Precision Temperature Controller

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Abstract

This document presents the design and implementation of a **precision temperature controller** utilizing the **AD620 instrumentation amplifier** and a **Wheatstone bridge circuit** with a **PT100 RTD sensor**. The system is designed to provide a highly accurate and stable temperature measurement over a range of ±40°C, corresponding to an output voltage range of $\pm 3V$, with 0V at 0°C. The Wheatstone bridge ensures accurate resistance-to-voltage conversion, while the AD620 module provides high-gain, low-noise signal amplification for precise temperature monitoring and control.

Keywords

• Precision Temperature Controller • Signal Conditioning • Temperature Measurement • Industrial Automation

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Contents

1 Temperature Controller

Precision temperature controller is implemented using AD620 instrument amplifier, Wheatstone bridge, PT100 RTD sensor and physlogger (data acquisition device). Figure 1 shows the block diagram of precision temperature control circuit.

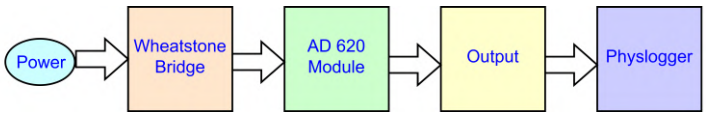
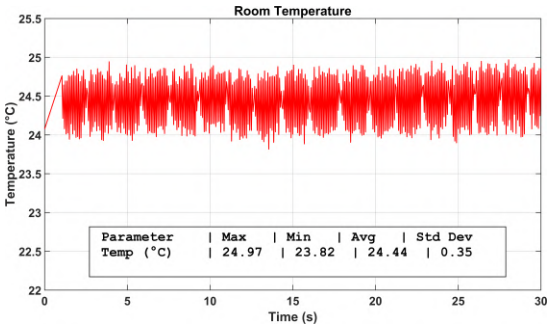


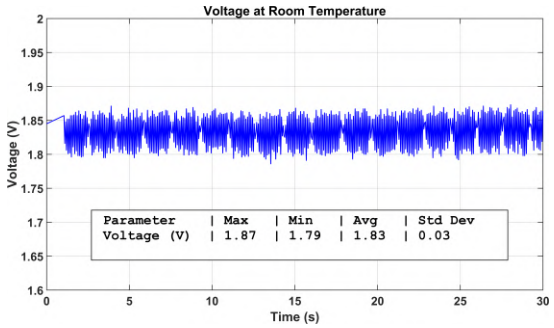
Figure 1: Block diagram of precision temperature control circuit.

1.1 RTD at Room Temperature

Figure 2a and Figure 2b shows the temperature and voltage reading respectively, of channel 1 RTD at room temperature.



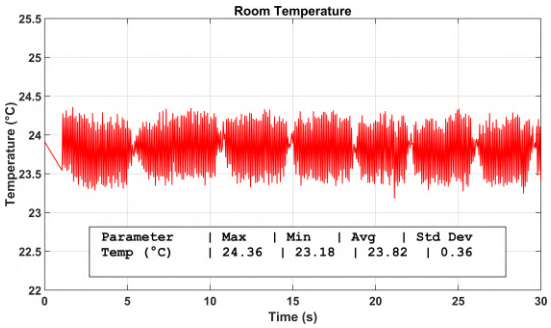
(a) Temperature.



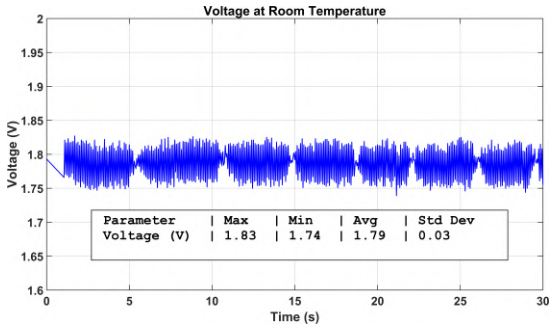
(b) Voltage.

Figure 2: Channel 1 RTD at room temperature.

Figure 3a and Figure 3b shows the temperature and voltage reading respectively, of channel 2 RTD at room temperature.



(a) Temperature.



(b) Voltage.

Figure 3: Channel 2 RTD at room temperature.

Figure 4a and Figure 4b shows the experimental setup at room temperature.

(a) Voltage.

(b) RTD sensor.

Figure 4: RTD at room temperature.

1.1.1 FFT Spectrum of RTD at Room Temperature

Figure 5 shows the FFT spectrum of RTD at room temperature (sampling frequency = 20 Hz).

