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Interaction Design of Programmable Logic Controllers to Adjust the Temperature in the Temporary Storage Buns of Cotton

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Abstract

In this scientific article, a SCADA system for continuous monitoring of temperature in temporary storage bunts of cotton was developed. The system was designed using 24-bit Programmable Logic Controllers (PLC) and Thermocouple Sensors (TS), as well as Analog Digital Converters (ADC). The main objectives of the project in the article are: (a) Formatting of signals from thermocouple sensors (TS), development of a method of ratiometric change of the sensor; (b) Programmable logic controllers and signal routing, system protection; (c) Designing programmable logic controllers, as well as developing and creating a sensor-PLC module for measuring temperature and sending signals to PLC.

Keywords: Sensor • Program • Module • Logic • Microchip • Temperature • Connection • Approximation • Design • Mathematics • Frequency • Interface • Microchip

Introduction

Continuous monitoring of the temperature in the temporary storage buns When creating a SCADA system, it is advisable to develop the technical parts of the system. The system was designed using 24-bit Programmable Logic Controllers (PLC) and Thermocouple Sensors (TS), as well as Analog Digital Converters (ADC) to perform basic functions. The main purpose of the project:

- Formatting of signals from Thermocouple Sensors (TS), development of a method of proportional change of the sensor;
- Programming of programmable logic controllers and signal routing, system protection;
- Design of programmable logic controllers, as well as the development and creation of a sensor-PLC module for measuring temperature and sending signals to the PLC.

Materials and Methods

This article is based on latest scientific literature presented in journals, books related on energy consumption, Growth and Environment, Internet sources and country data obtained from various ministries of the governments of Ethiopia to collect qualitative and quantitative information. Based on data collected a comprehensive literature review is carried out on Ethiopia the nexus between Energy Consumption, Growth and Environment in Ethiopian Economy. The article is divided in to five sections: in section 1 introduction, in section 2 methodology parts is discussed. Section 3 discusses energy prospects of Ethiopia, Theoretical and conceptual considerations. Finally, section 4 summarizes this article with intensive conclusion.

Interface module of programmable logic controllers

The SPLC interface module consists of a fully insulated part to transmit signals from the sensor element to the PLC. The basis of this module is the ADC1220 24-bit ADC, based on the delta-sigma architecture. This microchip provides system integration through a high-precision, low-noise DC power supply.

This module can be used for all K and L type TS. The presence of an ADC in the SPLC module, which converts analog signals to digital, takes up less space in the chip being created and is cost-effective. In addition, this module can provide a high level of integration with PLC. In addition, this chip meets the requirements of IEC61000-4 standards: EFT, ESD and Surge and does not lose its quality even in adverse conditions [1,2].

The SPLC interface module provides two differential input channels for measurement from two different TS. One channel supports 2-, 3- and 4-wire TD. One ADC1220 24-bit delta-sigma

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ADC and an external TS5A23159 dual-channel analog multiplexer were used in the chip design. The multiplexer provides two differential analog inputs to connect two identical ADC. The TCA6408A microchip is connected to the ISO1540 insulator via the I2C protocol via GPIO pins using an I2C (Inter-Integrated Circuit-integrated chip access) interface. The TCA6408A microchip, in turn, controls the TS5A23159, which redirects one of the two inputs to the ADC for measurement. The selection of the input channel is done using software. Any signal coming in or out of the module was protected by high voltage and various interference using insulators. Temperature Sensors (TS) generate voltages in the millivolt range, which in turn transmit external influences to the signals. Therefore, RC low-conductivity differential and common-mode filters were used until the analog signal entered the ADC1220 microchip. The filters effectively eliminate the reception of high frequency interference that may be present. The LM94022 analog output temperature sensor is connected to the ADS1220 microchip using a TS5A23159 dual-channel multiplexer after passing through low-frequency common-type filters. Another TMP275 digital temperature sensor is connected to ISO1540 using the I2C protocol. These sensors have been used to monitor devices and microchips as the temperature rises or falls during operation, as well as to ensure that the chip operates in a variety of climatic conditions. The digital signal from the ADC1220 (DRDY) provides the TCA6408A microchip via communication channels that connect to the GPIO pin. This chip transmits signals to the general system via the I2C bus and checks the accuracy of the data (Figures 1 and 2) (Table 1).

