Intelligent Vibrating Dosing System Using Automation Through Microcontroller

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Abstract: This paper presents an intelligent vibrating dosing system that is controlled using a microcontroller and a precision integrate circuit that makes the analog-digital conversion between the sensors and the microcontroler. This stand allows a better understanding of the flow behavior for different food bulk solids that are dosed using vibrator dosing systems and can be applied to other volumetric systems, too. A better understanding of dosing process can help us to project dosing system more advanced from speed and precision point of view.

Keywords: Vibrating dosing, microcontroller, automation.

1. Introduction

The vibrating dosing system uses an electromagnet to produce the vibrations on the conveying vibration chute. Depending on the value of the vibration parameters (amplitude and frequency) the bulk solids will flow accordingly. An important advantage of this dosing method is that material is fed in the weight cell 1 uniformly and with smaller impact on the weight scale.

The principle of this dosing system is that the flow speed of the material is given by the vibration and the angle of the chute. This two parameters are set by microcontroller depending on material dosed.

The regime process that I propose includes 2 steps. One to dosing 80% of material and another for the rest of 20 % of process.

The firs step that represent 80% of dosing process is made with DC vibrator motor at 100% maximum voltage. In this time the angle of the chute is modified according to the dosed material from a big angle to a normal angle.

At the second step that represents the end of dosing process the angle of the chute remains constantly at a normal position. In this time the voltage of vibrating DC motor is changed depending on dosing material that is dosed. In figure 1 is represented the running scheme of this automatic dosing system.

2. Using ATmega8535 microcontroler to control the system

For the automatic monitoring of the dosing process in the case of a volumetric dosing system with vibrator slot, it was built an automatic dosing system using the system presented in figure 1.

For automatize system an 8 bit microcontroler with RISC architecture is used.

The reasons for this chooses are:

- It has 4 input/ output ports. On these ports can be connected a keyboard and a leds display
- The maximum speed is 16 MHz and can execute 1 instruction per clock cycle.
- It has an internal ADC multiplexed on 8 channels. This ADC makes this system to be very flexible (easily upgradeable), because the special IC AD7730 can be replaced easily with a potentiometer. In future, the system can process information from other sensors like piezoelectric sensors to measure the vibration, humidity.