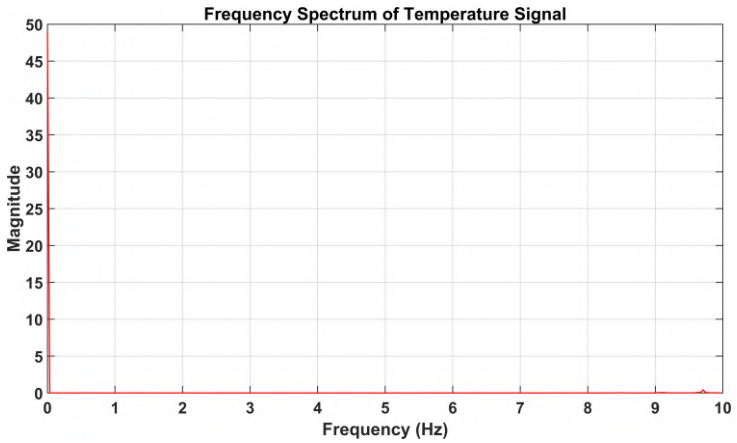
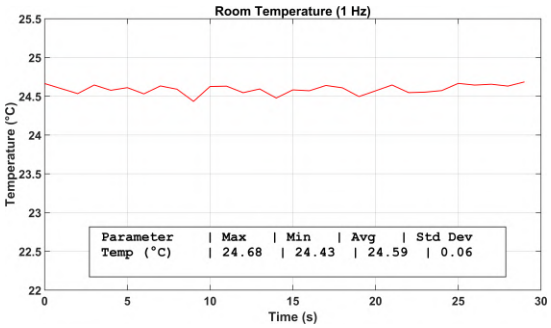


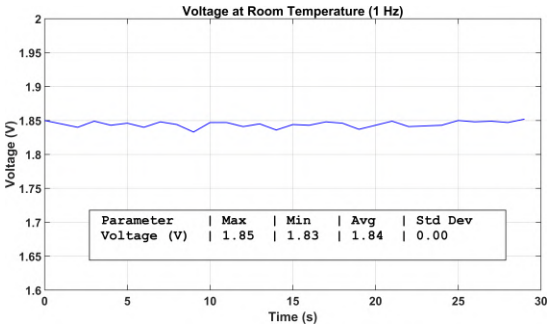
Figure 5: FFT spectrum of RTD at room temperature.

1.1.2 Room Temperature Signal Analysis at 1 Hz

Figure 6a and Figure 6b shows the temperature and voltage reading, of RTD with (f_s = 1Hz) at room temperature.



(a) Temperature.

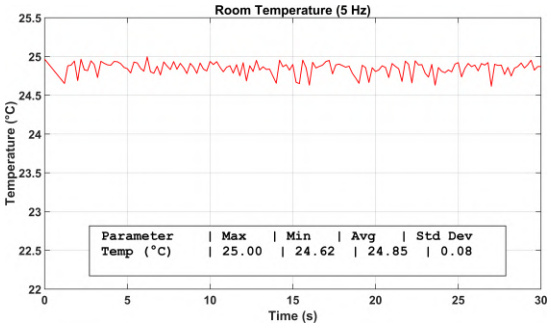


(b) Voltage.

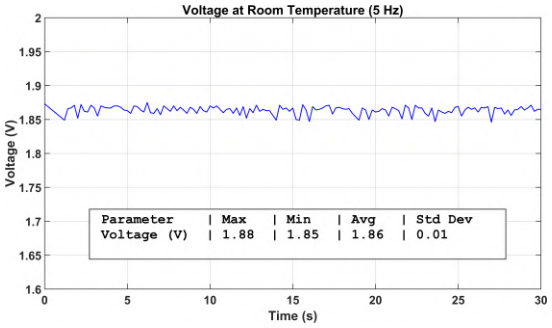
Figure 6: Signal analysis at 1 Hz

1.1.3 Room Temperature Signal Analysis at 5 Hz

Figure 7a and Figure 7b shows the temperature and voltage reading respectively, of RTD with (f_s = 5Hz) at room temperature.



(a) Temperature.

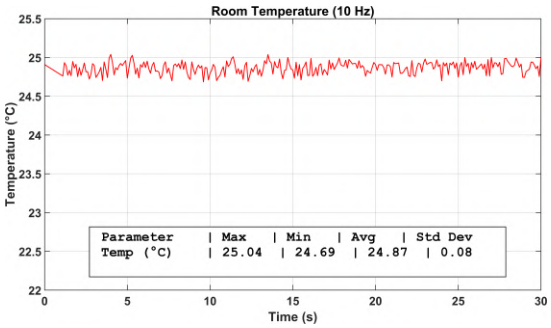


(b) Voltage.

