# MODULE BOTTOM MOISTURE CONTENT INDICATING SENSOR – PROGRESS REPORT

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## Abstract

Most seed cotton is harvested at a moisture content (mc) suitable for storage and is stored in modules before it is ginned. Sometimes these modules are located where they are flooded during rain storms and the bottom several inches become very wet. Automated drying control systems set the drying temperature based on an estimation of the overall mc of the seed cotton. Therefore, the extremely wet cotton on the bottom of the module can get to the gin stand with little drying. A sensor to detect the mc of the seed cotton on the bottom of the module was designed, installed, and operated for six ginning seasons. This system can alert the ginner to the problem or can automatically set the burner temperatures higher than needed for normal ginning. Some data obtained using this system are described.

## Introduction

A study was begun in 1990 to examine improved methods of controlling cotton drying (Byler and Anthony, 1991; Byler and Anthony, 1992; Anthony and Byler 1994; Byler and Anthony 1997) at Burdette Gin near Leland, MS. For the 1997 harvest season two moisture sensors were installed in the module feeder which measured the moisture content (mc) of the incoming seed cotton. A near infrared-type (NIR) moisture meter was installed between the air-type and saw-type lint cleaners behind the second gin stand to measure the fiber mc which was to be controlled (Anthony et al., 1995). This gin had two stages for drying, the first stage used a hi-slip drier, and then the cotton was split into two streams for the seed cotton cleaning and second stage of drying. Thus, there were three burners to control in this drying system. A Honeywell UDC 3000 controller was used for temperature control for each burner. The stage one temperature control sensor used by the UDC 3000, for the hi-slip drier, was ahead of the mix point but the stage two controllers sensed the temperature in the top of the tower drier. A personal computer (PC) was used to collect data and to set the desired burner temperature based on the incoming seed cotton mc, the final mc and the final mc set point chosen by the ginner. The PC communicated digitally with the UDC 3000's to set the target temperature and requested the current temperature readings from the UDC 3000's.

Resistance-based experimental cotton mc sensors were installed at two locations in the gin and used for several years. One seed cotton sampler and multi-channel resistance meter was installed in the head of the module feeder for the 1996 crop year and an additional one was installed for the 1997 crop year (Byler and Anthony, 1999). These meters take a small portion of the cotton being removed from the module by the module feeder cylinders and press it against the stainless steel sensor probes in each meter. The resulting mc data were then used for drying control. During testing of the drying system a problem was encountered for some modules because they had extremely wet bottoms but the majority of the modules contained relatively dry cotton. The samples were fairly representative of the whole module but cotton from the module bottom could be missed, especially if it was heavier than normal, as was the case when it was wet. Most of the very wet cotton fell directly from the bottom of the module into the hi-slip drier without ever being touched by the beaters in the feeder head, and could not have been sensed by the mc sensors. The automatic control system correctly sensed that the cotton in the module was relatively dry and therefore turned the drying temperature down, sometimes to the minimum allowed. The extremely wet cotton from the module bottom passed to the gin stand with almost no drying and caused problems. The ginner had to manually override the drying control system in order to gin satisfactorily.

As a possible solution, a roller in the module feeder floor was isolated electrically from the rest of the module feeder and used to sense the mc of the bottom of the module as described by Byler and Anthony (1999). The purpose of this study was to determine if a simple isolated roller in a module feeder bed could be used to detect wet-bottomed modules.

## Materials and Methods

The design, development, and testing of the equipment has been described in previous Beltwide presentations by Byler and Anthony (1999 and 2000). In summary, one roller of the module feeder was electrically isolated and a small voltage (2.5 V) impressed on it, Figure 1. The electrical current from that roller to the two adjacent rollers was detected and used to predict the mc of the seed cotton on the bottom of the module. The system sensed the mc of a strip of cotton several inches wide across the width of the module. The details of the operation of the sensor show that it will not produce an average mc but an overall representation of the mc which emphasizes the wettest portion of the strip of seed cotton being sensed because the portions of cotton act as resistors in parallel and because of the highly nonlinear nature of the resistance-mc relationship (Byler, 1998). Four small magnets were attached to the roller shaft which caused a reed relay to close and open four times per revolution, Figure 2. This feature produced a pulse for every 5 1/8" of movement of the module. The paint was removed from the electrically charged roller and the two adjacent rollers, Figure 3. This module bottom mc measurement device was connected to a PC through a four wire cable, one pair for power and the other pair for communication between the mc sensor and the PC. The cost of the electronic portion of the sensor, excluding the PC, was about $500.

