Moisture content measurement in paddy

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Abstract. Moisture content is an important quantity for agriculture product especially in paddy. In principle, the moisture content can be measured by a gravimetric method which is a direct method. However, the gravimetric method is time consuming. There are indirect methods such as resistance and capacitance methods. In this work, we developed an indirect method based on a 555 integrate circuit timer. The moisture content sensor was capacitive parallel plates using the dielectric constant property of the moisture. The instrument generated the output frequency that depended on the capacitance of the sensor. We fitted a linear relation between periods and moisture contents. The calibrated equation has standard uncertainty of 1.23 % of moisture content in the range of 14 % to 20 %.

1. Introduction

Rice is an important agriculture product. In general, it is recommended that rice for food purposes be stored in paddy form rather than milled rice as the husk helps prevent quality deterioration and provides some protection against insects. To control the quality of paddy, moisture content plays a vital roll. Safe storage for longer period is possible if paddy is maintained at moisture levels of 14 % or less [1-3].

Moisture in paddy is defined as water in liquid state. To measure moisture content, there are direct methods and indirect methods [4]. Loss on drying of moisture is a direct method that can be used as a reference method [5]. The direct method provides high accuracy and high precission of the value of moisture content. However, this method is time consuming. Hence, some indirect methods such as resistance type [6] and capacitance type [7-8] instruments were developed.

The resistance type instruments have low accuracy because of pure water does not conduct electrical current. The moisture can conduct by some contaminated ions. The 555 integrate circuit timer were configured for a soil moisture meter based on resistance method [9].

The capacitance type instruments have higher accuracy because the dielectric constant that is an intrinsic property of the moisture is linear proportional to the capacitance. In this work, we used the 555 timer to develop a capacitance type instrument for moisture content measurement in paddy.

2. Experiment

To develop a capacitance type instrument, we need a direct method to be the reference method. We employed the air-oven method. The paddy sample was weighted about 5 g before put into an oven to heat at 130 °C for 2 h. After drying, the paddy was weighted again. The moisture content was calculated in % given by

$$MC_{\text{wb}} = \frac{m_0 - m_1}{m_0} \times 100 \quad (1)$$

Where m_0 is the mass of paddy before drying and m_1 is the mass of paddy after drying.

We designed an instrument circuit based on IC555 timer. The circuit was controlled by Arduino Uno R3 and displayed the result of moisture content measurement on LCD display. The circuit diagram is shown in figure 1.

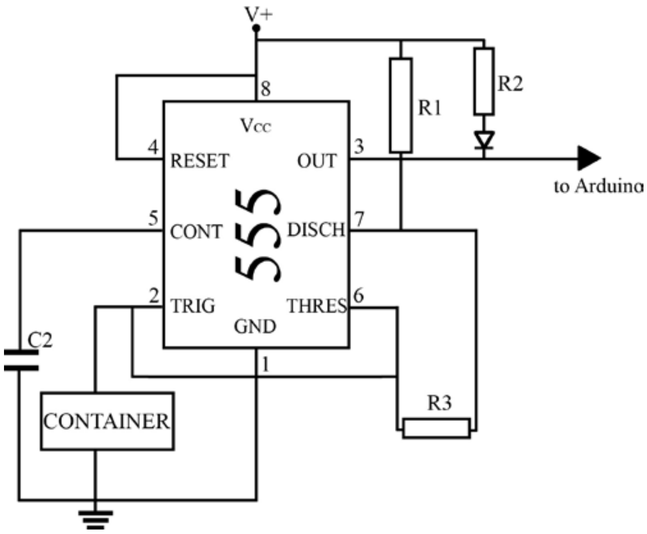

Figure 1. 555 integrated timer circuit diagram for the moisture content measurement in paddy.

In figure 1, we configured the IC555 timer to be astable multivibrator mode for frequency generating output. We replaced the capacitor at pin 2 with a container for the paddy. The container was designed a parallel capacitor. The paddy sample was put between the two conductive parallel plates. The capacitor C2 was selected as $0.01\ \mu$F. The resistors were selected as 20 kΩ, 330 Ω and 470 kΩ for R1, R2 and R3 respectively.

The output frequency was related to the value of resistances R1, R2 and the capacitance of the paddy container C as given by

$$f = \frac{1}{0.693(\mathrm{R}_1 + 2\mathrm{R}_2)\mathrm{C}} \quad (2)$$

In equation 2, the frequency is inverse proportional to C. The linear relation is preferred for the capacitance sensor. Using $f = 1/T$ we obtained

$$T = 0.693(\mathrm{R}_1 + 2\mathrm{R}_2)\mathrm{C} \quad (3)$$

where *T* is the period of the output signal.