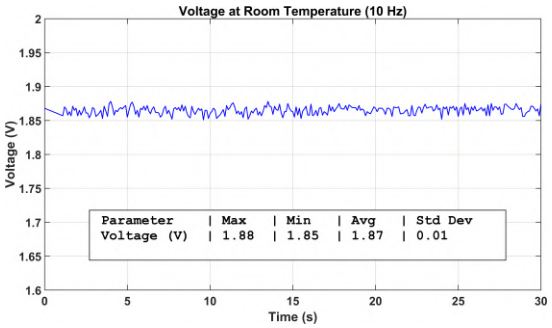
Figure 7: Signal analysis at 5 Hz

1.1.4 Room Temperature Signal Analysis at 10 Hz

Figure 8a and Figure 8b shows the temperature and voltage reading respectively, of RTD with ($f_s = 10$Hz) at room temperature.



(a) Temperature.

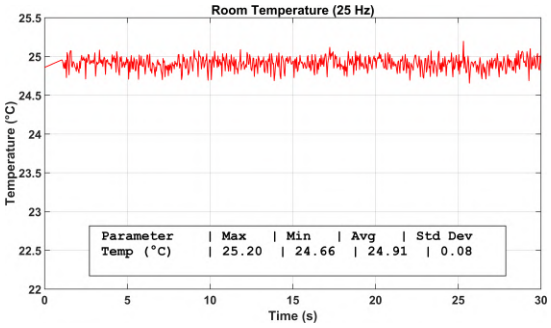


(b) Voltage.

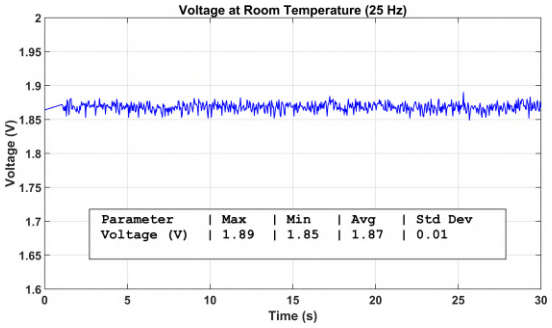
Figure 8: Signal analysis at 10 Hz

1.1.5 Room Temperature Signal Analysis at 25 Hz

Figure 9a and Figure 9b shows the temperature and voltage reading respectively, of RTD with ($f_s = 25$Hz) at room temperature.



(a) Temperature.

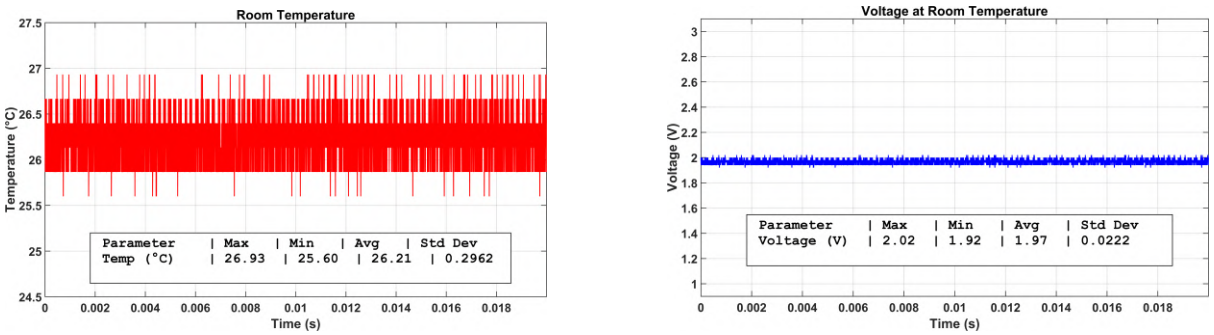


(b) Voltage.

Figure 9: Signal analysis at 25 Hz

1.1.6 RTD at Room Temperature (oscilloscope Data)

Figure 10a and Figure 2b shows the temperature and voltage reading (recorded by oscilloscope) respectively, of RTD at room temperature.