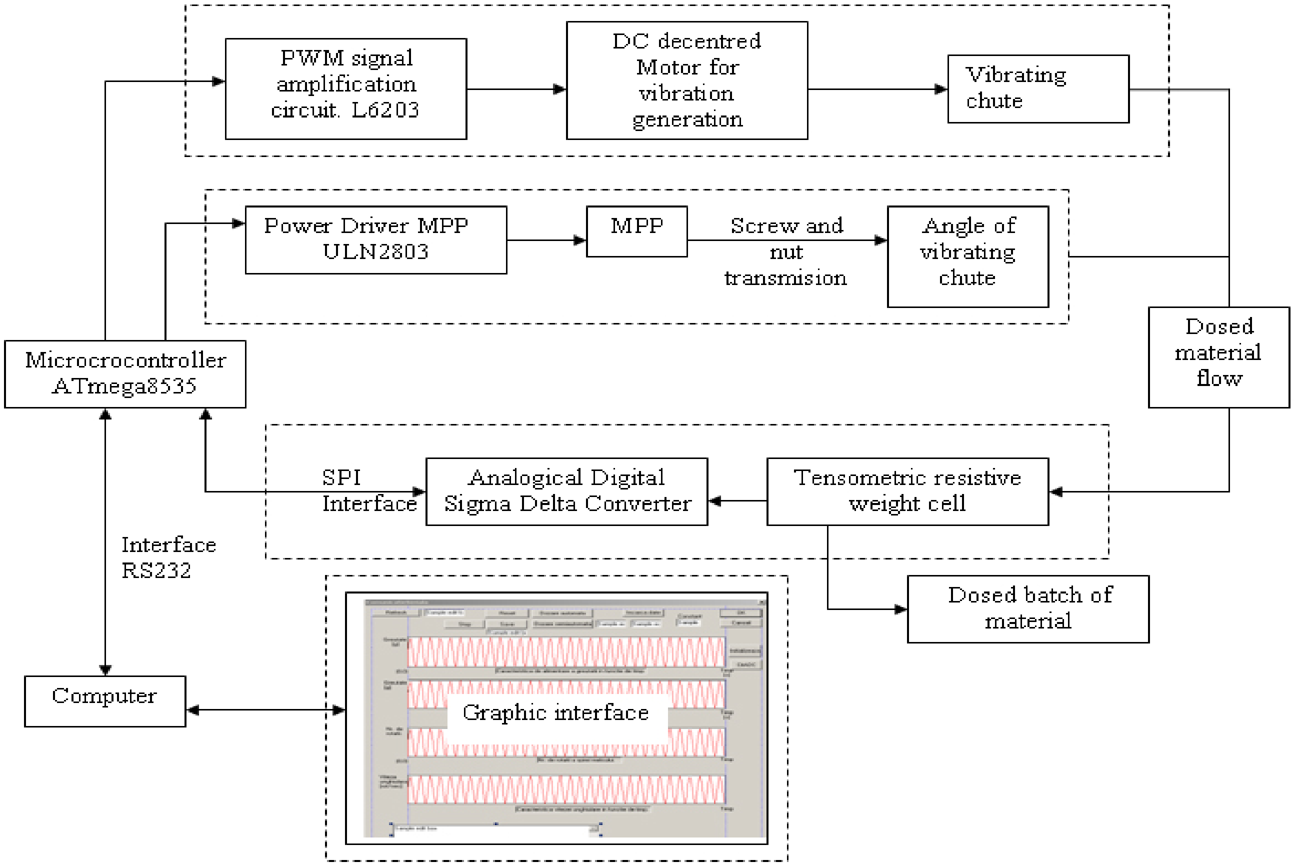

Fig. 1. Schematic representation of the automatic control of the vibrating dosing system.

3. Communication interfaces

For the data processing of the control unit it was used a microcontroller produced by Atmel Atmega 8535
The Atmega 8535 flexible serial interface allows an easy interface to most microcomputers and microprocessors. The serial interface on the AD7730 has the capability of operating from just three wires and it is compatible with SPI interface protocols. The three-wire operation makes the part ideal for isolated systems where minimizing the number of interface lines minimizes the number of opto-isolators required in the system. Register lengths of the AD7730 vary from 8 to 16 to 24 bits. The 8-bit serial ports of most microcontrollers can handle communication with any of these registers, two or three 8-bit transfers.
The microcontroller communicates with the AD7730BN integrate through a Serial Peripheral Interface (SPI) that uses the following three connections from the microcontroller: data receiving connection (MISO), data transmission connection (MOSI) and one connection for the synchronization of the data (SCK).
The microcontroller receives trough the SPI (Serial Peripheral Interface) interface the results of the analog-digital conversion (ADC) and the integrated circuit that realizes the conversion (AD7730) is made by Analog Devices and is responsible with the processing of the information collected from the weight resistive transducer.
Figure 2 shows an interface between the AD7730 and the ATmega8535 microcontroller. The diagram shows the minimum (three-wire) interface with CS on the AD7730 hardwired low. In this scheme, the RDY bit of the Status Register is monitorized to determine when the Data Register is updated. An alternative scheme, which increases the number of interface lines to four, is to monitor the RDY output line from the AD7730. For interfaces that require control of the CS input on the AD7730, one of the

port bits of the Atmega8535, which is configured as an output, can be used to drive the CS input. The ATmega8535 is configured in the master mode with its CPOL bit set to a logic zero and its CPHA bit set to logic one. When the ATmega8535 is configured like this, its SCLK line idles low between data transfers.

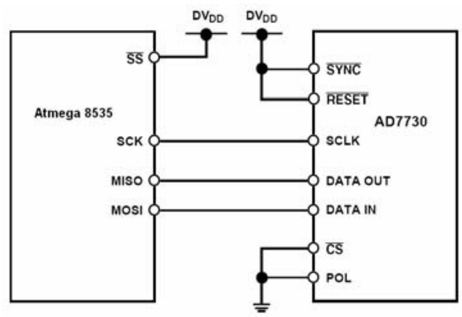

Fig. 2. Serial peripheral interface between the microcontroller Atmega 8535 and weight conversion integrated circuit AD7730.

USART
The Atmega 8535 microcontroller communicates with the PC through the serial interface type RS-232, and the human user can activate through the software application on the PC the following operations: single conversion, calibration, beginning of automatic dosing batch, reset or saving of the dosing data.