### System operation and testing

The data obtained from the module bottom mc sensor were logged on the PC with the time of measurement. One mc measurement was used for each 5 1/8" movement of the module. It took about 4 minutes for cotton to travel from the sensor to the hi-slip drier under normal ginning conditions. These data were smoothed to provide more stable mc data for control. Seed cotton samples were removed from the bottom of the module through the rock trap in the module feeder and returned to the lab for analysis for mc by the oven method (Shepherd, 1972). The mc ranged from 9% to nearly 18%. These data were used to calibrate the meter.

## Results

This system was operated from installation in 1998 through the current harvest year. The A/D converter was replaced in 1999; the failure was due to electrical damage believed to have been caused by lightning. No other problems have occurred with the system. For the 6 years between 1998 and 2003 over 170,000 bales were ginned at this gin and the vast majority of the modules were fed into the gin using the module feeder. The system appears to be reasonably rugged based on this record.

Data that were collected over several two-hour periods is shown in Figures 4 to 7. The points represent the individual readings; the line shows the moving average of the individual reading and the four previous mc readings. Averaging several readings is one approach to smoothing noisy data such as was obtained by this sensor. The average will lag the actual readings when there is a sudden change of mc. The solid line represents the type of data which might be used in drier control. Figure 4 is a plot of data obtained between 3:00 and 5:00 AM on Nov. 1, 2000. The mc can be seen to vary from about 14% to a little over 16% during this time period. A module typically takes about a half hour to gin in this facility so the sensor showed that these modules had a fairly constant mc. Figure 5 shows data collected on Oct. 1, 2000 between 10:00 AM and noon. These modules had a mc from about 12% to 14% but it would appear that the module being ginned from about 10:45 to 11:15 was drier than the modules before and after it.

The resistance sensor was sensitive to contact pressure. When the seed cotton was being pressed against the rollers by the full weight of the module, the resistance was lower than when there was less weight on the seed cotton. Lower pressure on the seed cotton resulted in higher resistance which was indicated as lower mc. Under some conditions there was not much space between the modules and there were only small dips in the mc, as in Figure 4. However in other cases, there was more loose cotton between the modules and larger dips in the indicated mc were measured such as in Figures 5 and 6.

Figure 6 shows data collected between 3:00 and 5:00 PM on Nov. 2, 2001. The module being ginned from about 3:20 to 3:50 appeared to have an increasing mc from one end to the other. Several modules can be seen to have been separated enough to produce obvious dips in the mc reading. The module being ginned at the end of this period appeared to have a somewhat higher mc than the previous ones. Figure 7 shows data collected between 4:00 and 6:00 PM on Nov. 9, 2001. In this plot the module being ginned from about 4:50 to 5:20 had noticeably drier seed cotton on the bottom than the other modules.

In summary, this simplistic, low cost system provides adequate indication of wet cotton on the bottom of a cotton module to enable a ginner or automated system to respond appropriately.

**Acknowledgement**

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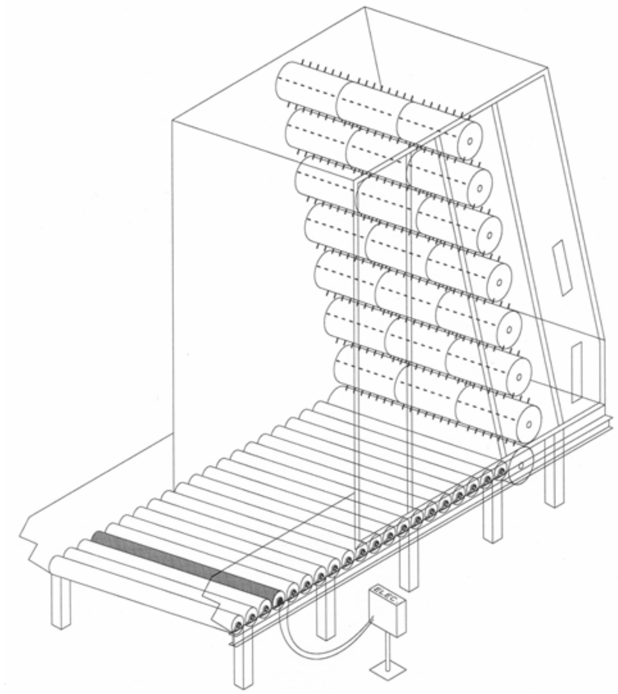

Figure 1. Schematic showing the electrically isolated roller used as part of the module bottom moisture meter in the module feeder.