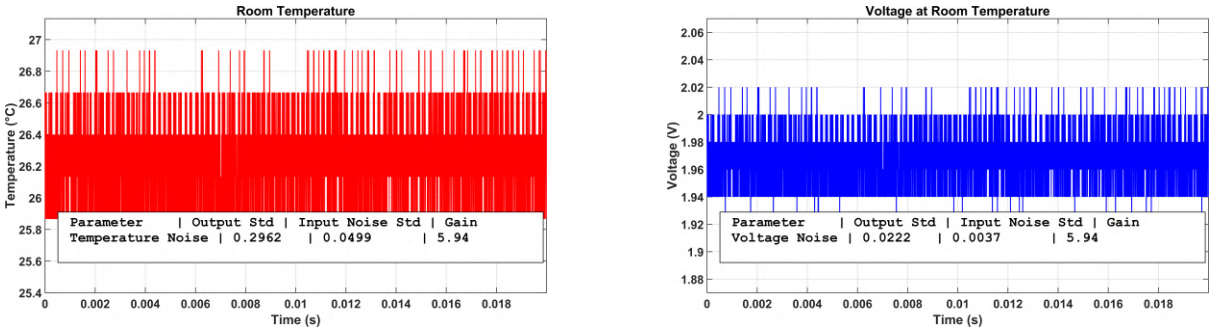


(a) Temperature. (b) Voltage.

Figure 10: RTD at room temperature (data recorded by oscilloscope).

1.1.7 RTD at Room Temperature (oscilloscope Data with noise analysis)

Figure 11a and Figure 11b shows the temperature and voltage reading (recorded by oscilloscope) with noise analysis respectively, of RTD at room temperature.

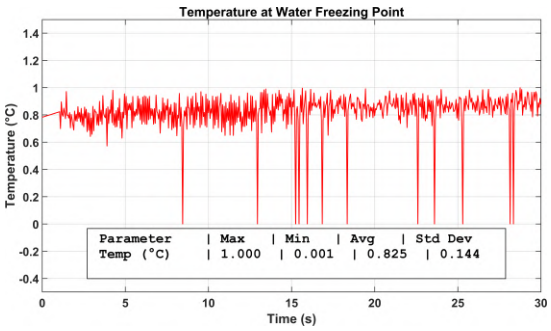


(a) Temperature. (b) Voltage.

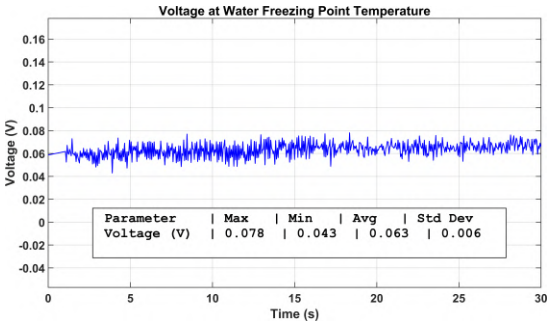
Figure 11: RTD at room temperature with noise analysis(data recorded by oscilloscope).

1.2 RTD at Water Freezing Point

Figure 12a and Figure 12b shows the temperature and voltage reading respectively, of channel 1 RTD at water freezing point.



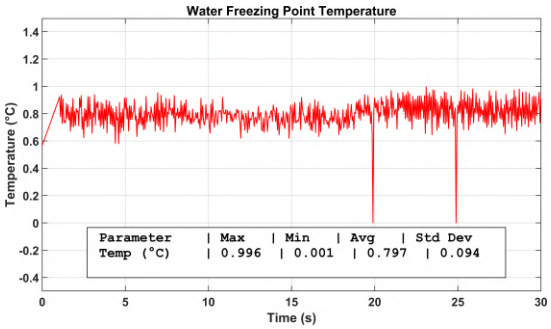
(a) Temperature.



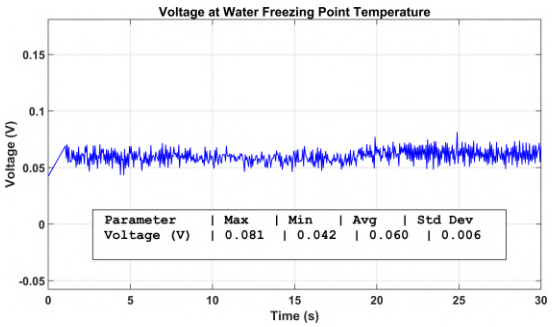
(b) Voltage.

Figure 12: Channel 1 RTD at water freezing point.

Figure 13a and Figure 13b shows the temperature and voltage reading respectively, of channel 2 RTD at water freezing point.



(a) Temperature.