4. Actuators and sensors

Tensiometric cell
Mass flow monitoring. The bulk solid material is conveyed by the vibrator chute into the weighing vat that is placed upon a weighing cell that continuously monitors the added weight of material. The weight cell is working on the tensometric principle that modifies the value of the resistance of the tensometric bridge with the variation of the vat's weight. The analogical value of the tension from the tensometric bridge is converted then into a discrete value by the analogical digital converter, which is built inside the integrated circuit AD7730BN specialized for weighing applications. The weighing cell is connected directly to AD7730BN integrate without any prior amplification, because the processing of the analogical signal is processed completely by the AD7730BN integrate through the specialized components from it. The result of one conversion represents a numerical value of 24 bits and resolution of the conversion will be of 230.000 units for in tensions for the interval - 40mV and + 40mV.
Connections between the AD7730 and the bridge are very straightforward in this type of application as illustrated in figure 3.

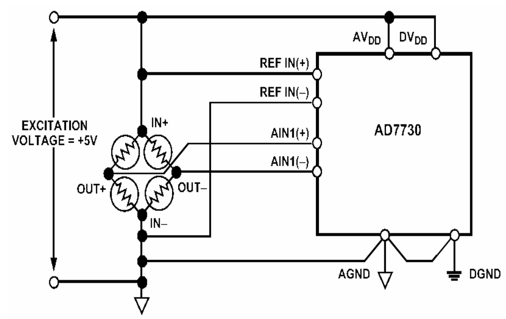

Fig. 3. Sketch representing the connections of the weight cell with the weight monitoring integrate AD7730BN.

DC Decenter motor
The vibrating dosing system uses an DC Decenter motor to produce the vibrations on the conveying vibration chute. Depending on the value of the vibration parameters the bulk solids will flow accordingly. An important advantage of this dosing method is that material is fed in the weight cell uniformly and with smaller impact on the weight scale. The dosing system is periodically fed with material from hopper, and will be refilled at the moment when the minimum level of material in the hopper is reached.
The command block for the control of the vibrating dosing system works with the microcontroller that sends PWM signals on the data in TTL gates of the power integrate L6203, which is capable to command an output tension of maximum 42V and electric current up to 4A. Through the control of the voltage of DC motor can be adjusted in real time the vibration frequency of the chute result in controlling the material flow.
Stepper motor
For the dosing process optimization it is used a step motor, which allows the gradual change of the chute angle. This angle determine the speed and precision of dosing process.
The angle chute is set with unipolar stepper motor with four phases (MPP) that is powered through

amplified signals by the ULN2803 power integrate that receives data in signals from the microcontroller. The ULN2803 is foreseen with 8 levels of Darlington amplification that can command the phases of stepper motor with a tension equal with 50V and an intensity of 500 mA.

5. Optimize of dosing process using PID algorithm for generation of vibrations and angle plan change.

The principal aim of this study consists in the conception of an algorithm that makes the dosing process faster with the maximum precision. I tried to do this optimization though having a fast flow of material at the start and a good precision at the end of the process. That is the motivation that made me to divide the process in two parts. One part where that the angle is graduate change depending on the dosing material. And in the last part the angle remains constant and the power of the chute vibration depend on the rest of the material that remains to be dosed.
The algorithm calculates in real time the proportional error. This is obtained from the difference of the value of the material that must be dosed and the material that was dosed. This error is multiplicated with a constant and the result is proportional error. This proportional error is applied on the actuator. In this way is obtain a feedback and a good optimization of process.
To tune the optimization, the parameters: the percentage of the 2 parts, angle maxim and minimum of the chute, limits of voltage for vibrating motor can be switched for different material.

6. Conclusion

Automatic control has been an essential part of primary processing elements. Computer-based control systems permitted the coordination of machines and production lines, and have enabled management information to be made available from directly from the dosing systems.
The automatic control interface of the realized stand can offer a high precision of the dosing of each batch and can help in the understanding of the material behavior during the transport process.

References

H. A., Janssen, Versuche über Getreidedruck in Silozen, Z. VDI 39 (1985) H.35.
G., Vetter, The Dosing Handbook, Vulkan – Verlag, Essen, 1994.
XXX, Analog Dialogue, Analog Devices, Norwood, 2000,Volume 34, pag. 33-37.
XXX, Bridge Trnasducer ADC, Analog Devices, Rev.A, pag. 16-41, www.analog.com.

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