Figure 2. Photograph of the installation at the end of one roller showing the roller, pillow bock, proximity switch and two magnets, and electrical connections including the end of the slip ring.

Figure 3.  Photograph of the measurement roller and the two adjacent ground reference rollers with the paint removed.

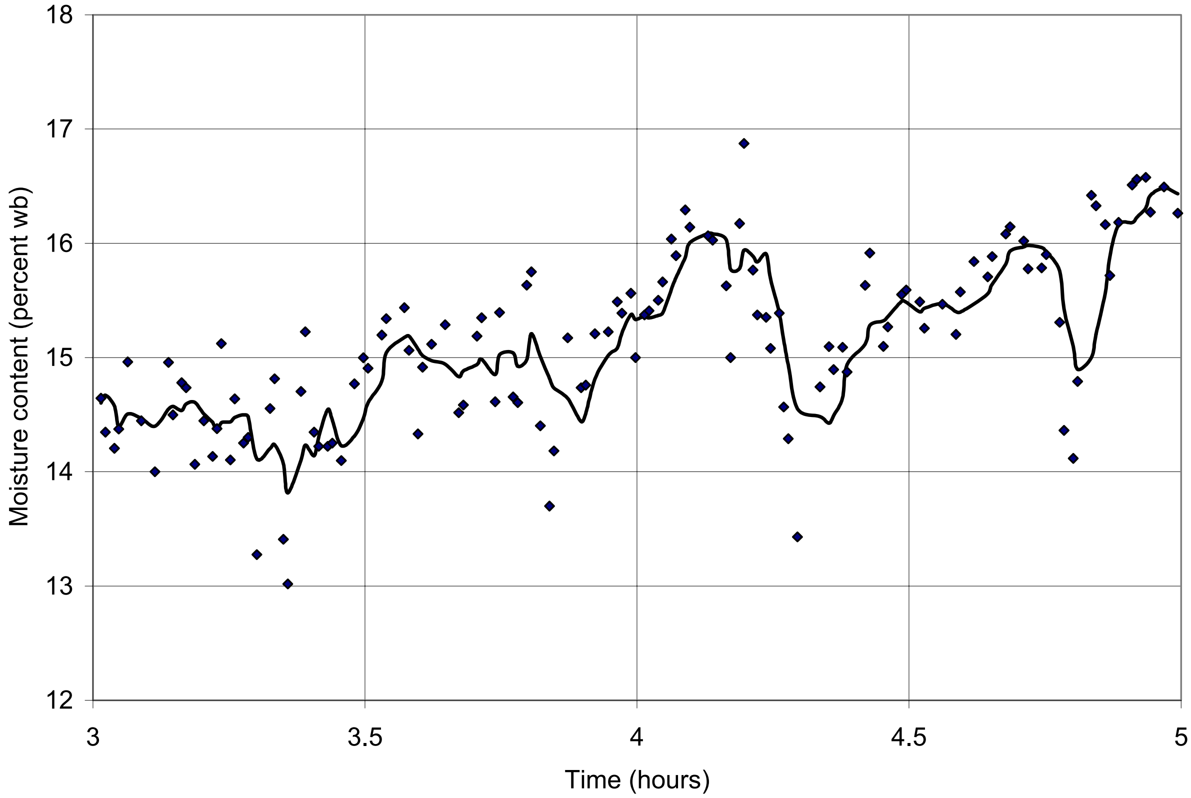


Figure 4. Plot of the moisture content data (points) and a smoothed line collected between 3:00 and 5:00 AM on Nov. 1, 2000.