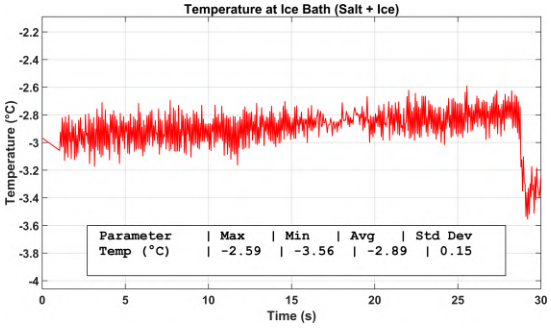


(b) Voltage.

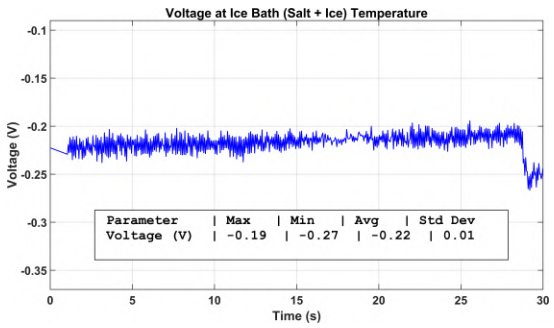
Figure 13: Channel 2 RTD at water freezing point.

1.3 RTD at Ice Bath(Ice + Table Salt)

Figure 14a and Figure 14b shows the temperature and voltage reading respectively, of channel 1 RTD at ice bath (table salt + ice).



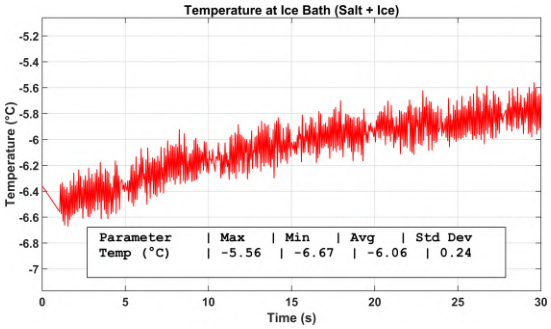
(a) Temperature.



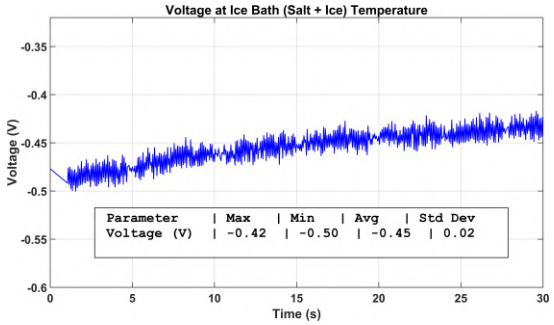
(b) Voltage.

Figure 14: Channel 1 RTD at ice bath (table salt + ice).

Figure 15a and Figure 15b shows the temperature and voltage reading respectively, of channel 2 RTD at ice bath (table salt + ice).



(a) Temperature.



(b) Voltage.

Figure 15: Channel 2 RTD at ice bath (table salt + ice).

Figure 16a and Figure 16b shows the experimental setup at ice bath (table salt + ice) temperature.

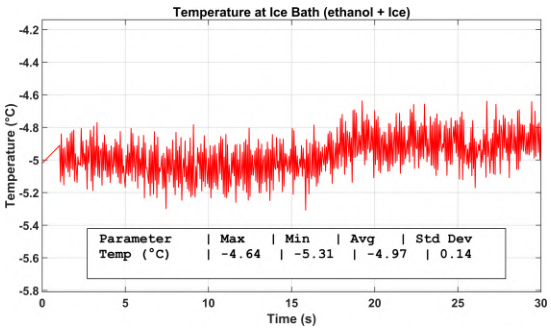
(a) Voltage.

(b) RTD sensor.

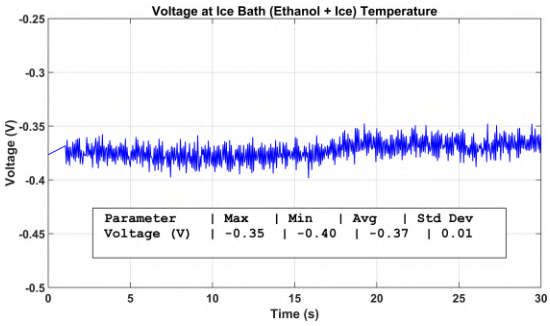
Figure 16: RTD at ice bath (table salt + ice).

1.4 RTD at Ice Bath(Ice + Ethanol)

Figure 17a and Figure 17b shows the temperature and voltage reading respectively, of channel 1 RTD at ice bath (ice + ethanol).



