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SINGLE CHANNEL RTD INPUT MODULE

1. Overview

This system implements complete RTD measurement system based on a microcontroller and an SPI-compatible ADC. The system supports both Pt100 and Pt1000 RTDs and converts sensor resistance to digital temperatures using the inverse Callendar–Van Dusen equation. The RTD interface circuit with a microcontroller interface offers the facility to read and interpret temperature from industrial-grade platinum RTD sensors.

The system design includes significant hardware components such as precision constant current source using an op-amp and reference resistor, a differential amplifier for accurate voltage measurement across the RTD, an analog low-pass filter for noise elimination, and a 12-bit SPI ADC for digitization of the sensor voltage. The digitized data is processed by a microcontroller programmed in the Arduino IDE and computes the real-time temperature values and transmits them via serial communication.

By following the 4-wire RTD measurement technique, the circuit is compensated for lead wire resistance for more accurate temperature measurement. The firmware offers SPI initialization, ADC communication, RTD resistance calculation, and temperature conversion with optional RTD type selection for dynamic

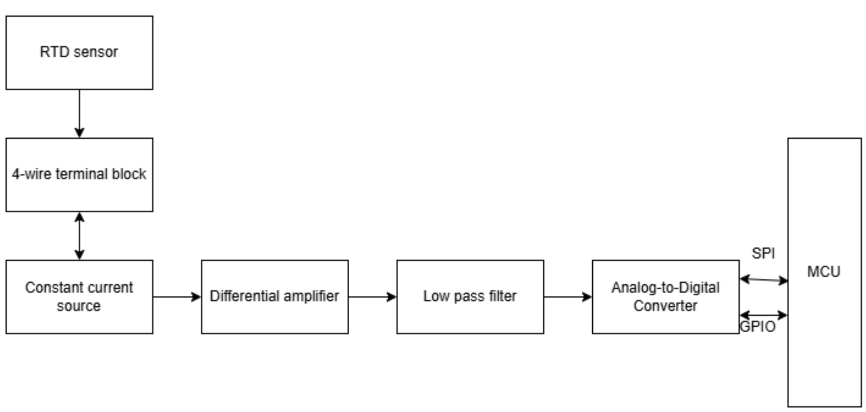

Figure 1: Single-channel input module block diagram

configuration. Figure 1 shows the general structure of the single-channel RTD input module, showing the signal flow from the RTD sensor to the microcontroller for the calculation of the temperature.

2. Features

a) Pt100 and Pt1000 RTD support

b) 4-Wire Measurement Technique

c) Constant Current Source

d) Differential Amplifier Stage

e) Low-Pass Filtering

f) 12-bit SPI ADC

g) MCU Firmware in C

h) Dynamic RTD Type Selection (Optional)

i) Scalable Interface to Microcontroller

3. Description

This Pt100 and Pt1000 resistance temperature detector RTD signal conditioning system is developed for accurate temperature measurement in harsh industrial applications. It is derived from a modular analog front-end design that addresses precision and immunity to noise requirements.

i. Support of Pt100 and Pt1000 Sensors

The Pt100 and Pt1000 sensors are supported by the design through the firmware layer. The two sensors are connected with a 4-wire interface that removes the effect of wire resistance. Both sensors share the same analog front-end circuit, but the microcontroller firmware makes use of the correct scaling factors based on the selected RTD type. A firmware parameter allows the user to specify the RTD type (Pt100 or Pt1000), and corresponding adjustments are made when converting resistance to temperature through the use of the reverse Callendar–Van Dusen equation.

ii. Noise Reduction and Self-Healing Compensation

For minimizing electrical noise, a low-pass RC filter is placed between ADC and differential amplifier to attenuate high-frequency interference. The 4-wire configuration inherently decouples voltage measurement from the current path, minimizing the effect of contact and wire resistance.

Self-heating is controlled by choosing the excitation current carefully with a constant current source reference resistor (e.g., 3.3 kΩ) that restricts the current to <1 mA. This ensures RTD power dissipation is kept below the typical 1 mW limit, thus keeping the sensor element from internal heating.

iii. Stable Operation at High Ambient Temperatures (up to 101°C)

Low-drift, high-thermal-stability op-amps and high-temperature-rated passive components ensure operation at high ambient conditions. Decoupling capacitors and power regulation protect sensitive analog stages from voltage ripple and thermal stress.

iv. Schematic Diagram

The schematic diagram in Figure 2 shows the complete circuit implementation of the single-channel RTD input module, including the constant current source, differential amplifier, low-pass filter, SPI ADC, and microcontroller interface. The firmware is provided in the GitHub repository with the link in the Resources section.