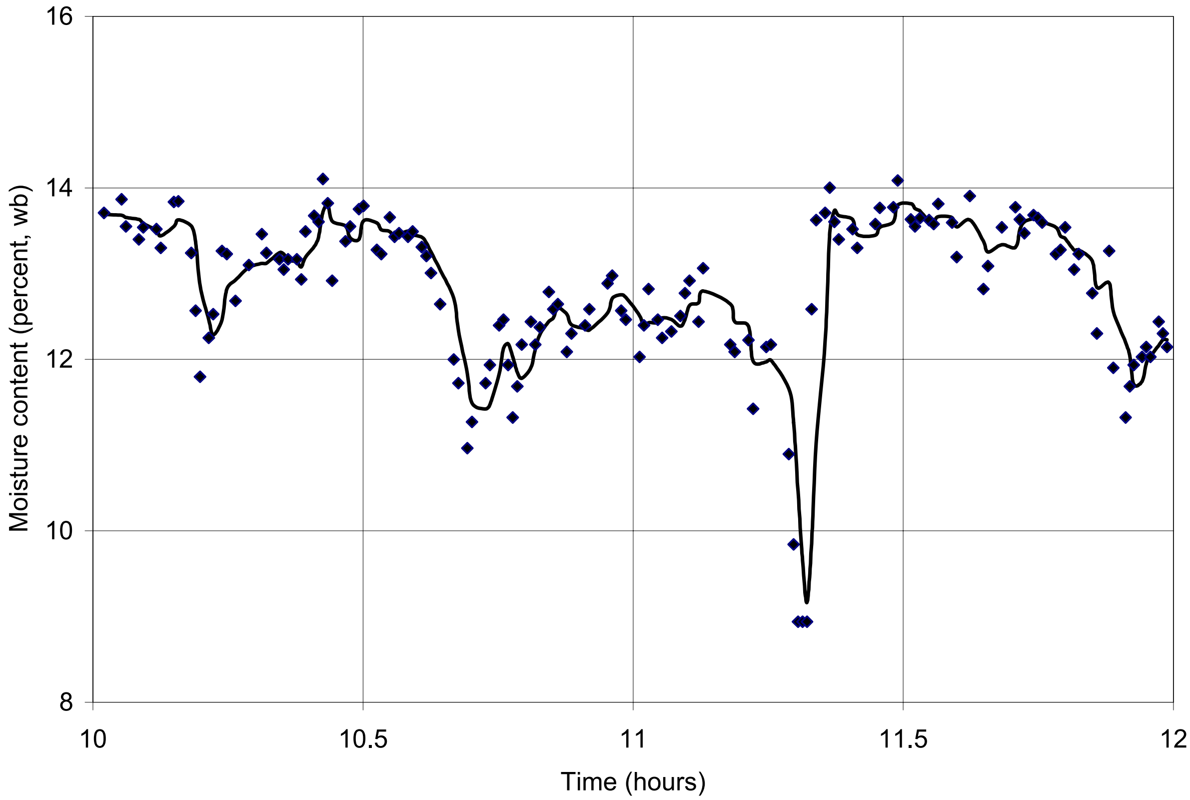


Figure 5. Plot of the moisture content data (points) and a smoothed line through them collected between 10:00 AM and noon on Oct. 1, 2000.