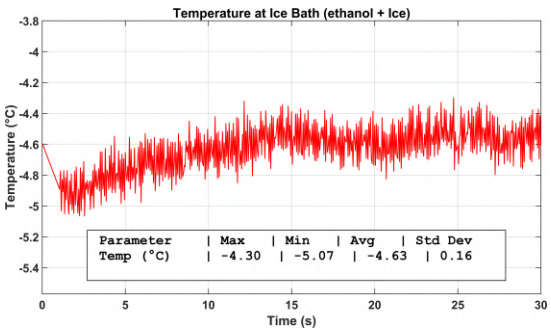
(a) Temperature.



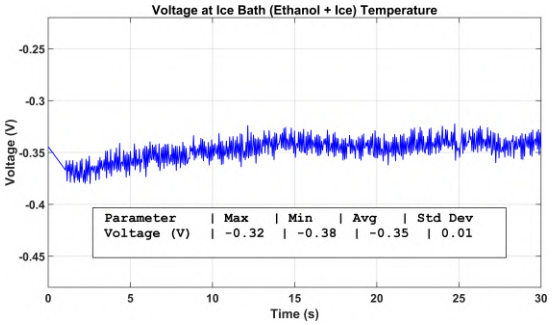
(b) Voltage.

Figure 17: Channel 1 RTD at ice bath (ethanol + ice).

Figure 18a and Figure 18b shows the temperature and voltage reading respectively, of channel 2 RTD at ice bath (ice + ethanol).



(a) Temperature.

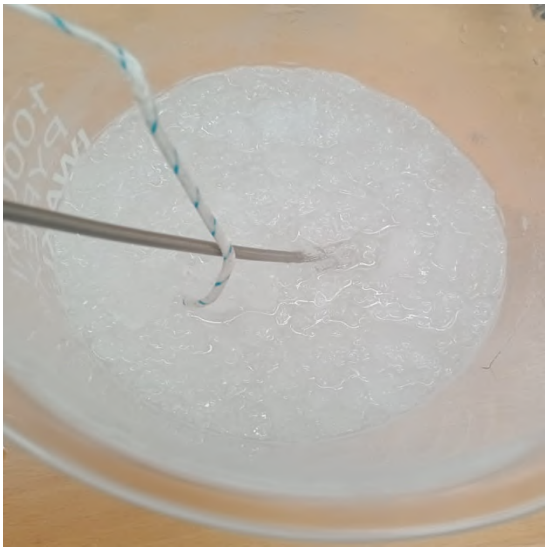


(b) Voltage.

Figure 18: Channel 2 RTD at ice bath (ethanol + ice).

Figure 19a and Figure 19b shows the experimental setup at ice bath (table salt + ice) temperature.

(a) Voltage.

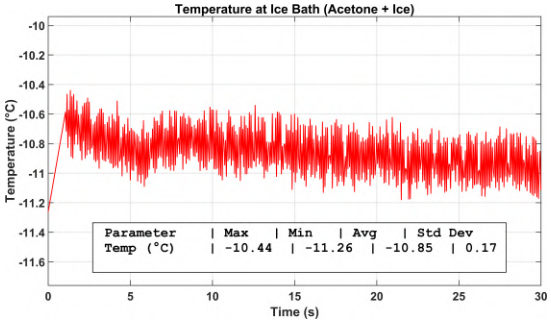


(b) RTD sensor.

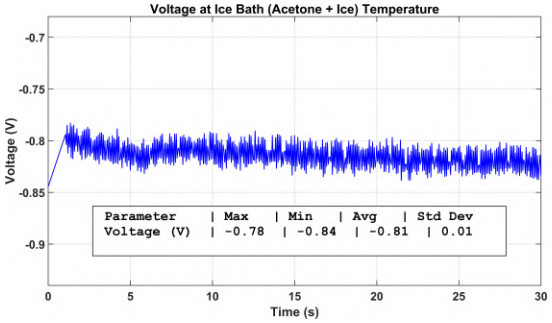
Figure 19: RTD at ice bath (ethanol + ice).

1.5 RTD at Ice Bath(Ice + Acetone)

Figure 20a and Figure 20b shows the temperature and voltage reading respectively, of channel 1 RTD at ice bath (ice + acetone).