3. Results and discussion

The paddy samples were measured by the capacitance instrument before measured again by the reference method. The results of frequency, period and moisture content are tabulated in table 1.

Table 1. Comparison between frequencies, periods and moisture contents.

f/kHz	*T*/s	*MC*/%
298.46	0.0033505	23.00
298.66	0.0033483	22.88
298.90	0.0033456	19.67
299.22	0.0033420	21.44
299.30	0.0033411	21.29
299.80	0.0033356	21.26
300.14	0.0033318	20.07
301.44	0.0033174	15.80
301.80	0.0033135	14.63
301.92	0.0033121	14.24
301.96	0.0033117	14.97
302.00	0.0033113	15.63
302.04	0.0033108	16.01
302.14	0.0033097	16.18
302.22	0.0033088	14.76
302.48	0.0033060	15.40
302.56	0.0033051	16.31
302.80	0.0033025	15.61
303.06	0.0032997	14.09
303.40	0.0032960	16.14

The linear relationship between moisture content measured by the reference method and time period measured by the capacitance instrument are fitted as shown in figure 2. The fitted relation can be shown as

$$MC = 159957.458\,T - 513.585 \tag{4}$$

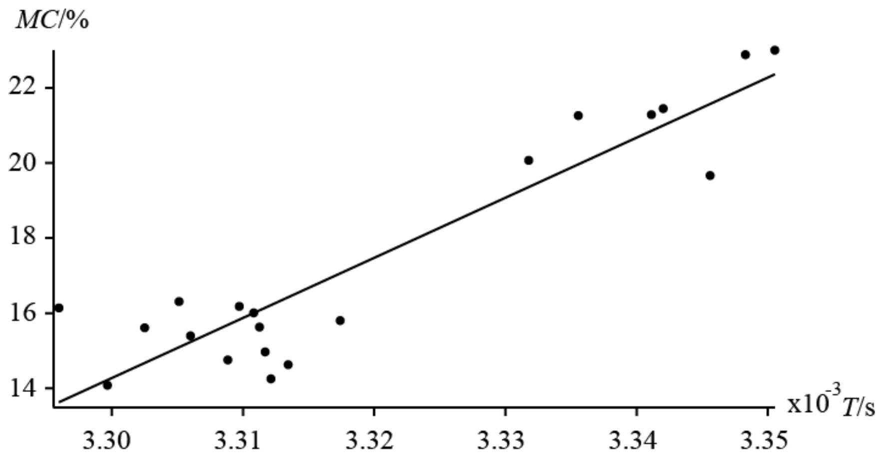

Figure 2. Relationship between periods and moisture contents.

From the linear equation, we got the standard uncertainty of the moisture content of 1.23 %. The equation 4 was validated again with the reference method. The measurement results are shown as in table 2. The measurement results were valid within 95 % degree of confident.

Table 2. Comparison of moisture contents between the capacitive instrument and the reference method

Capacitive instrument	Reference method	Difference
15.41	14.75	0.66
15.13	14.85	0.28
13.60	14.86	-1.26
14.85	14.88	-0.03
17.34	16.54	0.80
17.27	16.86	0.41
18.12	16.85	1.27
20.07	18.12	1.95
20.28	18.18	2.10

4. Conclusion

A capacitive instrument based on IC555 timer circuit can be used to measure the moisture content in paddy. The standard uncertainty of the measurement was 1.23 % of the moisture content in the range of 14 % to 20 %.

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References

[1] Booker D B, Bakker-Arkema F W and Hall C W 1992 *Drying and Storage of Grains and Oilseeds* (New York: Van Nostrand Reinhold) chapter 5 pp 87-124
[2] Tipples K H 1995 *Stored-Grain Ecosystems* (New York: Marcel Dekker) chapter 10 p 340
[3] Bala B K 1997 *Drying and Storage of Cereal Grains* (New Hampshire: Science Publishers) chapter 2 pp 4-23
[4] ElSayed N I, Mekawy M M and Megahed F M 2011 *Aust. J. Basic & Appl. Sci.* **5** 582-7
[5] Jindal V K and Siebenmorgen T J 1987 *Trans. ASAE* **30** 1185-92
[6] Janier J B and Maidin M B 2011 *J. Appl. Sci.* **11** 1476-8
[7] Zhang H, Liu W, Tan B and Lu W 2013 *J.Comput.* **8** 1627-31
[8] Ponglangka W 2015 *Int. Conf. Control Automation and System* (Busan: IEEE) pp 1709-13
[9] Onoja S B, Enokela J A and Ebute G O 2014 *ARPN J. Eng. & Appl. Sci.* **9** 1994-8