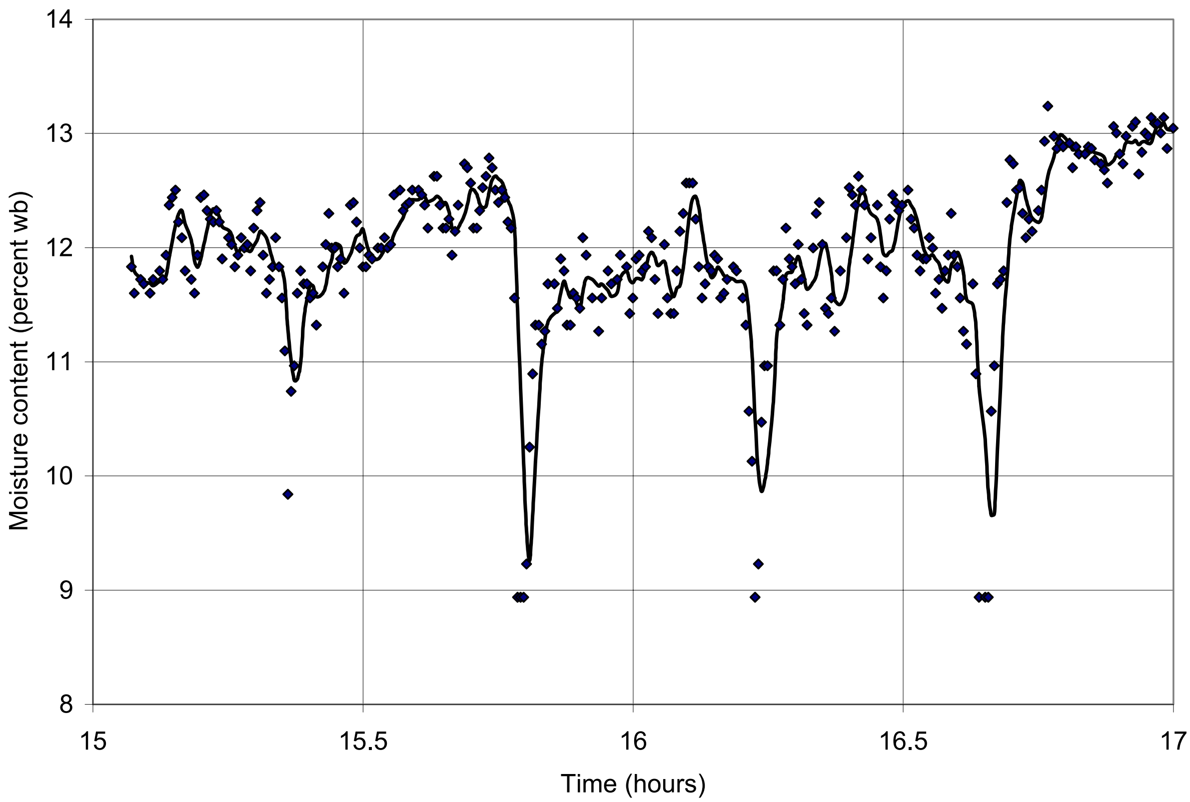


Figure 6. Plot of the moisture content data (points) and a smoothed line through them collected between 3:00 PM and 5:00 PM on Nov. 2, 2001.

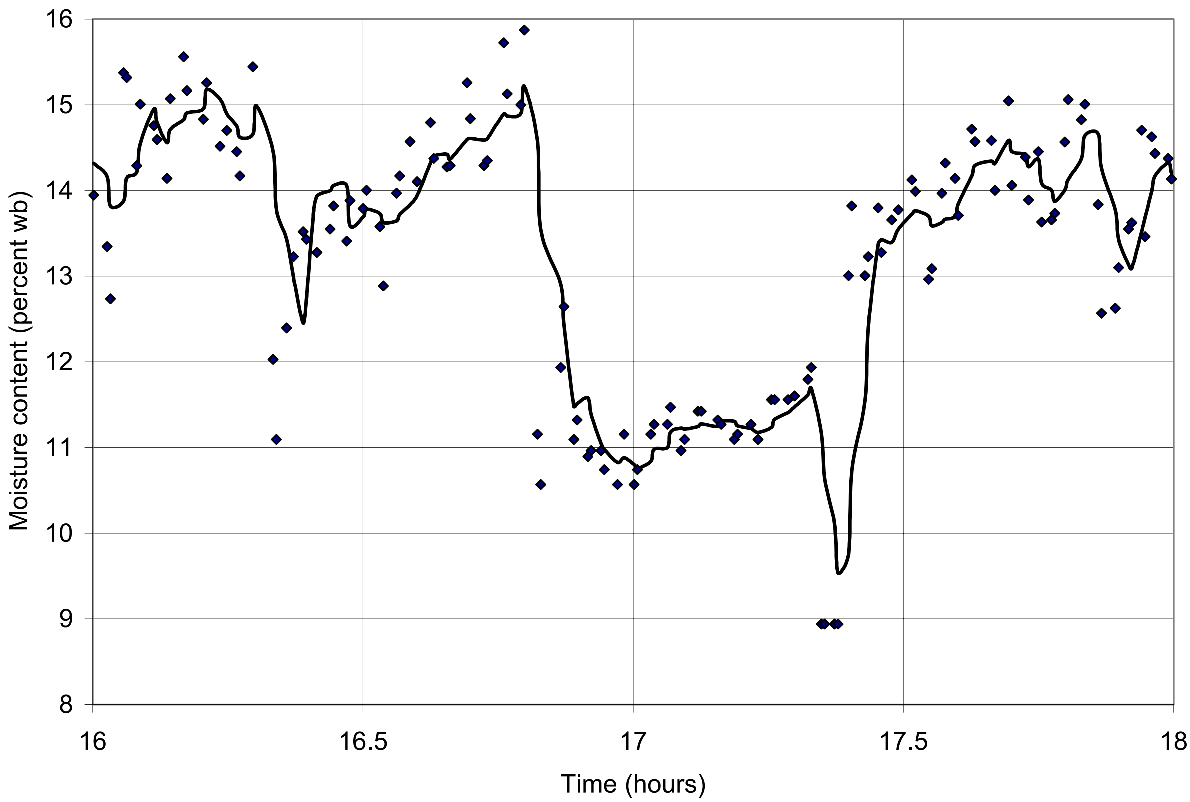


Figure 7. Plot of the moisture content data (points) and a smoothed line through them collected between 4:00 PM and 6:00 PM on Nov. 9, 2001.