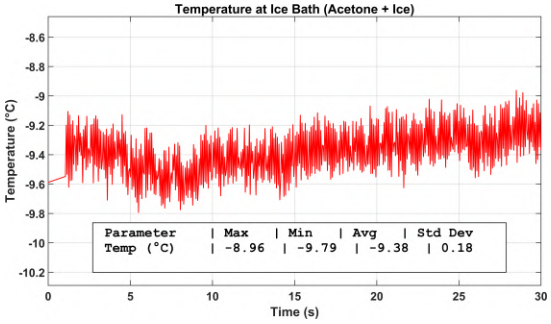
(a) Temperature.



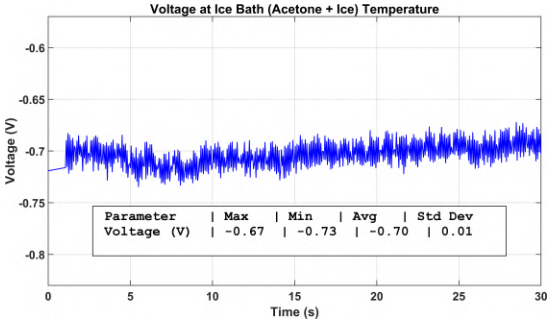
(b) Voltage.

Figure 20: Channel 1 RTD at ice bath (acetone + ice).

Figure 21a and Figure 21b shows the temperature and voltage reading respectively, of channel 1 RTD at ice bath (ice + acetone).



(a) Temperature.



(b) Voltage.

Figure 21: Channel 2 RTD at ice bath (acetone + ice).

Figure 22a and Figure 22b shows the experimental setup at ice bath (table salt + ice) temperature.

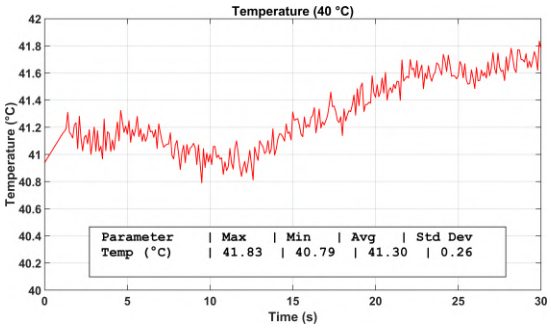
(a) Voltage.

(b) RTD sensor.

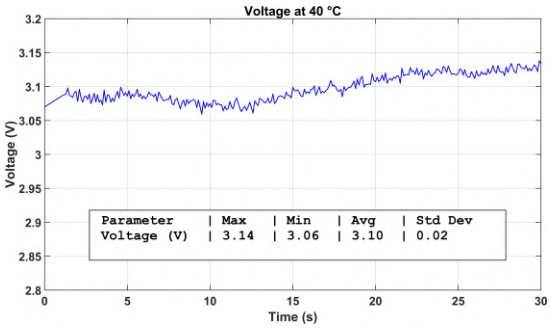
Figure 22: RTD at ice bath (acetone + ice).

1.6 Temperature Signal Analysis (Peltier data) at 40 °C

Figure 23a and Figure 23b shows the temperature and voltage reading respectively, of RTD at 40 °C temperature.



(a) Temperature.

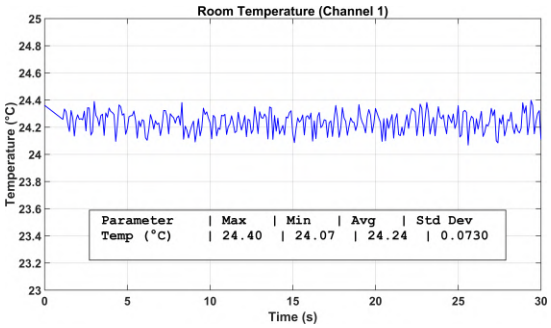


(b) Voltage.

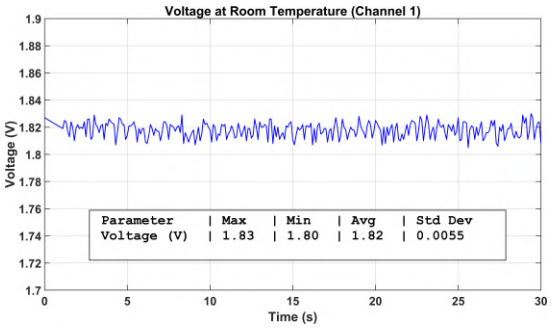
Figure 23: Signal analysis (40 °C) at 10 Hz

1.6.1 RTD at Room Temperature (Dual Channel)

Figure 24a and Figure 24b shows the temperature and voltage reading respectively, of channel 1 RTD at room temperature.



