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FREQUENCY ANALYSIS OF THE MEASURING SYSTEM IN THE NIR MOISTURE METER

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Abstract: *The infrared radiation measurement system based on the cooled PbS photoconductive detector with a preamplifier and a mechanical chopper in the moisture meter* with one beam *is designed by the authors and analysed in this paper. Two pairs of the band pass near infrared (NIR) filters, the first one being 1800nm, and second one 1940nm, are embedded in the wheel which is rotated by the motor. The mechanical chopper has a double function. First, the reference NIR radiation which is not absorbing for water and narrow band at 1940nm which is absorbing for water extracts from the incident radiation generated by the source. Second, the reference and the absorbing beam are mechanically modulated by the signal of designated frequency and directed to the tested sample. So in the frequency spectre of the signal produced by the PbS detector consequent upon the reflected radiation from the sample contains information about moisture content. The basic aim of this paper is to carry out a frequency analysis. The final aim is to develop an optimal optoelectronical measuring system for the infrared moisture meter for practical use but with some specific substances firstly. The overall results can be kept in the numerous variety applications later.*
Key words: *moisture, NIR, harmonic, PbS detector*

1. INTRODUCTION

The moisture measuring system analysed in this paper consists of a radiation source, mechanical chopper with two pairs of optical filters, the reference beam is 1800nm and the absorbing beam is 1940nm. Moreover, it consists of PbS based photoconductive detector with the Peltier one stage cooler, preamplifier with the power source frequency filter and signal processing circuit. The radiation from the source includes NIR gets into the optical filters which rotate with the wheel together. So, two beams, reference and measuring are separated by the corresponding optical filter and directed to the sample. These two beams are reflected from the sample, are collected and directed to the photodetector by the mirror. In the photodetector, the optical signal is converted into an electrical one which is amplified before further processing. This electrical signal consists of the information about values of both beams

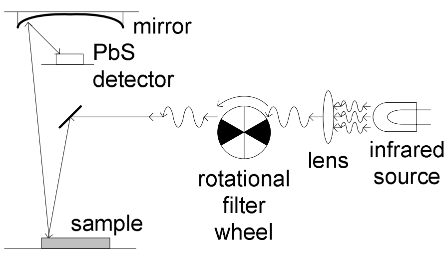

Fig. 1. Optical part in the NIR moisture meter

reference and measuring ones, modulated by the mechanical chopper. These two components of the signal lie on the different frequencies which have to be extracted by the processing circuit. However, the signal modulated by the mechanical chopper is not sinusoidal. The accuracy of an optoelectronic measuring system depends on noise level mixed with useful signal. The noises that overlie outside the useful frequency bands can be eliminated by the processing circuit. It is necessary to minimise the noises from various sources, like background, noise from the detector, power and any additional noises from the preamplifier. A practical method used to select the signal frequency components by the choice of rotary speed with a chopper drive, minimising in that way the noises and increasing the signal versus noise ratio at the same time.

2. MEASURING SYSTEM

The solution of a NIR moisture meter with one beam and two beams are possible [3]. Although the solution with two beams can eliminate some negative influence factors like the influence of sample surface, the particle size and the sample colour, a moisture meter with one beam shown in Fig.1 is chosen due to its lower expenses.

2.1. Block diagram of the system

The characteristics of PbS photoconductive detectors such as high detection levels in wavelengths of between 1000nm and 3200nm, good response speed and reasonable price, mean that they can be used in various applications for the moisture

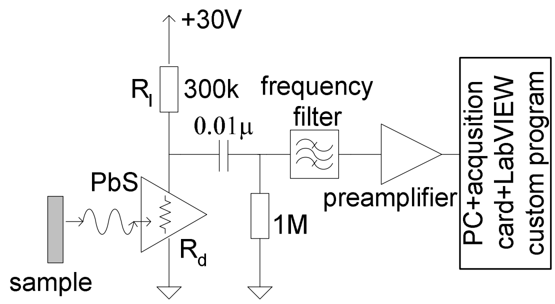

Fig. 2. Conditioning PbS detector signal and acquisition

detection due to one distinctive absorption wavelengths of water at 1940nm[2]. The response time is limited by the chopping frequency. The bias voltage for the supply detector and the other active elements for the conditioning signal (Fig. 2) are obtained by the stabilized rectifier supply module from the AC power line. The small AC signal from the detector is conditioned by the AC coupled processing circuit consisting of two different stages. The power line generated noise (50Hz) is filtered by the first, the frequency filter and useful signal is amplified by the bandwidth preamplifier which is the second. The amplification of the preamplifier is arranged so this output signal gets around adequate levels for acquisition into the awaited work of the moisture meter. It levels are specified by the properties of the PC acquisition card analog channel. Not only was the output signal from the preamplifier measured, stored and processed by the PC with acquisition card and LabVIEW custom program but also other important measuring parameters like the voltage and current of the thermistor embedded in the detector and synchronisation signal.