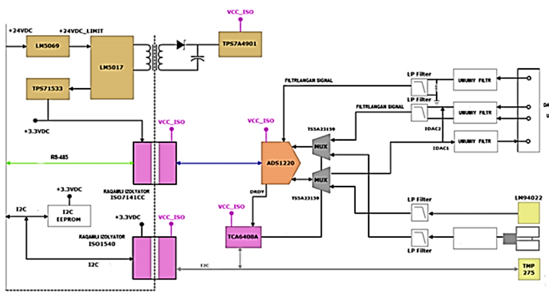

Figure 1. Block diagram of programmable logic controllers.

Table 1. Share of fuel imports (%).

Share in	1991/92	2000/01	2011/12	1991/92-2011 /12
Export	42.0	52.0	40.9	51.0
Import	31.8	35.5	11.6	28.5
GDP	0.6	3.7	3.7	3.1

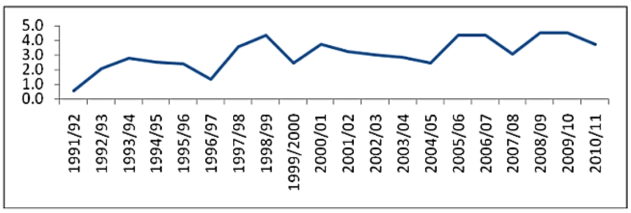

Figure 2. Trends in the share of fuel imports in GDP (%).

Results

The use of thermocouple sensors in the determination of temperature and the design of its signal module to the PLC

Temperature is one of the oldest physical quantities. Temperature is the most important factor that needs to be constantly measured, monitored and controlled in various industrial processes. Today, the industry requires accurate and reliable [3-9]. Temperature sensors measure temperature by sensing changes in the physical properties of a substance. A wide range of temperature sensors is available, for example:

- Thermocouple
- Thermal resistance
- Thermistor
- Semiconductor temperature sensor

Measurement of temperature, because temperature has a significant impact on the cost, quality, efficiency and safety of the product (Table 2).

Table 2. Various types of sensors, thermocouples and resistance temperature sensors.

Indicators	Thermocouple	Thermal resistance	Thermistor	Semiconductor temperature sensor
Range	-270°C from 2000°C to	-200°C from 850° C to	-50°C from 300° C to	-55°C from 200°C to
Physical magnitude of the output signal	Voltage (V)	Resistance (R)	Resistance (R)	Resistance (R)
The condition for the signal to appear	Spontaneously	Current value	Current value	Power source required
Signal loss	low	High	Moderate	Past
Responding to external influences	Average	Average	Average	Average
Accuracy	Average	High	well	bed
Special requirements	Reinforcement, filtering, linearization	Kompetsatsiy, filtering	linearization	Kompetsatsiy, filtering
Size	Small	Average	Small	Very small

Among the various types of sensors, thermocouples and resistance temperature sensors are most commonly used in industrial applications.

When there is a temperature difference between the two ends, a voltage is created on a simple metal rod. In these sensors, the part that touches the medium in which the temperature is measured is called the hot connection, and the part that touches the constant medium is called the cold connection. The electrons at the hot junction end are more thermally excited than the electrons at the cold junction end. At the end of the hot bond, more thermally excited electrons begin to propagate in the colder direction. The redistribution of electrons produces a negative charge at the cold end and an equal positive charge at the hot end.

This process creates an electrostatic voltage between the two ends of the sensor. The free flow of voltage across the sensors is called the Zeebek voltage, and the process is called the Zeebek effect. It is not possible to create a sensor using a single metal or compound. The schematic diagram of the thermocouple sensors is shown in Figure 3.

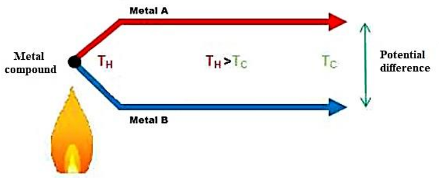

Figure 3. General view of thermocouple sensors.