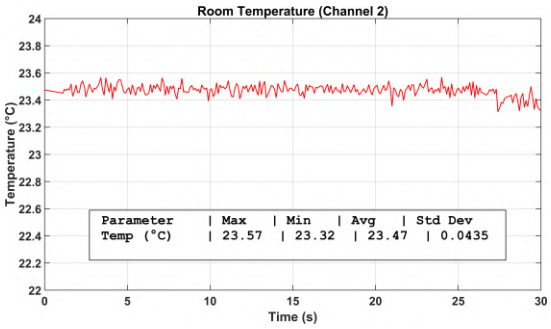
(a) Temperature.



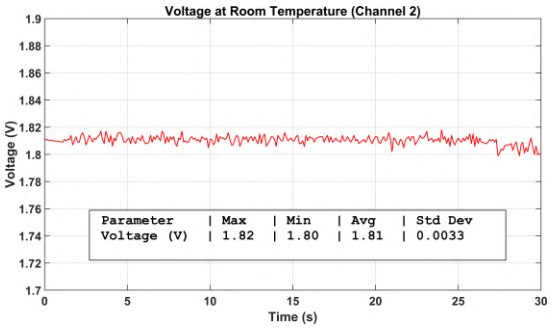
(b) Voltage.

Figure 24: Channel 1 RTD at room temperature.

Figure 25a and Figure 3b shows the temperature and voltage reading respectively, of channel 2 RTD at room temperature.



(a) Temperature.

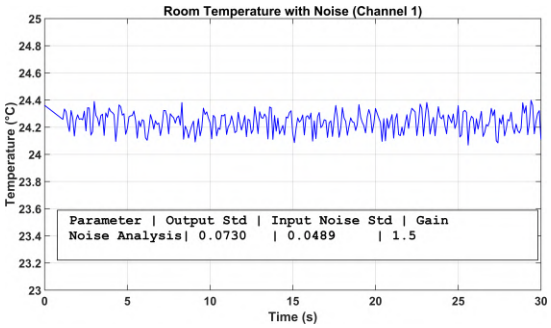


(b) Voltage.

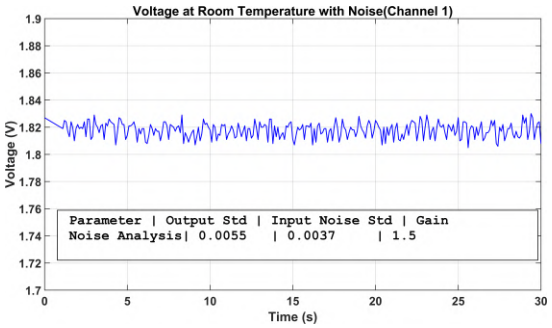
Figure 25: Channel 2 RTD at room temperature.

1.6.2 Noise Analysis at Room Temperature (Dual Channel)

Figure 26a and Figure 26b shows the temperature and voltage reading with noise standard deviation respectively, of RTD channel 1 at room temperature.



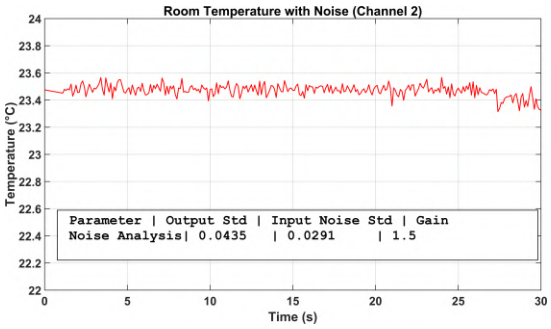
(a) Temperature with noise.



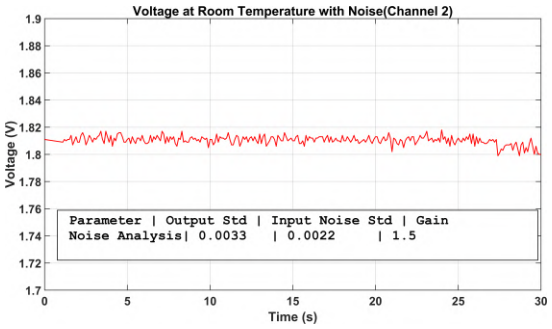
(b) Voltage with noise.

Figure 26: Signal noise analysis at channel 1

Figure 27a and Figure 27b shows the temperature and voltage reading with noise standard deviation respectively, of RTD channel 2 at room temperature.



(a) Temperature with noise.



(b) Voltage with noise.

Figure 27: Signal noise analysis at channel 2