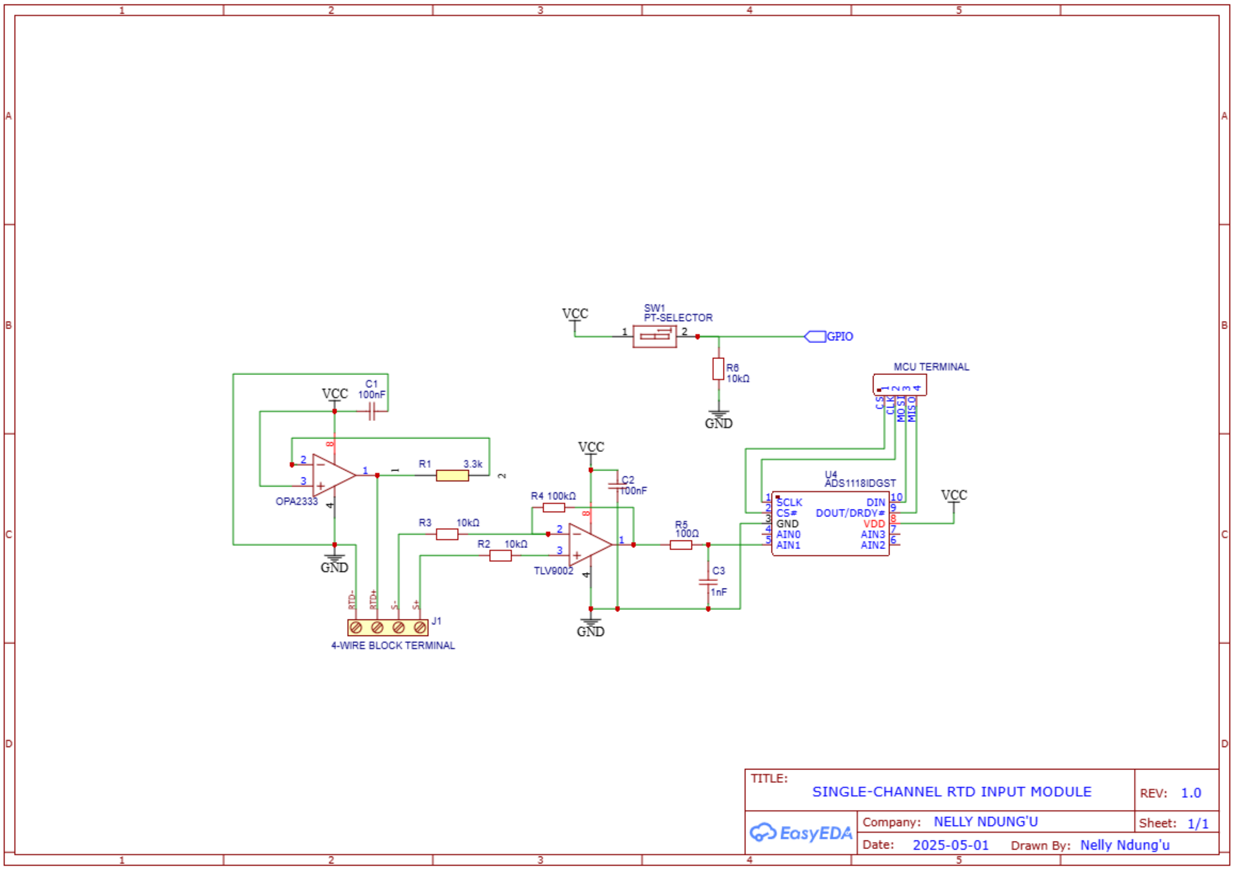

Figure 2: Schematic diagram

4. Conclusion

This RTD input module provides temperature measurement for both PT100 and PT1000 sensors. The implementation uses a constant current source, differential amplifier, and 12-bit SPI ADC to achieve accurate resistance-to-temperature conversion. A 4-wire connection prevents lead resistance errors, and low-pass filtering reduces noise. Microcontroller firmware controls SPI communication and calculates real-time temperature using the inverse Callendar–Van Dusen equation. Dynamic RTD type selection allows the system to be scalable and flexible.

5. Resources

GitHub repository – Schematic and firmware

Link: https://github.com/nellyndungu/SINGLE_CHANNEL_RTD_INPUT_MODULE.git