2.2. Frequency response characteristics

The frequency characteristics of the analog circuit shown in Fig. 2 are measured by digital scope, Fig. 3. The photodetector is disconnected and the function generator is temporarily

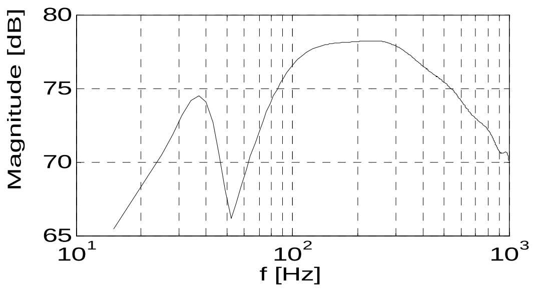

Fig. 3. Frequency response of analog circuit

attached. The pick-to-pick output sine signal from the generator, the output signal from the preamplifier and its phase shifts are measured at various frequencies. The frequency responses of the detector can be obtained from the following expression

$$V(f) = \frac{V_0}{\sqrt{1 + (2\pi f \tau)^2}} \quad (1)$$

where

- V (f) -voltage signal from the detector /V/
- V_0 -DC response /V/
- f -chopping frequency /Hz/
- τ -time constant /μs/.

3. EXAMPLES AND EXPERIMENTAL RESULTS

Many of the output signals from the preamplifier are measured at the constant temperature of the photodetector and ambient 22^0C for the same wheat grain sample with known moisture content of 16% at various chopping frequencies up to the 800Hz. Time response and frequency response of these output signals at the rotary speed of the chopper 2702min^{-1} (45.05Hz) are shown in Fig. 4. The expressed frequency response is calculated by the discrete Fourier transformation from the time response.

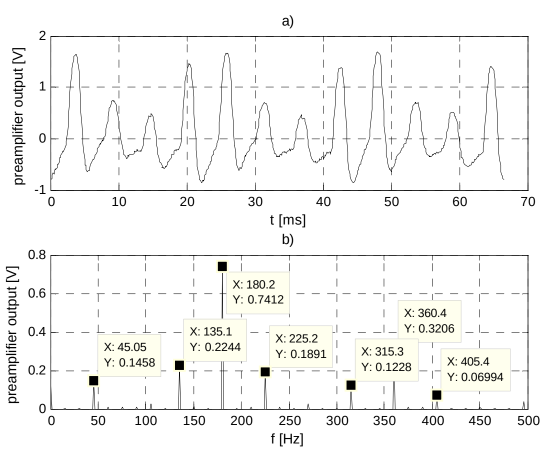

Fig. 4. Time response a) and frequency response b)

The signals of the absorbing and reference beams come up to the frequencies 180.2Hz and 135.1Hz successive. These signals and some other frequency components are marked in Fig. 4b). 45.05Hz is the fundamental frequency at given velocity. The frequency components 135.1Hz and 180.2Hz are its 3rd and 4th components successive. 7th, 8th and 9th components are also

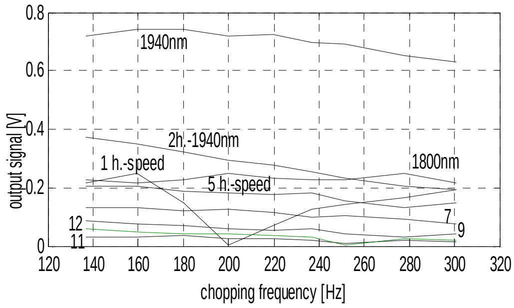

Fig. 5. Different frequency output signals

marked in Fig.4b). All of these components are measured at different rotary speed of the chopper wheel and are shown in Fig.5. Proper measuring of the absorbed beam is substantial for the estimation of the moisture content. Hence, the chopping frequency was noted to interchange this component.

4. CONCLUSIONS

The NIR moisture meter measuring system is analysed by the discrete Fourier transform at the different chopping frequency and the constant detector temperature. This system is tested by the measuring reflection from the same wheat grain sample with known moisture content. Two pairs of the band pass optical filters are embedded, for wavelength 1940nm and 1800nm, in the rotational chopper wheel thereby. The detector temperature is measured by the embedded thermistor. The high order frequency components exist in the output signal of the analog preamplifier due to the applied frame of the optical filter windows, firstly. The frequency content can be changed by the appropriate frame or/and size of the hols chosen in filter wheel. But, the signals of the reference and absorbing beams are unmistakably measurable in the applied configuration. The changing of these signals, when the samples with different moisture content are introduced, need investigation in the next period. Many problems can be anticipated when the signal of the absorbed beam is small. The ratios between the absorbed beam and reference signal beam are non linear when the moisture content is changed.

6. REFERENCES

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