigated. From the results as summarized in table 2, we found that the weighting system has an accuracy of 99.27%, while a precision of the system is 98.3% respectively.

Table 2 Summary of weight investigation in range of ~500 - 10,000 grams over 20 times of repeatability

Average	Standard deviation	Error bar	% Error
509	25.95	18.56	3.64
1,003	15.18	10.86	1.08
2,025	45.24	32.36	1.60
3,016	30.57	21.86	0.72
4,056	61.09	43.70	1.07
5,042	36.14	25.85	0.51
5,952	42.51	30.41	0.51
7,014	56.36	40.32	0.57
7,972	42.99	30.75	0.38
9,025	38.25	27.36	0.30
9,976	37.81	27.05	0.27

In last experiment, the performance of controlling system has been studied. By dividing the weight condition into 2 levels; lower and upper levels, the controlling signal generated from the MCU has been used to switch on/off the stepping motor. However, the time duration to switch is, normally, corresponded to the feeding quantity. Moreover, it can be assumed that the lower level has a weight range of ~500 - 5,000 grams, while the latter are approximately 5,500 - 10,000 grams. In the experiment, we attempt to enter the input weight from ~500 to 10,000 grams into the weighting system and then measure the output signal from the feeding machine. We found that the feeding machine can, correctly, be switched on/off the stepping motor by relating to the input weight. This implies that there is no error occurred. It should, therefore, be emphasized that the controlling system has, excellently, be operated on the desired functions/procedures as the developed system needed.

Conclusion

An automatic swine's feeding machine cooperated with the RFID technique has been developed in this work. The system was consisted of three main parts; RFID reading system, weighting system and controlling system, respectively. The first part was employed for tag detection. The experimental results were shown that a 100% of the developed system has capability to detect the RFID tags in both statuses; registered and non-registered tags. In second part, the weighting system controlled by the microcontroller has consequently been investigated. By investigating the swine's weight in the range of ~500 - 10,000 grams over 20 times of repeatability, a minimum and maximum percentage error were obtained of 0.27% and 3.64% respectively. These lead to an accuracy and a precision of 99.27% and 98.3% achieved. The controlling system developed by the microcontroller cooperated with *C programming* was next studied. This part, in generally, was used to generate a controlling signal to control the stepping motor for the feeding machine. The signal was related to the tag information and also swine's weight. By investigating the 100 registered tags with the weight's range of ~500 - 10,000 grams over 20 times of repeat-

ability, a 100% of accuracy was exploited. This implies that the developed system has excellent performance and reliable for applying to operate in the real swine's farm.

Last but not least, the developed system have had three important factors to obtain the measurement error; unstable of the sensing signal due to low quality of the output signal from the strain gauge, gross error by the user, and also conversional error from the ADC part inside the micro-controlling unit, respectively. To improve or eliminate such problem, several factors such as environmental controlling, using of a signal conditioning circuit, comparing the measured data with the reference data from a commercial instrument, and also using of the weighting standard, have significantly been offered for operating to the system.

References

1. Centre for Agricultural information. Thailand foreign agricultural trade statistic 2009. Office of Agricultural Economics; 2009.
2. Trevarthen A, Michael K. The RFID-enabled dairy farm: towards total farm management. Proceeding of the 7th International Conference on Mobile Business; 2008 Jul 7-8; Barcelona, Spain; p. 1-10.
3. Garfinkel S. RFID: applications, security, and privacy. Addison-Wesley Professional; 2005.
4. Glover B. RFID essentials. O'Reilly Media; 2006.
5. Li D, Chen Y. Computer and Computing in Agriculture V. Springer; 2012.
6. Xu M. Managing strategic intelligence: technique and technologies. IGI Global; 2007.
7. Roper AT et al. Forecasting and management of technology. John Wiley & Sons Inc; 2011.
8. Hunt VD, Puglia A, Puglia M. RFID: a guide to radio frequency identification. John Wiley & Sons Inc; 2007.
9. Prakashan N. Emerging trends in information technology. Rachana Enterprises; 2007.
10. Boukas EK, Sunni FM. Mechatronic systems: analysis, design and implementation. Springer; 2011.
11. Wilmshurst T. Design embedded systems with PIC microcontroller: principles and applications. Elsevier Ltd; 2010.