The magnitude and direction of the free electron voltage developed between the two ends are proportional to the temperature difference, as shown in Equation 1.

Where S is the Zeebek coefficient or thermoelectric sensitivity.

When designing thermocouple sensors, thermocouples (metal or compound rods inside the sensor) are bipolar. Bipolar thermocouples can generate positive or negative voltages, depending on whether the measured temperature is above or below the system temperature. Each thermocouple sensor has a non-linear voltage curve in the temperature range, depending on its specific sensitivity (mV/°C), temperature range and its metals and calibration type. The thermocouple voltage curves are shown in Figure 4.

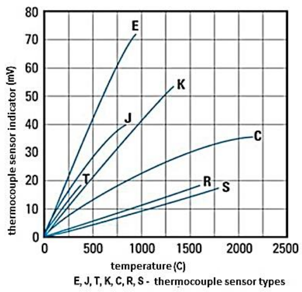

Figure 4. Voltage curves in thermocouple sensors.

The Zeebek coefficient is a nonlinear function of temperature, so we can see that the voltages emanating from the thermocouple sensors in the operating state are nonlinear. Thermocouple sensors measure the temperature difference between hot and cold connections. TS do not measure absolute temperature on a single rod, as shown in Figure 5.

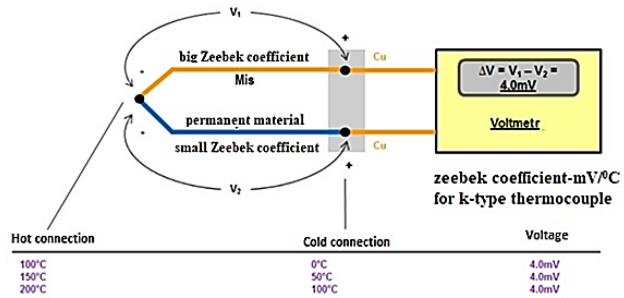

Figure 5. Simplified view of cold connection compensation.

Discussion

Therefore, RC low-conductivity differential and common-mode filters were used until the analog signal entered the ADC1220 microchip. The filters effectively eliminate the reception of high frequency interference that may be present. The LM94022 analog output temperature sensor is connected to the ADS1220 microchip using a TS5A23159 dual-channel multiplexer after passing through low-frequency common-type filters. Another TMP275 digital temperature sensor is connected to ISO1540 using the I2C protocol. These sensors have been used to monitor devices and microchips as the temperature rises or falls during operation, as well as to ensure that the chip operates in a variety of climatic conditions. The digital signal from the ADC1220 (DRDY) provides the TCA6408A microchip via communication channels that connect to the GPIO pin. When there is a temperature difference between the two ends, a voltage is created on a simple metal rod. In these sensors, the part that touches the medium in which the temperature is measured is called the hot connection, and the part that touches the constant medium is called the cold connection. The electrons at the hot junction end are more thermally excited than the electrons at the cold junction end. At the end of the hot bond, more thermally excited electrons begin to propagate in the colder direction. The redistribution of electrons produces a negative charge at the cold end and an equal positive charge at the hot end.

Conclusion

SCADA system has been created to constantly monitor the temperature in the temporary storage bunts of cotton. In order to eliminate the effect of external influences on the signals due to the occurrence of voltages in the millivolt range in Temperature Sensors (TS), DC low-conductivity differential and common mode filters were used before the analog signal was input to the ADC1220 microchip. The use of thermocouple sensors in temperature detection and the design of its signal transmission module to the DMC have been developed. A thermocouple sensor was used to determine the temperature in the temporary storage bunts of cotton and two more temperature sensors were used to determine the temperature at its connections. Using this system, it is possible to determine the temperature in the cotton bunts at any level and length. The LPS chip was implemented by an analog temperature gauge LM94022 with a resolution of ± 1.5°C (maximum) from 0°C to 50°C and a two-contact digital output temperature sensor TMP275 with a resolution of ± 2°C (maximum).

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